LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

LEED

REFERENCE GUIDE FOR **BUILDING DESIGN AND CONSTRUCTION**

Updated August 2020

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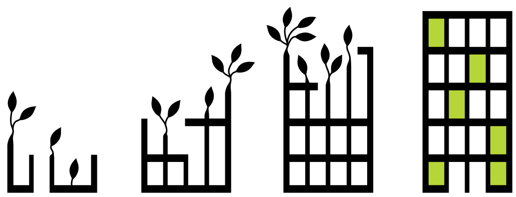


THE CASE FOR GREEN BUILDING

Green buildings are an integral part of the solution to the environmental challenges facing the planet.

Today we use the equivalent of 1.5 Earths to meet the resource needs of everyday life and absorb the resulting wastes. This measure of our planet's carrying capacity means that it takes Earth 18 months to regenerate what is used in only 12 months. If current trends continue, estimates suggest, by the year 2030 we will need the equivalent of two planets.[1] Turning resources into waste faster than they can be regenerated puts the planet into ecological overshoot, a clearly unsustainable condition that we all must address.

The forces driving this situation are numerous. Human population has increased exponentially in the past 60 years, from about 2.5 billion in 1950 to more than 7 billion today. Our linear use of resources, treating outputs as waste, is responsible for the toxins that are accumulating in the atmosphere, in water, and on the ground. This pattern of extraction, use, and disposal has hastened depletion of finite supplies of nonrenewable energy, water, and materials and is accelerating the pace of our greatest problem—climate change. Buildings account for a significant portion of greenhouse gas emissions; in the U.S., buildings are associated with 38% of all emissions of carbon dioxide[2]; globally, the figure is nearly one-third.[3] The problem is anticipated to worsen as developing countries attain higher standards of living. These forces are bringing us to a tipping point, a threshold beyond which Earth cannot rebalance itself without major disruption to the systems that humans and other species rely on for survival.

The impetus behind development of the Leadership in Energy and Environmental Design (LEED) rating systems was recognition of those problems, coupled with awareness that the design and construction industry already had the expertise, tools, and technology to transform buildings and make significant advances toward a sustainable planet. LEED projects throughout the world have demonstrated the benefits of taking a green design approach that reduces the environmental harms of buildings and restores the balance of natural systems.

Buildings have a major role to play in sustainability through their construction, the lifetime of their operation, and patterns of development. As Earth's population continues to increase, construction and renovation of buildings expand even more rapidly. For example, estimates for the U.S. indicate that two-thirds of the structures that will exist in 2050 will have been built between now and then.[4] What we build today and where we build it are profoundly important.

The green building portion of the construction market is rapidly expanding. It represented 2% of nonresidential construction starts in 2005, 12% in 2008, and 28% to 35% in 2010.[5] The concept of green buildings provides a vision for resource equity between developing and developed nations. As green building practices guide developed nations toward a more responsible use of resources, they enable developing nations to attain essential improvements in quality of life without overtaxing local resources.

1. *Global Footprint Network, http://footprintnetwork.org/en/index.php/gfn/page/world_footprint/, accessed 9/11/2012*
2. *Energy Information Administration (2008). Assumptions to the Annual Energy Outlook*
3. *unep.org/sbci/pdfs/SBCI-BCCSummary.pdf.*
4. *Ewing, R., K. Bartholomew, S. Winkleman, J. Walters, and D. Chen, Growing Cooler: The Evidence on Urban Development and Climate Change (Washington, DC: Urban Land Institute, 2008), p. 8, smartgrowthamerica.org/documents/growingcoolerCH1.pdf.*
5. *Green Outlook 2011: Green Trends Driving Growth (McGraw-Hill Construction, 2010).*

ABOUT LEED

Developed by the U.S. Green Building Council, LEED is a framework for identifying, implementing, and measuring green building and neighborhood design, construction, operations, and maintenance. LEED is a voluntary, market-driven, consensus-based tool that serves as a guideline and assessment mechanism. LEED rating systems address commercial, institutional, and residential buildings and neighborhood developments.

LEED seeks to optimize the use of natural resources, promote regenerative and restorative strategies, maximize the positive and minimize the negative environmental and human health consequences of the construction industry, and provide high-quality indoor environments for building occupants. LEED emphasizes integrative design, integration of existing technology, and state-of-the-art strategies to advance expertise in green building and transform professional practice. The technical basis for LEED strikes a balance between requiring today's best practices and encouraging leadership strategies. LEED sets a challenging yet achievable set of benchmarks that define green building for interior spaces, entire structures, and whole neighborhoods.

LEED for New Construction and Major Renovations was developed in 1998 for the commercial building industry and has since been updated several times. Over the years, other rating systems have been developed to meet the needs of different market sectors.

Since its launch, LEED has evolved to address new markets and building types, advances in practice and technology, and greater understanding of the environmental and human health effects of the built environment. These ongoing improvements, developed by USGBC member-based volunteer committees, subcommittees, and working groups in conjunction with USGBC staff, have been reviewed by the LEED Steering Committee and the USGBC Board of Directors before being submitted to USGBC members for a vote. The process is based on principles of transparency, openness, and inclusiveness.

LEED'S GOALS

The LEED rating systems aim to promote a transformation of the construction industry through strategies designed to achieve seven goals:

- To reverse contribution to global **climate change**
- To enhance individual **human health** and well-being
- To protect and restore **water resources**
- To protect, enhance, and restore **biodiversity** and ecosystem services
- To promote sustainable and regenerative **material resources** cycles
- To build a **greener economy**
- To enhance social equity, environmental justice, **community** health, and quality of life

These goals are the basis for LEED's prerequisites and credits. In the BD+C rating system, the major prerequisites and credits are categorized as Location and Transportation (LT), Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), and Indoor Environmental Quality (EQ).

The goals also drive the weighting of points toward certification. Each credit in the rating system is allocated points based on the relative importance of its contribution to the goals. The result is a weighted average: credits that most directly address the most important goals are given the greatest weight. Project teams that meet the prerequisites and earn enough credits to achieve certification have demonstrated performance that spans the goals in an integrated way. Certification is awarded at four levels (Certified, Silver, Gold, Platinum) to incentivize higher achievement and, in turn, faster progress toward the goals.

BENEFITS OF USING LEED

LEED is designed to address environmental challenges while responding to the needs of a competitive market. Certification demonstrates leadership, innovation, environmental stewardship, and social responsibility. LEED gives building owners and operators the tools they need to immediately improve both building performance and the bottom line while providing healthful indoor spaces for a building's occupants.

LEED-certified buildings are designed to deliver the following benefits:

- Lower operating costs and increased asset value
- Reduced waste sent to landfills
- Energy and water conservation
- More healthful and productive environments for occupants
- Reductions in greenhouse gas emissions
- Qualification for tax rebates, zoning allowances, and other incentives in many cities

By participating in LEED, owners, operators, designers, and builders make a meaningful contribution to the green building industry. By documenting and tracking buildings' resource use, they contribute to a growing body of knowledge that will advance research in this rapidly evolving field. This will allow future projects to build on the successes of today's designs and bring innovations to the market.

LEED CERTIFICATION PROCESS

The process begins when the owner selects the rating system and registers the project (see *Rating System Selection*). The project is then designed to meet the requirements for all prerequisites and for the credits the team has chosen to pursue. After documentation has been submitted for certification, a project goes through preliminary and final reviews. The preliminary review provides technical advice on credits that require additional work for achievement, and the final review contains the project's final score and certification level. The decision can be appealed if a team believes additional consideration is warranted.

LEED has four levels of certification, depending on the point thresholds achieved:

- Certified, 40–49 points
- Silver, 50–59 points
- Gold, 60–79 points
- Platinum, 80 points and above

There are also two alternative certification processes for owners with multiple buildings pursuing LEED certification, (1) LEED volume certification and (2) LEED campus certification. This reference guide covers credit-specific guidance for LEED campus certification. In some cases the LEED campus certification is used to achieve one single certification for many buildings (group certification project) and in others it used to achieve pre-approval for credits to be utilized by a number of certifications (campus credits).

See www.gbci.org for more information about the review processes and eligibility requirements.

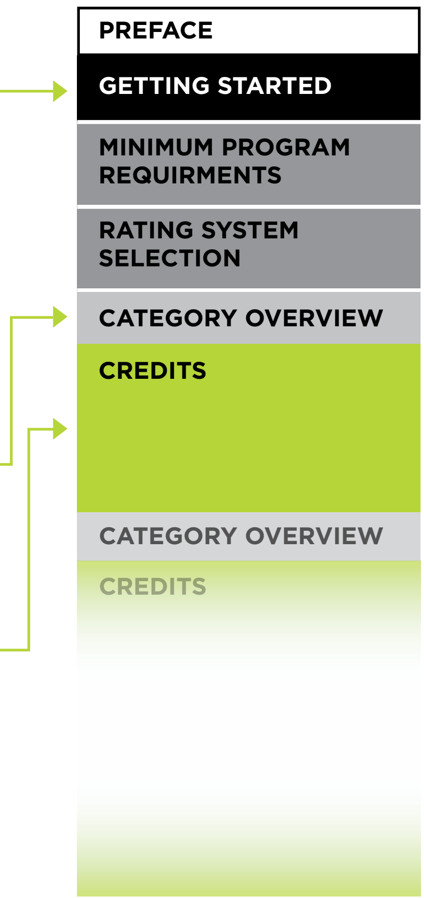
REFERENCE GUIDE OVERVIEW

GUIDE STRUCTURE

GETTING STARTED provides a recommended process for achieving certification and addresses issues that cut across the entire rating system.

CATEGORY OVERVIEWS emphasize sustainability topics, market factors, and credit relationships that are specific to a single credit category and information that is applicable to multiple credits within that category.

CREDITS contain content that is specific to the achievement of that credit.



ICONS THAT MAY APPEAR WITHIN EACH CREDIT REFER THE USER TO FOLLOWING SECTIONS:

Getting Started (beginning of book)

Further Explanation (within same credit)

CREDIT STRUCTURE

Each credit category begins with an overview that discusses sustainability and market factors specific to the category. For each prerequisite and credit, readers will then find the following sections:

INTENT & REQUIREMENTS
outlines the rating system requirements for achieving the prerequisite or credit. They were approved through the rating system development process and can also be found on the USGBC website.

BEHIND THE INTENT
connects credit achievement with larger sustainability issues and provides information on how the credit requirements meet the intent stated in the rating system.

STEP-BY-STEP GUIDANCE
suggests the implementation and documentation steps that can be used by most projects, as well as generally applicable tips and examples.

FURTHER EXPLANATION
provides guidance for lengthy calculations or for special project situations, such as tips for nonstandard project types or different credit approaches. It includes a *Campus* section and, sometimes, an *International Tips* section.

REQUIRED DOCUMENTATION
lists the items that must be submitted for certification review.

RELATED CREDIT TIPS
identifies other credits that may affect a project team's decisions and strategies for the credit in question; the relationships between credits may imply synergies or trade-offs.

CHANGES FROM LEED 2009
is a quick reference of changes from the previous version of LEED.

REFERENCED STANDARDS
lists the technical standards related to the credit and offers weblinks to find them.

EXEMPLARY PERFORMANCE
identifies the threshold that must be met to earn an exemplary performance point, if available.

DEFINITIONS
gives the meaning of terms used in the credit.

Getting Started

HOW TO USE THIS REFERENCE GUIDE

This reference guide is designed to elaborate upon and work in conjunction with the rating system. Written by expert users of LEED, it serves as a roadmap, describing the steps for meeting and documenting credit requirements and offering advice on best practices.

Within each section, information is organized to flow from general guidance to more specific tips and finally to supporting references and other information. Sections have been designed with a parallel structure to support way finding and minimize repetition.

CREDIT CATEGORIES

INTEGRATIVE PROCESS

LOCATION AND TRANSPORTATION (LT)

SUSTAINABLE SITES (SS)

WATER EFFICIENCY (WE)

ENERGY AND ATMOSPHERE (EA)

MATERIALS AND RESOURCES (MR)

INDOOR ENVIRONMENTAL QUALITY (EQ)

INNOVATION (IN)

REGIONAL PRIORITY (RP)

MORE ABOUT THE FURTHER EXPLANATION SECTION

Further Explanation contains varied subsections depending on the credit; two of the common subsections are elaborated upon here.

PROJECTS USING CAMPUS CERTIFICATION

The Campus section is for projects using LEED campus certification.

The guidance under Group Approach must be followed by group certification projects. Group certification projects receive a single certification for all buildings included in the group, but are still required to demonstrate credit compliance at the building level for some credits. If the guidance under Group Approach states "All buildings in the group may be documented as one.", then credit compliance can be demonstrated for the group as a whole, for example, by pooling resources or purchasing. However, if the guidance under Group Approach states "Submit separate documentation for each building.", then credit compliance must be demonstrated for each building individually, for example, by performing one calculation per building.

The guidance under Campus Approach must be followed by projects pursuing the credit as a campus credit. Note that an additional registration and review under a master site is required, which results in a pre-approval of the credit for all projects registered under the master site. Only certain credits are available and appropriate to be pursued at the campus level. The guidance under Campus Approach will indicate whether the credit is "Eligible." or "Ineligible.". If the credit is ineligible, each project may still earn the credit but it must be pursued during the regular individual or group project review process rather than through the master site.

PROJECTS OUTSIDE THE US

The *International Tips* section offers advice on determining equivalency to U.S. standards or using non-U.S. standards referenced in the rating system. It is meant to complement, not replace, the other sections of the credit. Helpful advice for projects outside the U.S. may also appear in the *Step-by-Step Guidance* section of each credit. When no tips are needed or available, the *International Tips* heading does not appear.

Units of measurement are given in both Inch-Pound (IP) and International System of Units (SI). IP refers to the system of measurements based on the inch, pound, and gallon, historically derived from the English system and commonly used in the U.S. SI is the modern metric system used in most other parts of the world and defined by the General Conference on Weights and Measures.

Where "local equivalent" is specified, it means an alternative to a LEED referenced standard that is specific to a project's locality. This standard must be widely used and accepted by industry experts and when applied, must meet the credit's intent leading to similar or better outcomes.

Where "USGBC-approved local equivalent" is specified, it means a local standard deemed equivalent to the listed standard by the U.S. Green Building Council through its process for establishing non-U.S. equivalencies in LEED.

TAKING AN INTEGRATIVE APPROACH TO DESIGN AND CONSTRUCTION

The realization of benefits associated with LEED starts with a transformation of the design process itself. Success in LEED and green building design is best accomplished through an integrative design process that prioritizes cost-effectiveness over both the short and long terms and engages all project team members in discovering beneficial interrelationships and synergies between systems and components. By integrating technical and living systems, the team can achieve high levels of building performance, human performance, and environmental benefits.

Conventionally, the design and construction disciplines work separately, and their solutions to design and construction challenges are fragmented. These "solutions" often create unintended consequences—some positive, but mostly negative. The corollary is that when areas of practice are integrated, it becomes possible to significantly improve building performance and achieve synergies that yield economic, environmental, and human health benefits.[1]

In the conventional design process, each discipline's practitioner is expected to design the subassemblies and system components under his or her control for the most benefit and the least cost. In an integrative process, an entire team—client, designers, builders, and operators—identifies overlapping relationships, services, and redundancies among systems so that interdependencies and benefits (which otherwise would have gone unnoticed) can be exploited, thereby increasing performance and reducing costs.

To work this way requires that project teams, whose members represent various disciplines, come together so that the knowledge, analyses, and ideas from each discipline can inform and link with the systems and components of all other disciplines. In this way, LEED credits become aspects of a whole rather than separate components, and the entire design and construction team can identify the interrelationships and linked benefits across multiple LEED credits.

The coordination of building and site systems should be addressed early, preferably before schematic design. The Integrative Process credit formally introduces this way of working into LEED so that the team members' expertise in building and site systems can inform the performance, efficiency, and effectiveness of every system.

The strategies in the Integrative Process credit are recommended for all LEED projects because they encourage integration during early design stages, when it will be the most effective. The credit introduces an integrative process by focusing on engaging energy- and water-related research and analysis to inform early design decisions through high levels of collaboration among all project team members.

Approaching certification using an integrative process gives the project team the greatest chance of success. The process includes three phases:

- **Discovery.** The most important phase of the integrative process, discovery can be thought of as an extensive expansion of what is conventionally called predesign. A project is unlikely to meets its environmental goals cost-effectively without this discrete phase. Discovery work should take place before schematic design begins.
- **Design and construction** (**implementation**)**.** This phase begins with what is conventionally called schematic design. It resembles conventional practice but integrates all the work and collective understanding of system interactions reached during the discovery phase.
- **Occupancy, operations, and performance feedback.** This third stage focuses on preparing to measure performance and creating feedback mechanisms. Assessing performance against targets is critical for informing building operations and identifying the need for any corrective action.

Achieving economic and environmental performance requires that every issue and all team members (clients, designers, engineers, constructors, operators) be brought into the project at the earliest point, before anything is yet designed. The structure to manage this flow of people, information, and analysis is as follows:

- All project team members, representing all design and construction disciplines, gather information and data relevant to the project.
- Team members analyze their information.
- Team members participate in workshops to compare notes and identify opportunities for synergy.

This process of research, analysis, and workshops is done in an iterative cycle that refines the design solutions. In the best scenario, the research and workshops continue until the project systems are optimized, all reasonable synergies are identified, and the related strategies associated with all LEED credits are documented and implemented.

1. *Integrative Process (IP) ANSI Consensus National Standard Guide© 2.0 for Design and Construction of Sustainable Buildings and Communities (February 2, 2012), p. 4, webstore.ansi.org/RecordDetail.aspx?sku=MTS+2012%3a1.*

DEVISING A LEED WORK PLAN

It is recommended that LEED applicants follow a series of steps to certification.

STEP 1. INITIATE DISCOVERY PHASE

Begin initial research and analysis (see Integrative Process Credit). When sufficient information has been gathered, hold a goal-setting workshop to discuss findings.

STEP 2. SELECT LEED RATING SYSTEM

The LEED system comprises 21 adaptations designed to accommodate the needs of a variety of market sectors (see *Rating System Selection Guidance*). For many credits, *Further Explanation* highlights rating system and project type variations to help teams develop a successful approach.

STEP 3. CHECK MINIMUM PROGRAM REQUIREMENTS

All projects seeking certification are required to comply with the minimum program requirements (MPRs) for the applicable rating system, found in this reference guide and on the USGBC website.

STEP 4. ESTABLISH PROJECT GOALS

Prioritize strategies for certification that align with the project's context and the values of the project team, owner, or organization. Once these values are articulated, project teams will be able to select appropriate strategies and associated LEED credits to meet the goals.

The recommended method for establishing project goals is to convene a goal-setting workshop (see Integrative Process Credit) for the project team members and the owner. Understanding the owner's goals, budget, schedule, functional programmatic requirements, scope, quality, performance targets, and occupants' expectations will promote creative problem solving and encourage fruitful interaction.

To capture the most opportunities, the workshop should occur before any design work and include wide representation from the design and construction disciplines.

STEP 5. DEFINE LEED PROJECT SCOPE

Review the project's program and initial findings from the goal-setting workshop to identify the project scope. Special considerations include off-site or campus amenities or shared facilities that may be used by project occupants.

Next, map the LEED project boundary along property lines. If the project boundary is not obvious because of ownership by multiple entities, partial renovations, or other issues, see the minimum program requirements. Share the final project boundary decision with the entire team, since this site definition affects numerous prerequisites and credits.

Finally, investigate any special certification programs that may apply based on the project's scope, such as the Volume Program or the Campus Program. If the project owner is planning multiple similar buildings in different locations, Volume may be a useful program to streamline certification. If the project includes multiple buildings in a single location, Campus may be appropriate.

STEP 6. DEVELOP LEED SCORECARD

Use the project goals to identify the credits and options that should be attempted by the team. The *Behind the Intent* sections offer insight into what each credit is intended to achieve and may help teams align goals with credits that bring value to the owner, environment, and community of the project.

This process should focus the team on those credits with the highest value for the project over the long term. Once the high-priority credits have been selected, identify related credits that reinforce the priority strategies and provide synergistic benefits.

Finally, establish the target LEED certification level (Certified, Silver, Gold, or Platinum) and identify additional credits needed to achieve it. Make sure that all prerequisites can be met and include a buffer of several points above the minimum in case of changes during design and construction.

STEP 7. CONTINUE DISCOVERY PHASE

Project team members should perform additional research and analysis as the project progresses, refining the analysis, testing alternatives, comparing notes, generating ideas in small meetings, and evaluating costs. Examples of research and analysis for energy- and water-related systems are outlined in the Integrative Process credit.

The project team should reassemble occasionally to discuss overlapping benefits and opportunities (e.g., how best to use the waste products from one system to benefit other systems). This approach encourages the discovery of new opportunities, raises new questions, and facilitates testing across disciplines.

STEP 8. CONTINUE ITERATIVE PROCESS

The above pattern of research and analysis followed by team workshops should continue until the solutions satisfy the project team and owner.

STEP 9. ASSIGN ROLES AND RESPONSIBILITIES

Select one team member to take primary responsibility for leading the group through the LEED application and documentation process. This leadership role may change from the design to the construction phase, but both the design and the construction leaders should be involved throughout the process to ensure consistency, clarity, and an integrative approach.

Cross-disciplinary team ownership of LEED credit compliance can help foster integrative design while ensuring consistent documentation across credits. On a credit-by-credit basis, assign primary and supporting roles to appropriate team members for credit achievement and documentation. Clarify responsibilities for ensuring that design decisions are accurately represented in drawings and specifications and that construction details match design documentation.

Establish regular meeting dates and develop clear communication channels to streamline the process and resolve issues quickly.

STEP 10. DEVELOP CONSISTENT DOCUMENTATION

Consistent documentation is critical to achieving LEED certification.

Data accumulated throughout the construction process, such as construction materials quantities, should be gathered and assessed at regular intervals to allow the team to track ongoing progress toward credit achievement and ensure that information is not misplaced or omitted. *Maintaining Consistency in the Application*, below, and the credit category overviews discuss the numeric values and meaning of terms that affect achievement of multiple credits within a credit category.

STEP 11. PERFORM QUALITY ASSURANCE REVIEW AND SUBMIT FOR CERTIFICATION

A quality assurance review is an essential part of the work program. A thorough quality control check can improve clarity and consistency of the project's LEED documentation, thereby avoiding errors that require time and expense to correct later in the certification process. The submission should be thoroughly proofread and checked for completeness. In particular, numeric values that appear throughout the submission (e.g., site area) must be consistent across credits.

MAINTAINING CONSISTENCY IN THE APPLICATION

Certain issues recur across multiple credits and credit categories and must be treated consistently throughout the submission.

SPECIAL PROJECT SITUATIONS

Projects with a combination of space types or unusual space types should pay particular attention to how these characteristics influence credit achievement. Common project programs that require additional consideration include the following:

Mixed Use
Projects with a mix of uses may find it helpful to consult the *Project Type Variations* and *Rating System Variations* sections in the reference guide for advice. For example, if an office building certifying under BD+C: New Construction includes a small data center, the team should follow the data center guidelines for certain credits; these guidelines are not limited to BD+C: Data Centers projects. Another common scenario is a hotel project certifying under BD+C: Hospitality; in designing the retail spaces on the hotel's ground floor, the team could benefit from guidance for BD+C: Retail projects.

Multitenant Complex
Some projects may be part of a large complex of buildings or a master planned development. Any project can follow the multitenant complex approach if it is part of a master plan development, regardless of whether the project is using LEED campus certification.

Incomplete Spaces
Buildings and spaces that earn LEED certification should be completed by the time they have submitted their final application for LEED certification. *Complete* means that no further work is needed and the project is ready for occupancy. No more than 40% of the certifying gross floor area of a LEED project may consist of incomplete space unless the project is using the LEED BD+C: Core and Shell rating system. Additionally, projects that include incomplete spaces must use Appendix 2 Default Occupancy Counts to establish occupant counts for incomplete spaces.

For incomplete spaces in projects using a rating system other than LEED BD+C: Core and Shell, the project team must provide supplemental documentation.

- Submit a letter of commitment, signed by the owner, indicating that the remaining incomplete spaces will satisfy the requirements of each prerequisite and credit achieved by this project if and when completed by the owner. This letter may cover the commitment in general terms and need not address each prerequisite or credit individually.
- For incomplete spaces intended to be finished by tenants (i.e., parties other than the owner), submit a set of nonbinding tenant design and construction guidelines, with a brief explanation of the project circumstances.

For prerequisites with established baselines (e.g., WE Prerequisite Indoor Water Use, EA Prerequisite Minimum Energy Performance) and the credits dependent on the calculations in the prerequisites, the proposed design must be equivalent to the baseline for the incomplete spaces. Project teams that wish to claim environmental performance or benefit beyond the baseline for incomplete spaces should refer to the Tenant Lease and Sales Agreement section.

Projects with Several Physically Distinct Structures
Primary and secondary school projects, hospitals (general medical and surgical), hotels, resorts, and resort properties, as defined for ENERGY STAR building rating purposes, with more than one physically distinct structure do not have to use the campus certification process (and register the project as a group certification project) if the following conditions are met.

- The buildings to be certified must be a part of the same identity. For example, the buildings are all part of the same elementary school, not a mix of elementary school and high school buildings.

- The project must be analyzed as a whole (i.e., in aggregate) for all minimum program requirements (MPRs), prerequisites, and credits in the LEED rating system.
- All the land area and all building floor areas within the LEED project boundary must be included in every prerequisite and credit submitted for certification.
- There is no specific limit on the number of structures, but the aggregate gross floor area included in a single project must not exceed 1 million square feet (92 905 square meters).

Any single structure that is larger than 25,000 square feet (2 320 square meters) must be registered as a separate project or treated as a separate building in a group certification project.

RENOVATIONS AND ADDITIONS

Refer to the minimum program requirements for information on how boundaries should be drawn for renovation and addition projects. Additionally, use the following guidance for treating energy systems in any project with mechanical systems.

- **Separate systems.** Mechanical systems are completely separate from those in the existing building (emergency generators excepted) and can be modeled separately.
- **Shared central systems located outside the project building or space.** Each prerequisite and credit section related to energy modeling offers specific guidance on how to handle this situation; in particular, see the guidance for EA Prerequisite Minimum Energy Performance.

TENANT SALES AND LEASE AGREEMENT

LEED BD+C: Core and Shell is designed to address the speculatively driven development market where project teams routinely do not control all aspects of the building's construction. The scope of Core and Shell is limited to those elements of the project under the direct control of the owner/developer. At a minimum, the scope includes the core and the shell of the base building but can vary significantly from project to project.

Given that Core and Shell is limited in its ability to control the design and construction of tenant interior fit-outs, project teams should pursue credits that address parts of the building within the LEED project scope. Only portions of the building within the LEED project scope should be used in credit calculations. If a project team wishes to pursue additional credits or thresholds beyond the construction scope of the LEED project, a binding tenant sales and lease agreement must be provided as documentation. This must be signed by the future tenant and include terms related to how the technical credit requirements will be carried out by the tenant. An unsigned or sample lease agreement is not acceptable. Please note that lease agreements are not required in order to pursue Core and Shell. They are only used if a project is aiming to earn additional points considered outside of the project design and construction scope that will be fit-out by a future tenant.

PREVIOUS DEVELOPMENT

Several credits require the assessment of a piece of land to determine whether it has been previously developed, defined as follows:

> **previously developed** altered by paving, construction, and/or land use that would typically have required regulatory permitting to have been initiated (alterations may exist now or in the past). Land that is not previously developed and landscapes altered by current or historical clearing or filling, agricultural or forestry use, or preserved natural area use are considered undeveloped land. The date of previous development permit issuance constitutes the date of previous development, but permit issuance in itself does not constitute previous development.

Tricky lands to assess include those with few buildings present. If the land previously had buildings, then it is considered previously developed even if those buildings have since been torn down. Another frequently confusing situation is parkland. Pay careful attention to the type of parkland. Improved parks with manicured landscaping and constructed features like playgrounds (e.g., a city park) are considered previously developed. Land that has only been cleared or graded, with no additional improvements, is not considered previously developed. Land maintained in a natural state (e.g., a forest preserve) is not considered previously developed, even if minor features like walking paths are present.

DEVELOPMENT FOOTPRINT

A project's development footprint is all of its impervious surfaces.

development footprint the total land area of a project site covered by buildings, streets, parking areas, and other typically impermeable surfaces constructed as part of the project

Surfaces paved with permeable pavement (at least 50% permeable) are excluded from the development footprint.

DENSITY

Density can be calculated separately for residential and nonresidential elements or as a single value. The following definitions apply:

density a ratio of building coverage on a given parcel of land to the size of that parcel. Density can be measured using floor area ratio (FAR); dwelling units per acre (DU/acre) or dwelling units per hectare (DU/hectare); square feet of building area per acre of buildable land; or square meters of building area per hectare of buildable land. It does not include structured parking.

buildable land the portion of the site where construction can occur, including land voluntarily set aside and not constructed on. When used in density calculations, buildable land excludes public rights-of-way and land excluded from development by codified law.

Land voluntarily set aside and not built on, such as open space, is considered buildable because it was available for construction but set aside voluntarily. For example, 5 acres (2 hectares) of park space required by local government code would be considered nonbuildable, but if a developer voluntarily sets aside an additional 3 acres (1.2 hectares) for more park space, those 3 acres (1.2 hectares) must be categorized as buildable land.

After determining buildable land, calculate residential or nonresidential density or a combined density. To calculate residential density, divide the number of dwelling units by the amount of residential land. To calculate nonresidential density, use floor area ratio (FAR):

floor-area ratio (**FAR**) the density of nonresidential land use, exclusive of structured parking, measured as the total nonresidential building floor area divided by the total buildable land area available for nonresidential buildings.

For example, on a site with 10,000 square feet (930 square meters) of buildable nonresidential land area, a building of 10,000 square feet (930 square meters) of floor area would have a FAR of 1.0. On the same site, a building of 5,000 square feet (465 square meters) would have a FAR of 0.5; a building of 15,000 square feet (1 395 square meters) would have a FAR of 1.5; and a building of 20,000 square feet (1 860 square meters) would have a FAR of 2.0.

To calculate the combined density for residential and nonresidential areas, use FAR.

OCCUPANCY

Many kinds of people use a typical LEED building, and the mix varies by project type. Occupants are sometimes referred to in a general sense; for example, "Provide places of respite that are accessible to patients and visitors." In other instances, occupants must be counted for calculations. Definitions of occupant types are general guidelines that may be modified or superseded in a particular credit when appropriate (such changes are noted in each credit's reference guide section). Most credits group users into two categories, regular building occupants and visitors.

Regular Building Occupants

Regular building occupants are habitual users of a building. All of the following are considered regular building occupants.

Employees include part-time and full-time employees, and totals are calculated using full-time equivalency (FTE).
A typical project can count FTE employees by adding full-time employees and part-time employees, adjusted for their hours of work.

EQUATION 1.

$$\text{FTE employees} = \text{Full-time employees} + (\Sigma \text{ daily part-time employee hours} / 8)$$

For buildings with more unusual occupancy patterns, calculate the FTE building occupants based on a standard eight-hour occupancy period.

EQUATION 2.

$$\text{FTE employees} = (\Sigma \text{ all employee hours} / 8)$$

Staff is synonymous with employees for the purpose of LEED calculations.

Volunteers who regularly use a building are synonymous with employees for the purpose of LEED calculations.

Residents of a project are considered regular building occupants. This includes residents of a dormitory. If actual resident count is not known, use a default equal to the number of bedrooms in the dwelling unit plus one, multiplied by the number of such dwelling units.

Primary and secondary school students are typically regular building occupants (see the exception in LT Credit Bicycle Facilities).

Hotel guests are typically considered regular building occupants, with some credit-specific exceptions. Calculate the number of overnight hotel guests based on the number and size of units in the project. Assume 1.5 occupants per guest room and multiply the resulting total by 60% (average hotel occupancy). Alternatively, the number of hotel guest occupants may be derived from actual or historical occupancy.

Inpatients are medical, surgical, maternity, specialty, and intensive-care unit patients whose length of stay exceeds 23 hours. **Peak inpatients** are the highest number of inpatients at a given point in a typical 24-hour period.

Visitors

Visitors (also "transients") intermittently use a LEED building. All of the following are considered visitors:

Retail customers are considered visitors. In Water Efficiency credits, retail customers are considered separately from other kinds of visitors and should not be included in the total average daily visitors.

Outpatients visit a hospital, clinic, or associated health care facility for diagnosis or treatment that lasts 23 hours or less (see SS Credit Direct Exterior Access for credit-specific exceptions).

Peak outpatients are the highest number of outpatients at a given point in a typical 24-hour period.

Volunteers who periodically use a building (e.g., once per week) are considered visitors.

Higher-education students are considered visitors to most buildings, except when they are residents of a dorm, in which case they are residents.

In calculations, occupant types are typically counted in two ways:

Daily averages take into account all the occupants of a given type for a typical 24-hour day of operation.

Peak totals are measured at the moment in a typical 24-hour period when the highest number of a given occupant type is present.

Whenever possible, use actual or predicted occupancies. If occupancy cannot be accurately predicted, one of the following resources to estimate occupancy:

a. Default occupant density from ASHRAE 62.1-2010, Table 6-1

b. Default occupant density from CEN Standard EN 15251, Table B.2

c. Appendix 2 Default Occupancy Counts

d. Results from applicable studies.

If numbers vary seasonally, use occupancy numbers that are a representative daily average over the entire operating season of the building.

If occupancy patterns are atypical (shift overlap, significant seasonal variation), explain such patterns when submitting documentation for certification.

Table 1 lists prerequisites and credits that require specific occupancy counts for calculations.

TABLE 1. Occupancy types for calculations, by project type variation					
PREREQUISITE, CREDIT	**REGULAR BUILDING OCCUPANTS**	**AVERAGE DAILY VISITORS**	**PEAK VISITORS**	**OTHER**	**NOTES**
LT CREDIT BICYCLE FACILITIES					
New Construction, Core and Shell, Data Centers, Warehouses and Distribution Centers, Hospitality	X		X		
Schools	X				Students grade 3 (age 8) and younger are not included in regular building occupants for this credit.
Retail	X				
Healthcare	X		X		Exclude patients.
LT CREDIT ACCESS TO QUALITY TRANSIT					
Schools				X	Count primary and secondary students only.
SS CREDIT DIRECT EXTERIOR ACCESS					
Healthcare				X	Count only peak inpatients and peak outpatients. For this credit, outpatients with clinical length of stay greater than 4 hours are included with inpatients.
WE PREREQUISITE AND CREDIT INDOOR WATER USE					
New Construction, Core and Shell, Data Centers, Warehouses and Distribution Centers, Hospitality, Retail, Healthcare	X	X			Retail customers are considered separately and not included in average daily visitors.
Schools	X	X			See credit-specific occupancy guidance.

QUICK REFERENCE

TABLE 2. Credit Attributes

Category	Prerequisite/ Credit	Credit Name	Eligibility		Design/ Construction	Exemplary Performance
			Campus Approach	Group Approach		
IP	P	Integrated Project Planning and Design	C	G	D	no
IP	C	Integrative Process	-	G	D	no
LT Location and Transportation						
LT	C	LEED for Neighborhood Development Location	C	G	D	no
LT	C	Sensitive Land Protection	-	G	D	no
LT	C	High Priority Site	C	G	D	yes
LT	C	Surrounding Density and Diverse Uses	-	G	D	yes, except WDC
LT	C	Access to Quality Transit	-	-	D	yes
LT	C	Bicycle Facilities	C	G	D	no
LT	C	Reduced Parking Footprint	C	G	D	yes
LT	C	Green Vehicles	C	G	D	no
SS Sustainable Sites						
SS	P	Construction Activity Pollution Prevention	-	G	C	no
SS	P	Environmental Site Assessment	C	G	D	no
SS	C	Site Assessment	C	G	D	no
SS	C	Site Development—Protect or Restore Habitat	C	G	D	yes
SS	C	Open Space	C	G	D	no
SS	C	Rainwater Management	C	G	D	yes
SS	C	Heat Island Reduction	C	G	D	yes
SS	C	Light Pollution Reduction	C	G	D	no
SS	C	Site Master Plan	C	-	D	no
SS	C	Tenant Design and Construction Guidelines	-	-	D	no
SS	C	Places of Respite	-	-	D	yes
SS	C	Direct Exterior Access	-	G	D	no
SS	C	Joint Use of Facilities	-	-	D	no

Points							
New Construction	Core and Shell	Schools	Retail	Data Centers	Warehouses and Distribution Centers	Hospitality	Healthcare
n/a	n/a	n/a	n/a	n/a	n/a	n/a	Req'd
1	1	1	1	1	1	1	1
16	20	15	16	16	16	16	9
1	2	1	1	1	1	1	1
2	3	2	2	2	2	2	2
5	6	5	5	5	5	5	1
5	6	4	5	5	5	5	2
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
n/a	n/a	Req'd	n/a	n/a	n/a	n/a	Req'd
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1
3	3	3	3	3	3	3	2
2	2	2	2	2	2	2	1
1	1	1	1	1	1	1	1
n/a	n/a	1	n/a	n/a	n/a	n/a	n/a
n/a	1	n/a	n/a	n/a	n/a	n/a	n/a
n/a	n/a	n/a	n/a	n/a	n/a	n/a	1
n/a	n/a	n/a	n/a	n/a	n/a	n/a	1
n/a	n/a	1	n/a	n/a	n/a	n/a	n/a

TABLE 2. Credit Attributes

Category	Prerequisite/ Credit	Credit Name	Eligibility		Design/ Construction	Exemplary Performance
			Campus Approach	Group Approach		
WE Water Efficiency						
WE	P	Outdoor Water Use Reduction	C	G	D	no
WE	P	Indoor Water Use Reduction	-	-	D	no
WE	P	Building-Level Water Metering	-	-	D	no
WE	C	Outdoor Water Use Reduction	C	G	D	no
WE	C	Indoor Water Use Reduction	-	G	D	yes
WE	C	Cooling Tower Water Use	C	G	D	no
WE	C	Water Metering	-	-	D	no
EA Energy and Atmosphere						
EA	P	Fundamental Commissioning and Verification	-	G	C	no
EA	P	Minimum Energy Performance	-	-	D	no
EA	P	Building-Level Energy Metering	-	-	D	no
EA	P	Fundamental Refrigerant Management	C	-	D	no
EA	C	Enhanced Commissioning	-	G	C	no
EA	C	Optimize Energy Performance	-	G	D	yes
EA	C	Advanced Energy Metering	-	-	D	no
EA	C	Demand Response	-	G	C	no
EA	C	Renewable Energy Production	-	G	D	yes
EA	C	Enhanced Refrigerant Management	Opt 1 - yes Opt 2 - no	-	D	no
EA	C	Green Power and Carbon Offsets	-	G	C	no
MR Materials and Resources						
MR	P	Storage and Collection of Recyclables	C	G	D	no
MR	P	Construction and Demolition Waste Management Planning	-	G	C	no
MR	P	PBT Source Reduction—Mercury	C	G	D	no
MR	C	Building Life-Cycle Impact Reduction	-	OPT 1 - no OPT 2 - no OPT 3 - yes OPT 4 - yes	C	yes
MR	C	Building Product Dislosure and Optimization—Environmental Product Declarations	-	G	C	yes
MR	C	Building Product Disclosure and Optimization—Sourcing of Raw Materials	-	G	C	yes
MR	C	Building Product Disclosure and Optimization—Material Ingredients	-	G	C	yes
MR	C	PBT Source Reduction—Mercury	C	G	D	no
MR	C	PBT Source Reduction—Lead, Cadmium, and Copper	-	G	C	no
MR	C	Furniture and Medical Furnishings	-	G	C	yes
MR	C	Design for Flexibility	C	G	D	no
MR	C	Construction and Demolition Waste Management	-	G	C	yes

Points							
New Construction	Core and Shell	Schools	Retail	Data Centers	Warehouses and Distribution Centers	Hospitality	Healthcare
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
2	2	2	2	2	2	2	1
6	6	7	7	6	6	6	7
2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
6	6	6	6	6	6	6	6
18	18	16	18	18	18	18	20
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
n/a	n/a	n/a	n/a	n/a	n/a	n/a	1
5	6	5	5	5	5	5	5
2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2
n/a	n/a	n/a	n/a	n/a	n/a	n/a	1
n/a	n/a	n/a	n/a	n/a	n/a	n/a	2
n/a	n/a	n/a	n/a	n/a	n/a	n/a	2
n/a	n/a	n/a	n/a	n/a	n/a	n/a	1
2	2	2	2	2	2	2	2

TABLE 2. Credit Attributes

Category	Prerequisite/ Credit	Credit Name	Eligibility		Design/ Construction	Exemplary Performance
			Campus Approach	Group Approach		
EQ Indoor Environmental Quality						
EQ	P	Minimum Indoor Air Quality Performance	-	-	D	no
EQ	P	Environmental Tobacco Smoke Control	C	G	D	no
EQ	P	Minimum Acoustic Performance	-	-	D	no
EQ	C	Enhanced Indoor Air Quality Strategies	-	-	D	yes
EQ	C	Low-Emitting Materials	-	G	C	yes
EQ	C	Construction Indoor Air Quality Management Plan	-	G	C	no
EQ	C	Indoor Air Quality Assessment	-	-	C	no
EQ	C	Thermal Comfort	-	-	D	no
EQ	C	Interior Lighting	-	G	D	no
EQ	C	Daylight	-	-	D	no
EQ	C	Quality Views	-	-	D	yes
EQ	C	Acoustic Performance	-	-	D	no
IN Innovation						
IN	C	Innovation	C	G	D/C	no
IN	C	LEED Accredited Professional	-	G	D/C	no
RP Regional Priority						
RP	C	Regional Priority	-	-	D/C	no

Points							
New Construction	Core and Shell	Schools	Retail	Data Centers	Warehouses and Distribution Centers	Hospitality	Healthcare
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd	Req'd
n/a	n/a	Req'd	n/a	n/a	n/a	n/a	n/a
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
1	1	1	1	1	1	1	1
2	n/a	2	2	2	2	2	2
1	n/a	1	1	1	1	1	1
2	n/a	2	2	2	2	2	1
3	3	3	3	3	3	3	2
1	1	1	1	1	1	1	2
1	n/a	1	n/a	1	1	1	2
5	5	5	5	5	5	5	5
1	1	1	1	1	1	1	1
4	4	4	4	4	4	4	4

Minimum Program Requirements

INTRODUCTION

The Minimum Program Requirements (MPRs) are the minimum characteristics or conditions that make a project appropriate to pursue LEED certification. These requirements are foundational to all LEED projects and define the types of buildings, spaces, and neighborhoods that the LEED rating system is designed to evaluate.

1. MUST BE IN A PERMANENT LOCATION ON EXISTING LAND

INTENT

The LEED rating system is designed to evaluate buildings, spaces, and neighborhoods in the context of their surroundings. A significant portion of LEED requirements are dependent on the project's location, therefore it is important that LEED projects are evaluated as permanent structures. Locating projects on existing land is important to avoid artificial land masses that have the potential to displace and disrupt ecosystems.

REQUIREMENTS

All LEED projects must be constructed and operated on a permanent location on existing land. No project that is designed to move at any point in its lifetime may pursue LEED certification. This requirement applies to all land within the LEED project.

ADDITIONAL GUIDANCE

Permanent location

- Movable buildings are not eligible for LEED. This includes boats and mobile homes.
- Prefabricated or modular structures and building elements may be certified once permanently installed as part of the LEED project.

Existing land

- Buildings located on previously constructed docks, piers, jetties, infill, and other manufactured structures in or above water are permissible, provided that the artificial land was not constructed by the owner of the LEED project for the express purpose of constructing the LEED project.

2. MUST USE REASONABLE LEED BOUNDARIES

INTENT

The LEED rating system is designed to evaluate buildings, spaces, or neighborhoods, and all environmental impacts associated with those projects. Defining a reasonable LEED boundary ensures that project is accurately evaluated.

REQUIREMENTS

The LEED project boundary must include all contiguous land that is associated with the project and supports its typical operations. This includes land altered as a result of construction and features used primarily by the project's occupants, such as hardscape (parking and sidewalks), septic or stormwater treatment equipment, and landscaping. The LEED boundary may not unreasonably exclude portions of the building, space, or site to give the project an advantage in complying with credit requirements. The LEED project must accurately communicate the scope of the certifying project in all promotional and descriptive materials and distinguish it from any non-certifying space.

ADDITIONAL GUIDANCE

Site

- Non-contiguous parcels of land may be included within the LEED project boundary if the parcels directly support or are associated with normal building operations of the LEED project and are accessible to the LEED project's occupants.
- Facilities (such as parking lots, bicycle storage, shower/changing facilities, and/or on-site renewable energy) that are outside of the LEED project boundary may be included in certain prerequisites and credits if they directly serve the LEED project and are not double-counted for other LEED projects. The project team must also have permission to use these facilities.

- The LEED project boundary may include other buildings.
  - If another building or structure within the LEED project boundary is ineligible for LEED certification, it may be either included or not included in the certification of the LEED project.
  - If another building within the LEED project boundary is eligible for LEED certification, it may be either included or not included in the certification. If included, the project must be registered as a group certification project and the LEED campus certification process must be used.
- Sites with a master plan and/or phased development must designate a LEED project boundary for each LEED project.
- The gross floor area of the LEED project should be no less than 2% of the gross land area within the LEED project boundary.

Building

- The LEED project should include the entire building and complete scope of work.
- Buildings or structures primarily dedicated to parking are not eligible for LEED certification. Parking that serves an eligible LEED project should be included in the certification.
- Buildings that are physically connected by programmable space are considered one building for LEED purposes unless they are physically distinct and have distinct identities as separate buildings or if they are a newly constructed addition. If separated, the projects should also have separate air distribution systems and water and energy meters (including thermal energy meters).
- Buildings that have no physical connection or are physically connected only by circulation, parking, or mechanical/storage rooms are considered separate buildings and individual projects for LEED purposes, with the following exceptions:
  - Primary and secondary school projects, hospitals (general medical and surgical), hotels, resorts, and resort properties, as defined by ENERGY STAR building rating purposes, may include more than one physically distinct building in a single LEED project. For new construction projects, each building in the application must be less than 25,000 sq. ft. Please contact USGBC if with any questions.
  - For other cases such as buildings that have programmatic dependency (spaces – not personnel – within the building cannot function independently without the other building) or architectural cohesiveness (the building was designed to appear as one building), project teams are encouraged to contact USGBC to discuss their project prior to proceeding.

Interiors

- The LEED project should be defined by a clear boundary such that the LEED project is physically distinct from other interior spaces within the building.

Neighborhood

- The LEED neighborhood includes the land, water, and construction within the LEED project boundary.
- The LEED boundary is usually defined by the platted property line of the project, including all land and water within it.
  - Projects located on publicly owned campuses that do not have internal property lines must delineate a sphere-of-influence line to be used instead.
  - Projects may have enclaves of non-project properties that are not subject to the rating system, but cannot exceed 2% of the total project area and cannot be described as certified.
  - Projects must not contain non-contiguous parcels, but parcels can be separated by public rights-of-way.
- The project developer, which can include several property owners, should control a majority of the buildable land within the boundary, but does not have to control the entire area.

3. MUST COMPLY WITH PROJECT SIZE REQUIREMENTS

INTENT

The LEED rating system is designed to evaluate buildings, spaces, or neighborhoods of a certain size. The LEED requirements do not accurately assess the performance of projects outside of these size requirements.

REQUIREMENTS

All LEED projects must meet the size requirements listed below.

LEED BD+C and LEED O+M Rating Systems
The LEED project must include a minimum of 1,000 square feet (93 square meters) of gross floor area.

LEED ID+C Rating Systems
The LEED project must include a minimum of 250 square feet (22 square meters) of gross floor area.

LEED for Neighborhood Development Rating Systems
The LEED project should contain at least two habitable buildings and be no larger than 1500 acres.

LEED for Homes Rating Systems
The LEED project must be defined as a "dwelling unit" by all applicable codes. This requirement includes, but is not limited to, the International Residential Code stipulation that a dwelling unit must include "permanent provisions for living, sleeping, eating, cooking, and sanitation."

Rating System Selection Guidance

INTRODUCTION

This document provides guidance to help project teams select a LEED rating system. Projects are required to use the rating system that is most appropriate. However, when the decision is not clear, it is the responsibility of the project team to make a reasonable decision in selecting a rating system before registering their project. The project teams should first identify an appropriate rating system, and then determine the best adaptation. Occasionally, USGBC recognizes that an entirely inappropriate rating system has been chosen. In this case, the project team will be asked to change the designated rating system for their registered project. Please review this guidance carefully and contact USGBC if it is not clear which rating system to use.

RATING SYSTEM DESCRIPTIONS

LEED FOR BUILDING DESIGN AND CONSTRUCTION

Buildings that are new construction or major renovation. At least 60% of the project's *gross floor area* must be *complete* by the time of certification (except for LEED BD+C: Core and Shell). Must include the entire building's gross floor area in the project.

- **LEED BD+C: New Construction and Major Renovation.** New construction or major renovation of buildings that do not primarily serve K-12 educational, retail, data centers, warehouses and distribution centers, hospitality, or healthcare uses. High-rise residential buildings 4 stories or more can use New Construction or Multifamily Midrise.
- **LEED BD+C: Core and Shell Development.** Buildings that are new construction or major renovation for the exterior shell and core mechanical, electrical, and plumbing units, but not a complete interior fit-out. LEED BD+C: Core and Shell is the appropriate rating system to use if more than 40% of the gross floor area is incomplete at the time of certification.
- **LEED BD+C: Schools.** Buildings made up of core and ancillary learning spaces on K-12 school grounds. LEED BD+C: Schools may optionally be used for higher education and non-academic buildings on school campuses.
- **LEED BD+C: Retail.** Buildings used to conduct the retail sale of consumer product goods. Includes both direct customer service areas (showroom) and preparation or storage areas that support customer service.
- **LEED BD+C: Data Centers.** Buildings specifically designed and equipped to meet the needs of high density computing equipment such as server racks, used for data storage and processing. LEED BD+C: Data Centers only addresses whole building data centers (greater than 60%).
- **LEED BD+C: Warehouses and Distribution Centers.** Buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings, such as self-storage.
- **LEED BD+C: Hospitality.** Buildings dedicated to hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.
- **LEED BD+C: Healthcare.** Hospitals that operate twenty-four hours a day, seven days a week and provide inpatient medical treatment, including acute and long-term care.
- **LEED BD+C: Homes and Multifamily Lowrise.** Single-family homes and multi-family residential buildings of 1 to 3 stories. Projects 3 to 5 stories may choose the Homes rating system that corresponds to the ENERGY STAR program in which they are participating.
- **LEED BD+C: Multifamily Midrise.** Multi-family residential buildings of 4 or more occupiable stories above grade. The building must have 50% or more residential space. These buildings may also use LEED BD+C: New Construction.

LEED FOR INTERIOR DESIGN AND CONSTRUCTION.

Interior spaces that are a complete interior fit-out. In addition, at least 60% of the project's gross floor area must be complete by the time of certification.

- **LEED ID+C: Commercial Interiors.** Interior spaces dedicated to functions other than retail or hospitality.
- **LEED ID+C: Retail.** Interior spaces used to conduct the retail sale of consumer product goods. Includes both direct customer service areas (showroom) and preparation or storage areas that support customer service.
- **LEED ID+C: Hospitality.** Interior spaces dedicated to hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.

LEED FOR BUILDING OPERATIONS AND MAINTENANCE.

Buildings that are fully operational and occupied for at least one year. The project may be undergoing improvement work or little to no construction. Must include the entire building's gross floor area in the project.

- **LEED O+M: Existing Buildings.** Existing buildings that do not primarily serve K-12 educational, retail, data centers, warehouses and distribution centers, or hospitality uses.
- **LEED O+M: Retail.** Existing buildings used to conduct the retail sale of consumer product goods. Includes both direct customer service areas (showroom) and preparation or storage areas that support customer service.

- **LEED O+M: Schools**. Existing buildings made up of core and ancillary learning spaces on K-12 school grounds. May also be used for higher education and non-academic buildings on school campuses.
- **LEED O+M: Hospitality.** Existing buildings dedicated to hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.
- **LEED O+M: Data Centers.** Existing buildings specifically designed and equipped to meet the needs of high density computing equipment such as server racks, used for data storage and processing. LEED O+M: Data Centers only addresses whole building data centers.
- **LEED O+M: Warehouses and Distribution Centers.** Existing buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage).

LEED FOR NEIGHBORHOOD DEVELOPMENT

New land development projects or redevelopment projects containing residential uses, nonresidential uses, or a mix. Projects may be at any stage of the development process, from conceptual planning through construction. It is recommended that at least 50% of total building floor area be new construction or major renovation. Buildings within the project and features in the public realm are evaluated.

- **LEED ND: Plan.** Projects in conceptual planning or master planning phases, or under construction.
- **LEED ND: Built Project.** Completed development projects.

CHOOSING BETWEEN RATING SYSTEMS

The following 40/60 rule provides guidance for making a decision when several rating systems appear to be appropriate for a project. To use this rule, first assign a rating system to each square foot or square meter of the building. Then, choose the most appropriate rating system based on the resulting percentages.

The entire gross floor area of a LEED project must be certified under a single rating system and is subject to all prerequisites and attempted credits in that rating system, regardless of mixed construction or space usage type.

PERCENTAGE OF FLOOR AREA APPROPRIATE FOR A PARTICULAR RATING SYSTEM

<40%	40% - 60%	>60%
SHOULD NOT USE THAT RATING SYSTEM	PROJECT'S TEAM CHOICE	SHOULD USE THAT RATING SYSTEM

- If a rating system is appropriate for less than 40% of the gross floor area of a LEED project building or space, then that rating system should not be used.
- If a rating system is appropriate for more than 60% of the gross floor area of a LEED project building or space, then that rating system should be used.
- If an appropriate rating system falls between 40% and 60% of the gross floor area, project teams must independently assess their situation and decide which rating system is most applicable.

PREREQUISITE

Integrative Project Planning and Design

This prerequisite applies to: **Healthcare**

INTENT

Maximize opportunities for integrated, cost-effective adoption of green design and construction strategies, emphasizing human health as a fundamental evaluative criterion for building design, construction and operational strategies. Utilize innovative approaches and techniques for green design and construction.

REQUIREMENTS

Use cross-discipline design and decision making, beginning in the programming and pre-design phase. At a minimum, ensure the following process:

OWNER'S PROJECT REQUIREMENTS DOCUMENT

Prepare an Owner's Project Requirements (OPR) document. Develop a health mission statement and incorporate it in the OPR. The health mission statement must address "triple bottom line" values—economic, environmental and social. Include goals and strategies to safeguard the health of building occupants, the local community and the global environment, while creating a high-performance healing environment for the building's patients, caregivers and staff.

PRELIMINARY RATING GOALS

As early as practical and preferably before schematic design, conduct a preliminary LEED meeting with a minimum of four key project team members and the owner or owner's representative. As part of the meeting, create a LEED® action plan that, at a minimum:

- Determines the LEED certification level to pursue (Certified, Silver, Gold, or Platinum);
- Selects the LEED credits to meet the targeted certification level; and
- Identifies the responsible parties to ensure the LEED requirements for each prerequisite and selected credit are met.

INTEGRATED PROJECT TEAM

Assemble an integrated project team and include as many of the following professionals as feasible (minimum of four), in addition to the owner or owner's representative.

- Owner's capital budget manager
- Architect or building designer
- Mechanical engineer
- Structural engineer
- Energy modeler
- Equipment planner
- Acoustical consultant
- Telecommunications designer
- Controls designer
- Food Service Consultant
- Infection Control Staff
- Building science or performance testing agents
- Green building or sustainable design consultant
- Facility green teams
- Physician and nursing teams
- Facility managers
- Environmental services staff
- Functional and space programmers
- Commissioning agent
- Community representatives
- Civil engineer
- Landscape architect
- Ecologist
- Land planner
- Construction manager or general contractor
- Life cycle cost analyst; construction cost estimator
- Lighting Designer
- Other disciplines appropriate to the specific project type

DESIGN CHARRETTE

As early as practical and preferably before schematic design, conduct a minimum four-hour , integrated design charrette with the project team as defined above. The goal is to optimize the integration of green strategies across all aspects of building design, construction and operations, drawing on the expertise of all participants.

BEHIND THE INTENT

The building systems and equipment of modern health care facilities impose large environmental burdens on regional energy and water resources and contribute significantly to greenhouse gas emissions. Hospitals in the United States, on average, consume 2.5 times more energy per square foot than the average commercial building, for example.[1] In addition, health care projects have the mission of improving the health and healing of patients while preventing the spread of disease. Because of their unique challenges and conditions, health care facilities especially can benefit from implementing an integrative process that guides the project from visioning to occupancy. A comprehensive, integrative process accounts for the interactions of all building and site systems, relying on an iterative cycle of analysis, workshops, implementation, and performance feedback.

This prerequisite focuses on establishing a framework for this process and requires an integrative charrette that clarifies the strategies and goals for the project's guiding documents.

STEP-BY-STEP GUIDANCE

Projects starting after the programming and predesign phase should complete requirements as early as practical and preferably before the schematic design phase. Projects beginning this process after predesign are still eligible for Healthcare certification but should complete the requirements as early as possible.

STEP 1. IDENTIFY PROJECT TEAM

During predesign or at the start of the design process, assemble an integrative project team with at least four members in addition to the owner or owner's representative.

- Review the list of eligible project team members in the prerequisite requirements.
- If possible, include a representative from the builder or construction manager so that cost and construction considerations are integrated into the development of design concepts.
- If possible, include a representative from the health care facility's staff.
- Ensure that the team members have broad enough experience to contribute meaningfully to the major areas of focus.

STEP 2. PREPARE FOR INTEGRATIVE DESIGN CHARRETTE

Before the initial integrative design charrette, become familiar with the integrative process and complete preliminary research and analysis to support effective and informed discussions about potential integrative design opportunities.

- Review the Integrative Process (IP) ANSI Consensus National Standard Guide© 2.0 for Design and Construction of Sustainable Buildings and Communities, which provides step-by-step guidance for implementing an integrative process.
- Review the Integrative Process credit, which is derived from the IP ANSI Standard Guide and focuses on early, iterative analysis of energy- and water-related systems.
- Collect information about the local climate, site conditions, waste treatment infrastructure, energy load distribution, water sources, transportation options, and potential building features.

STEP 3. CONVENE INTEGRATIVE DESIGN CHARRETTE

Hold an initial integrative charrette to align the project team around the owner's goals for the project, including budget, schedule, functional programmatic requirements, scope, quality and performance expectations, and occupants' expectations.

Use the charrette to accomplish the following:

- Introduce all project team members to the fundamentals of the integrative process
- Share initial background research and analysis from Step 2
- Elicit the owner's and stakeholders' values, aspirations, and requirements
- Clarify functional and programmatic goals
- Establish initial principles, benchmarks, metrics, and performance targets
- Identify desired LEED certification level and credits to be targeted
- Generate potential strategies for achieving performance targets

1. *U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey* (CBECS). *eia.gov/consumption/commercial/reports/2007/large-hospital.cfm* (*accessed June 8, 2013*).

- Determine the questions that must be answered to support project decisions
- Initiate development of the project's health mission statement

Retain a copy of the action plan.

STEP 4. DOCUMENT GOALS AND PERFORMANCE TARGETS

Prepare the owner's project requirements (OPR), including the project goals, performance and LEED targets, and health mission statement (see EA Prerequisite Fundamental Commissioning, *Further Explanation, Owner's Project Requirements*).

- Ensure that the health mission statement meets the credit requirements and reinforces any existing corporate and/or institutional commitments to environmental health and community responsibility.
- Consider continuing the integrative process throughout design.

FURTHER EXPLANATION

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects
Narrative explaining how health mission statement addresses credit requirements	X
Action plan from preliminary rating goals	X

RELATED CREDIT TIPS

Integrative Process Credit. The related credit requires implementing a detailed energy and water analysis to maximize synergies of the building systems through design improvements. Its initial steps will help Healthcare projects plan and implement a successful design charrette.

CHANGES FROM LEED 2009

- The required charrette duration has changed from a full day to four hours.
- Disciplines have been added to list of eligible professions on the integrative design team.

REFERENCED STANDARDS

ANSI Consensus National Standard Guide© 2.0 for Design and Construction of Sustainable Buildings and Communities (February 2, 2012): ansi.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

CREDIT

Integrative Process

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To support high-performance, cost-effective project outcomes through an early analysis of the interrelationships among systems.

REQUIREMENTS

Beginning in pre-design and continuing throughout the design phases, identify and use opportunities to achieve synergies across disciplines and building systems. Use the analyses described below to inform the owner's project requirements (OPR), basis of design (BOD), design documents, and construction documents.

Energy-Related Systems

DISCOVERY

Perform a preliminary "simple box" energy modeling analysis before the completion of schematic design that explores how to reduce energy loads in the building and accomplish related sustainability goals by questioning default assumptions. Assess at least two potential strategies associated with the following:

- **Site conditions.** Assess shading, exterior lighting, hardscape, landscaping, and adjacent site conditions.
- **Massing and orientation.** Assess how massing and orientation affect HVAC sizing, energy consumption, lighting, and renewable energy opportunities.
- **Basic envelope attributes.** Assess insulation values, window-to-wall ratios, glazing characteristics, shading, and window operability.
- **Lighting levels.** Assess interior surface reflectance values and lighting levels in occupied spaces.
- **Thermal comfort ranges.** Assess thermal comfort range options.
- **Plug and process load needs.** Assess reducing plug and process loads through programmatic solutions (e.g., equipment and purchasing policies, layout options).

- **Programmatic and operational parameters.** Assess multifunctioning spaces, operating schedules, space allotment per person, teleworking, reduction of building area, and anticipated operations and maintenance.

IMPLEMENTATION

Document how the above analysis informed design and building form decisions in the project's OPR and BOD and the eventual design of the project, including the following, as applicable:

- Building and site program;
- Building form and geometry;
- Building envelope and façade treatments on different orientations;
- Elimination and/or significant downsizing of building systems (e.g., HVAC, lighting, controls, Exterior materials, interior finishes, and functional program elements); and
- Other systems.

AND

Water-Related Systems

DISCOVERY

Perform a preliminary water budget analysis before the completion of schematic design that explores how to reduce potable water loads in the building and accomplish related sustainability goals. Assess and estimate the project's potential nonpotable water supply sources and water demand volumes, including the following:

- **Indoor water demand.** Assess flow and flush fixture design case demand volumes, calculated in accordance with WE Prerequisite Indoor Water-Use Reduction.
- **Outdoor water demand.** Assess landscape irrigation design case demand volume calculated in accordance with WE Credit Outdoor Water-Use Reduction.
- **Process water demand.** Assess kitchen, laundry, cooling tower, and other equipment demand volumes, as applicable.
- **Supply sources.** Assess all potential nonpotable water supply source volumes, such as on-site rainwater and graywater, municipally supplied nonpotable water, and HVAC equipment condensate.

IMPLEMENTATION

Document how the above analysis informed building and site design decisions in the project's OPR and BOD. Demonstrate how at least one on-site nonpotable water supply source was analyzed to reduce the burden on municipal supply or wastewater treatment systems by contributing to at least two of the water demand components listed above. Demonstrate how the analysis informed the design of the project, including the following, as applicable:

- plumbing systems;
- sewage conveyance and/or on-site treatment systems;
- rainwater quantity and quality management systems;
- landscaping, irrigation, and site elements;
- roofing systems and/or building form and geometry; and
- other systems.

BEHIND THE INTENT

An integrative process is a comprehensive approach to building systems and equipment. Project team members look for synergies among systems and components, the mutual advantages that can help achieve high levels of building performance, human comfort, and environmental benefits. The process should involve rigorous questioning and coordination and challenge typical project assumptions. Team members collaborate to enhance the efficiency and effectiveness of every system.

The Integrative Process credit goes beyond checklists and encourages integration during early design stages, when clarifying the owner's aspirations, performance goals, and project needs will be most effective in improving performance. An integrative process comprises three phases. The first—discovery—is also the most important and can be seen as an expansion of what is conventionally called predesign. Actions taken during discovery are essential to achieving a project's environmental goals cost-effectively. The second phase, design and construction, begins with what is conventionally called schematic design. Unlike its conventional counterpart, however, in the integrative process, design will incorporate all of the collective understandings of system interactions that were found during discovery. The third phase is the period of occupancy, operations, and performance feedback. Here, the integrative process measures performance and sets up feedback mechanisms. Feedback is critical to determining success in achieving performance targets, informing building operations, and taking corrective action when targets are missed.

A fully integrative process accounts for the interactions among all building and site systems; this credit serves as an introduction to the comprehensive process, rewarding project teams that apply an integrative approach to energy and water systems. By understanding building system interrelationships, project teams will ideally discover unique opportunities for innovative design, increased building performance, and greater environmental benefits that will earn more LEED points. By identifying synergies between systems, teams will save time and money in both the short and the long term while optimizing resource use. Finally, the integrative process can avoid the delays and costs resulting from design changes during the construction documents phase and can reduce change orders during construction.

Through the integrative process, project teams can more effectively use LEED as a comprehensive tool for identifying interrelated issues and developing synergistic strategies. When applied properly, the integrative process reveals the degree to which LEED credits are related, rather than individual items on a checklist.

STEP-BY-STEP GUIDANCE

Discovery Steps

STEP 1. BECOME FAMILIAR WITH INTEGRATIVE PROCESS.

Review the Integrative Process (IP) ANSI Consensus National Standard Guide© 2.0 for Design and Construction of Sustainable Buildings and Communities, which provides step-by-step guidance and a methodology for improving building design, construction, and operations through a replicable, integrative process. Although this standard encourages project teams to engage in a comprehensive integrative process, the credit requirements address only the discovery phase, whose steps are similar to those described in the ANSI guide for engaging energy and water-related systems.

STEP 2. CONDUCT PRELIMINARY ENERGY RESEARCH AND ANALYSIS (IN CONCERT WITH STEP 3)

Complete energy-related research and analysis to support effective and informed discussions about potential integrative design opportunities (see *Further Explanation, Recommended Preliminary Data Collection*).

- Collect information about the local climate, site conditions, energy sources, transportation options, and potential building features.
- Use the U.S. Environmental Protection Agency's Target Finder tool or other data sources to benchmark energy performance for the project's type, scope, occupancy, and location.
- Develop a "simple box" energy model (assuming a simplified building form) to generate a basic distribution of energy uses and identify dominant energy loads.

- Use this conceptual energy model to analyze design alternatives for potential load reduction strategies (see *Further Explanation, Recommended Preliminary Energy Analysis* and *Example 1*).

STEP 3. CONDUCT PRELIMINARY WATER RESEARCH AND ANALYSIS (IN CONCERT WITH STEP 2)

Complete water-related research and analysis to support effective and informed discussions about potential integrative design opportunities.

- Collect information about waste treatment infrastructure, water sources, and potential building features (see *Further Explanation, Recommended Preliminary Data Collection*).
- Assess expected water demand for indoor, outdoor, and process water using the methodologies for WE Prerequisite Indoor Water Use Reduction, WE Prerequisite Outdoor Water Use Reduction, and WE Credit Cooling Tower Water Use.
- Gather data to quantify the project's potential nonpotable supply sources, such as captured rainwater, graywater from flow fixtures, or condensate from HVAC cooling equipment.
- Conduct a preliminary water budget analysis to quantify how fixture and equipment selection and nonpotable supply sources may offset potable water use for the water demands.

STEP 4. CONVENE GOAL-SETTING WORKSHOP

Engage the project owner in a primary project team workshop to determine the project goals, including budget, schedule, functional programmatic requirements, scope, quality, performance, and occupants' expectations. Understanding the owner's goals promotes creative problem solving and encourages interaction. This workshop should accomplish the following:

- Introduce all project team members to the fundamentals of the integrative process.
- Share initial background research and analysis findings from Steps 2 and 3.
- Elicit the owner's and stakeholders' values and aspirations.
- Clarify functional and programmatic goals.
- Establish initial principles, benchmarks, metrics, and performance targets.
- Identify targeted LEED credits.
- Generate potential integrative strategies for achieving performance targets.
- Determine the questions that must be answered to support project decisions.
- Identify initial responsibilities and deliverables.
- Initiate documentation of the owner's project requirements (OPR).

All principal project team members should be present at the goal-setting workshop.

STEP 5. EVALUATE POSSIBLE ENERGY STRATEGIES (IN CONCERT WITH STEP 6)

Evaluate the proposed goals and performance targets for feasibility by exploring possible strategies for the project's energy-related systems. Evaluate strategies against the initial performance targets and targeted LEED credits. It is recommended that project teams engage this initial early research and analysis by evaluating each subsystem described in the ANSI Consensus National Standard Guide© 2.0 for Design and Construction of Sustainable Buildings and Communities.

Conduct preliminary comparative energy modeling using the "simple box" energy model (Step 2) before completing schematic design to evaluate energy load reduction strategies (see *Further Explanation, Recommended Preliminary Energy Analysis* and *Example 2*). Aspects to consider include the following:

- **Site conditions.** Landscape solar shading, exterior lighting, feasibility for natural ventilation, adjacent site conditions.
- **Massing and orientation.** Number of floors, building footprint, configuration, solar orientation.
- **Building envelope attributes.** Wall and roof insulation, thermal mass, window size and orientation, exterior shading devices, window performance (U-values, solar heat gain coefficient, visible light transmittance).
- **Lighting levels.** Lighting power density, lighting needs in workspaces, reflectance values for ceiling and wall surfaces, high-efficiency lighting fixtures and controls, daylighting.
- **Thermal comfort ranges.** Temperature setpoints and thermal comfort parameters.
- **Plug and process loads.** Equipment and purchasing policies, other programmatic solutions, layout options.
- **Programmatic and operational parameters.** Hours of operation, space allotment per person, shared program spaces, teleworking policies.

Conduct such preliminary modeling to assess at least two optional strategies for each of the above seven aspects.

STEP 6. EVALUATE POSSIBLE WATER STRATEGIES (IN CONCERT WITH STEP 5)

Evaluate the proposed goals and performance targets for feasibility by exploring possible strategies for the project's water-related systems. Conduct a preliminary water budget analysis using research on potential water-use reduction strategies (Step 3). Aspects to consider include the following:

- **Indoor water use demand.** Preliminary baseline and design case water consumption inside the building, based on the building occupants' use of assumed plumbing fixture flow and flush rates (using the methodology for WE Prerequisite Indoor Water Use).
- **Outdoor water use demand.** Preliminary baseline and design case water consumption for landscape irrigation, based on assumed landscape strategies and irrigation systems (using the methodology for WE Prerequisite Outdoor Water Use).

Gather data (in addition to that for Step 3) to assess and quantify the project's potential nonpotable supply sources, such as captured rainwater, graywater from flow fixtures, and condensate produced by initially assumed HVAC cooling equipment.

Assess and quantify how potential nonpotable supply sources can be used to offset potable water use for the water demands calculated above. Identify at least one on-site nonpotable water source that could supply a portion of at least two demand components.

Implementation Step

STEP 7. DOCUMENT HOW ANALYSIS INFORMED DESIGN AND BUILDING FORM

Document energy-related research and analysis from the discovery phase.

- Document how the above energy-related analysis informed design and building form decisions in the project's OPR and basis of design (BOD), including the following, as applicable:
  - Building and site program
  - Building form and geometry
  - Building envelope and façade treatments on different orientations
  - Elimination or significant downsizing of building systems (e.g., HVAC, lighting, controls, exterior materials, interior finishes, and functional program elements)
  - Other systems
- Provide narrative explanations of the energy evaluation in the energy analysis section of the Integrative Process worksheet (provided by USGBC) and identify at least two options for each of the seven aspects listed in Step 5.

Document water-related research and analysis from the discovery phase.

- Document how the water-related analysis informed building and site design decisions in the project's OPR and BOD, including the following, as applicable:
  - Plumbing systems
  - Sewage conveyance and/or on-site treatment systems
  - Rainwater quantity and quality management systems
  - Landscaping, irrigation, and site elements
  - Roofing systems and/or building form and geometry
  - Other systems
- Provide narrative explanations of the water evaluation in the water analysis section of the Integrative Process worksheet.

FURTHER EXPLANATION

RECOMMENDED PRELIMINARY DATA COLLECTION

To understand the likely energy load distribution by end use, use a “simple box” energy model to identify initial annual energy consumption percentages of total energy use for each of the following end uses (Figure 1):

- Space heating
- Space cooling
- Ventilation
- Domestic hot water
- Lighting
- Miscellaneous equipment
- Other, as applicable

Typical energy consumption by end use for a project depends on building type, occupancy, climate, and other project-specific conditions.

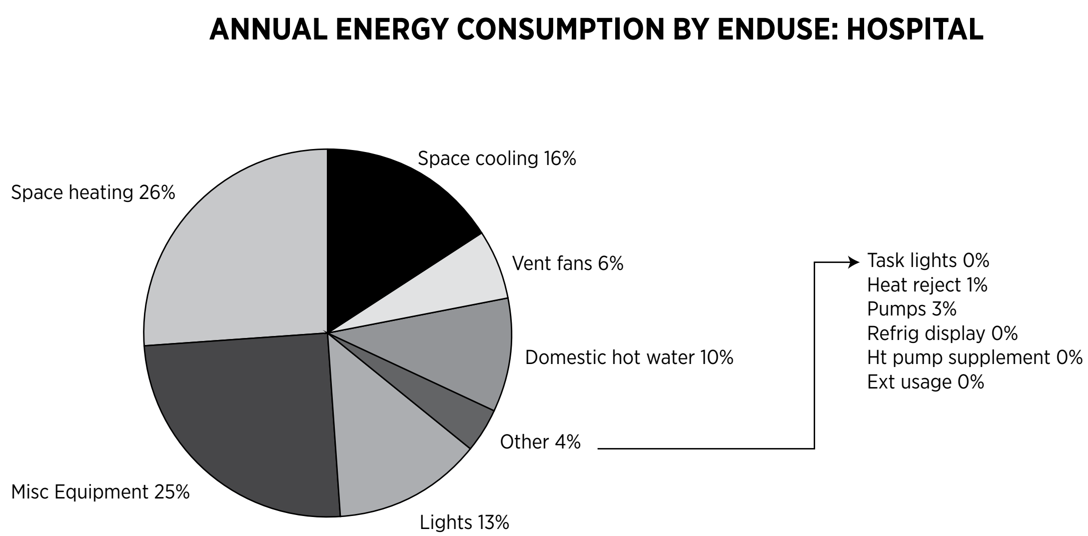


Figure 1. Example energy load distribution graph

Local climate data include annual and hourly dry-bulb temperature, wet-bulb depression, relative humidity, comfort hours, and average annual and monthly rainfall for the project site.

For Steps 2 and 3, gather the information outlined for SS Credit Site Assessment, including solar and wind capacity, heating and cooling degree days, seasonal wind velocity and direction, precipitation, microclimate, available energy sources, utility providers, energy and peak load costs, potential financial incentives, and other issues likely to affect energy-related systems.

For Step 3, consider the location (distance from site), capacity, and type and level of treatment for the sewage system serving the site, including any sewage plant facilities. Include data on average water treatment cost.

For Step 3, consider the location, capacity, and type of water sources serving the site, such as reservoirs, aquifers, wells, lakes, rivers, nonpotable sources, and municipal supply. Include monthly and annual rainfall data and the average cost of potable (and/or nonpotable) water.

RECOMMENDED PRELIMINARY ENERGY ANALYSIS

Before design of the building form begins, a building massing ("simple box") energy analysis can be used to evaluate potential energy and load reduction strategies, such as insulation levels and window performance levels. Initial modeling iterations should include the strategies in Step 5.

Site conditions. Consider options that integrate landscape components and strategies that reduce exterior lighting.

Massing and orientation. Consider two fundamental building footprint shapes or two building heights (e.g., one-story versus two stories for the same total gross square footage). Evaluate how rotating the building 90 degrees affects energy loads.

Building envelope performance. Consider options for the following aspects:

- Solar heat gain coefficients, overall U-value of glazing systems, performance criteria for windows in low, medium, and high ranges
- R-value (insulation) of walls, roofs, and conditioned below-grade structures in low, medium, and high ranges
- Effect of orientation on energy loads
- Effect of percentage of exterior glazing (e.g., 30%, 50%, and 70%) on energy loads

Lighting levels. Consider at least two options for reasonable reductions in lighting power density, including one aimed at a significant reduction from ASHRAE standards.

Thermal comfort ranges. Consider options for expanding the thermal comfort range.

Plug and process load needs. Consider at least two options for reasonable reductions in plug load density, including one aimed at a significant reduction from ASHRAE standards.

Programmatic and operational parameters. Consider options aimed at reducing building size, hours of occupancy, and/or number of occupants.

Simple massing sketches of rough configurations can be converted to simple box energy models. In both cases of this example, only a single wing of each sketch was modeled to simplify this early energy modeling, as depicted in Figures 2 and 3.

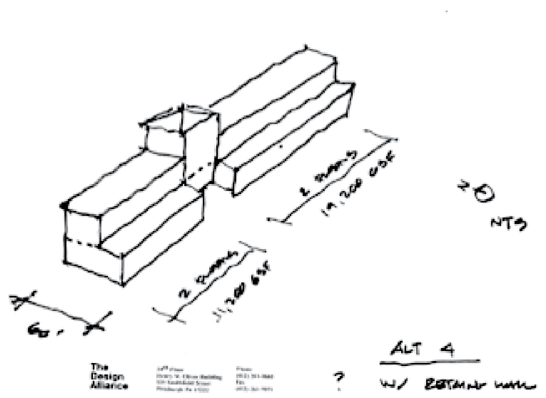


Figure 2. Simple massing sketches. Image courtesy of The Design Alliance Architects, Pittsburgh, PA © 2008. Phipps Center for Sustainable Landscapes.

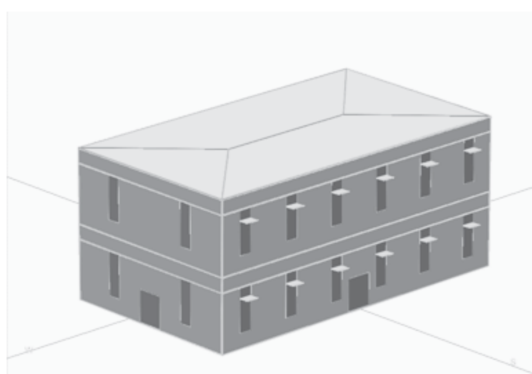


Figure 3. Simple model. Image courtesy of 7group.

The purpose of the modeling at this stage is to evaluate coarse-grain building configuration differences; only options that have large consequences need to be modeled (Figure 3).

Use this early iterative conceptual energy modeling to understand the building's heating and cooling loads and determine whether the project's energy use is likely to be dominated by internal or external loads. Small commercial and most residential projects are frequently dominated by external loads; that is, exterior conditions tend to affect the building's heating and cooling loads more than internal conditions. As a result, the performance of the building's envelope tends to have a larger effect than internal loads such as lighting. Large commercial buildings tend to be dominated by internal loads: occupants, equipment, and ventilation may be far greater contributors to the overall load than the performance of the building envelope, depending on climatic conditions.

EXAMPLES

Example 1. Light level analysis[1]

During the early stages of a Schools project, the team was able to reduce the number of lighting fixtures in classrooms by 25% compared with standard practice by selecting a paint color whose light reflectance value was 75%, instead of 64% for the initial proposed paint selection, while maintaining adequate illuminance (roughly 50 footcandles) on work surfaces.

The reduction in the number of light fixtures has multiple benefits, beyond the initial savings in fixture purchases and installation: the cost of electrical energy for lighting falls by 25% over the life of the building, and since lighting produces heat, the costs for cooling (roughly 1 watt of energy for every 3 watts of lighting) are reduced.

Example 2. Determining load reduction strategies

Determining effective load reduction strategies is the first step in creating an energy-efficient building. Early focus on load reduction is important because once the space programming is completed and the building is constructed, changing certain components that affect loads becomes difficult and expensive, especially for a building dominated by external or building envelope loads.

An example of a dominant external load is a fully glazed western façade in a mixed climate like New York City. This type of façade creates large loads for both cooling and heating, resulting in excessive energy use and oversizing of HVAC systems. Example strategies to decrease envelope loads include increasing insulated opaque wall area (balanced with daylighting strategies), increasing the insulating value of the glazing and window frame system, and summer solar shading.

On the other end of the spectrum are large buildings with dominant internal loads, like hospitals. Internal loads are often cooling loads, created by a combination of heat-producing lighting, equipment, and occupants. Conditioning of outside air is another big internal load. Load reduction strategies include decreasing lighting power, providing daylighting, reducing plug loads, using economizers for free cooling, and reducing the amount of ventilation air during periods of partial occupancy with CO_2 sensors.

In both cases, significant energy load reductions can be achieved. The concept model can provide feedback on which combination of strategies is likely to be the most effective and guide the design team in preparation for modeling HVAC systems. This allows HVAC systems to be properly sized and equipment efficiency improved in subsequent models; the team may be able to downsize or even eliminate equipment. The integrated approach can thus save both energy and capital costs of construction.

EXAMPLE WORKSHEET DOCUMENTATION

Describe how research and analysis uncovered through discovery influenced the project building program, form, geometry, and/or configuration.

> *The architect and mechanical engineer both started with the idea that two 100-ton chillers would be necessary for the AC system but had not thoroughly considered modifications to the building envelope design. Using the energy model to inform decisions about both, they instead specified two 50-ton chillers. The project also had a "future expansion" component that was not adequately defined, so the team experienced difficulty planning for design flexibility. The team paused and specifically addressed adaptability during the goal-setting workshop and then in the OPR, including which materials*

1. *Adapted from 7group and Bill G. Reed, The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability (John Wiley W Sons, Inc., 2009).*

would be reclaimed or reused during the future expansion phase. Although opinions differed on the best way forward, the team's interaction added clarity to the process and better defined the expectations for the building's operations and future phasing.

RATING SYSTEM VARIATIONS

Core and Shell

The energy-related systems analysis should include all system loads and occupants required by EA Prerequisite Minimum Energy Performance for Core and Shell projects. The water-related systems analysis should include all system loads and occupants required by both WE Prerequisite Outdoor Water Use and WE Prerequisite Indoor Water Use for Core and Shell projects.

PROJECT TYPE VARIATIONS

Major Renovations

The energy-related systems analysis and water-related systems analysis should include all of the same systems required for new construction projects, as described above, except for the massing and orientation component.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
Integrative Process worksheet (energy and water analysis tabs)	X

RELATED CREDIT TIPS

LT Credit Access to Quality Transit. The related credit's methodology for calculating transit service daily trips can be used to compare the suitability of project site locations for commuters.

LT Credit Reduced Parking Footprint. Reducing paved area and enlarging the landscaped area can expand the potential for rainwater infiltration aid the irrigation strategies connected with the preliminary water budget analysis required for this credit. This credit also requires that at least one on-site nonpotable water supply source contribute to at least two water demands; for example, a nonpotable water supply source such as harvested rainwater used for both irrigation and toilet flushing satisfies this requirement.

SS Credit Site Assessment. Addressing the related credit together with this credit will offer a more holistic perspective on the design opportunities and challenges. For best results, conduct the site assessment at the same time as the energy and water analyses required by this credit and present findings to the owner in one package. Climate data research and collection are recommended for both credits.

SS Credit Open Space. A larger landscaped area can increase graywater infiltration and aid irrigation—issues that relate to the preliminary water budget analysis required for this credit. Integrate vegetated areas (including roofs) to meet the requirements of SS Credit Rainwater Management, SS Credit Heat Island Reduction, WE Prerequisite and Credit Indoor Water Use Reduction, and WE Prerequisite and Credit Outdoor Water Use Reduction as part of a holistic analysis. Attention to the credits' interconnections allows optimization of the whole. Also take into account site design, building location, orientation, and massing, all of which can affect the preliminary energy-related systems analysis required for this credit—for example, using vegetation to provide solar shading.

SS Credit Rainwater Management. The preliminary water budget analysis required for this credit enables project teams to see how associated water issues interrelate. In developing the required water analysis, look for synergies with the related credit, plus SS Credit Open Space, SS Credit Heat Island Reduction, WE Prerequisite and Credit Indoor Water Use Reduction, and WE Prerequisite and Credit Outdoor Water Use Reduction, for achieving both cost and performance improvements.

SS Credit Heat Island Reduction. Many heat island reduction strategies alter both the preliminary water budget analysis and the preliminary energy-related systems analysis. For example, vegetated roofs that improve the energy performance of buildings are often paired with rainwater-harvesting systems.

SS Credit Light Pollution Reduction. Reducing exterior lighting power density addresses a site conditions aspect of the preliminary energy analysis.

WE Prerequisite and Credit Outdoor Water Use Reduction. The landscape water requirement calculation methodology of the related prerequisite and credit must be used for conducting the preliminary water budget analysis.

WE Prerequisite and Credit Indoor Water Use Reduction. The building water use and appliance and process use calculation methodologies of the related prerequisite and credit must be used for conducting the preliminary water budget analysis.

WE Credit Cooling Tower Water Use. For projects with cooling towers or evaporative condensers, the calculation methodologies in the related credit can be used for conducting the preliminary water budget analysis. This credit also requires that at least one on-site nonpotable water supply source contribute to at least two water demands; for example, a nonpotable water supply source such as harvested rainwater used for cooling tower cycling plus one other demand-side use satisfies this requirement.

EA Prerequisite Fundamental Commissioning and Verification. The narrative that this credit requires, describing the preliminary energy-related systems analysis and preliminary water budget analysis, must be included in the project's OPR and BOD, both of which are required by the related prerequisite. The purpose here is to give the commissioning authority an understanding of the process and criteria used to select the designed systems—that is, the "why," not just the "what."

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. The preliminary energy analysis required for this credit encourages project teams to focus on load reductions before analyzing system efficiencies. Using "simple box" energy modeling at an early stage, even before determining building form, gives a project team energy end-use benchmarks that directly inform design decisions during an iterative process, significantly improving energy performance and reducing operating costs.

EQ Prerequisite Minimum Indoor Air Quality Performance. The preliminary energy analysis requires project teams to calculate basic energy end use distribution in the earliest design stages. By doing so, teams can compare the relative energy demands of different ventilation strategies while meeting minimum ventilation requirements.

EQ Credit Enhanced Indoor Air Quality Strategies. The preliminary energy-related systems analysis requires project teams to calculate basic energy end use distribution in the earliest design stages. By doing so, teams can compare the relative energy demands of different ventilation strategies, including filtration, exhaust, demand control ventilation, and natural ventilation.

EQ Credit Thermal Comfort. Adjusting thermal comfort ranges can dramatically affect energy consumption. The preliminary energy-related systems analysis allows project teams to study the relative energy demands of adjustments to thermal comfort in the earliest design stages. Thermal comfort depends on many interrelated issues covered by a preliminary energy-related systems analysis, such as ventilation, internal loads from lighting and occupants, daylighting strategies, and external loads associated with envelope performance. Early modeling allows project teams to iteratively adjust and evaluate the associated parameters before schematic design.

EQ Credit Daylight. Effective daylighting, including appropriate levels of natural light with controls that reduce electric lighting, can dramatically affect energy consumption. The preliminary energy analysis allows project teams to compare daylighting design strategies, particularly balancing total glazing area with its effect on thermal performance and human comfort.

EQ Credit Quality Views. The preliminary energy-related systems analysis helps project teams give occupants exterior views while balancing total glazing area with its effect on thermal performance and comfort.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

ANSI Consensus National Standard Guide© 2.0 for Design and Construction of Sustainable Buildings and Communities (February 2, 2012): ansi.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

basis of design (BOD) the information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines

charrette an intensive, multiparty workshop that brings people from different disciplines and backgrounds together to explore, generate, and collaboratively produce design options

integrated project delivery an approach that involves people, systems, and business structures (contractual and legal agreements) and practices. The process harnesses the talents and insights of all participants to improve results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction. (Adapted from American Institute of Architects).

owner's project requirements (OPR) a written document that details the ideas, concepts, and criteria determined by the owner to be important to the success of the project

simple box energy modeling analysis (also known as "building-massing model energy analysis") a simple base-case energy analysis that informs the team about the building's likely distribution of energy consumption and is used to evaluate potential project energy strategies. A simple box analysis uses a basic, schematic building form.

water budget a project-specific method of calculating the amount of water required by the building and associated grounds. The budget takes into account indoor, outdoor, process, and makeup water demands and any on site supply including estimated rainfall. Water budgets must be associated with a specified amount of time, such as a week, month, or year and a quantity of water such as kGal, or liters.

Location and Transportation (LT)

OVERVIEW

The Location and Transportation (LT) category rewards thoughtful decisions about building location, with credits that encourage compact development, alternative transportation, and connection with amenities, such as restaurants and parks. The LT category is an outgrowth of the Sustainable Sites category, which formerly covered location-related topics. Whereas the SS category now specifically addresses on-site ecosystem services, the LT category considers the existing features of the surrounding community and how this infrastructure affects occupants' behavior and environmental performance.

Well-located buildings take advantage of existing infrastructure—public transit, street networks, pedestrian paths, bicycle networks, services and amenities, and existing utilities, such as electricity, water, gas, and sewage. By recognizing existing patterns of development and land density, project teams can reduce strain on the environment from the material and ecological costs that accompany the creation of new infrastructure and hardscape. In addition, the compact communities promoted by the LT credits encourage robust and realistic alternatives to private automobile use, such as walking, biking, vehicle shares, and public transit. These incremental steps can have significant benefits: a 2009 Urban Land Institute study concluded that improvements in land-use patterns and investments in public transportation infrastructure alone could reduce greenhouse gas emissions from transportation in the U.S. by 9% to 15% by 2050[1]; globally, the transportation sector is responsible for about one-quarter of energy-related greenhouse gas emissions.[2]

If integrated into the surrounding community, a building can offer distinct advantages to owners and building users. For owners, proximity to existing utility lines and street networks avoids the cost of bringing this infrastructure to the project site. For occupants, walkable and bikeable locations can enhance health by encouraging daily physical activity, and proximity to services and amenities can increase happiness and productivity. Locating in a vibrant, livable community makes the building a destination for residents, employees, customers, and visitors, and the building's occupants will contribute to the area's economic activity, creating a good model for future development. Reusing previously developed land, cleaning up brownfield sites, and investing in disadvantaged areas conserve undeveloped land and ensure efficient delivery of services and infrastructure.

1. *U.S. Environmental Protection Agency, Smart Growth and Climate Change, epa.gov/dced/climatechange.htm (accessed September 11, 2012).*
2. *International Council on Clean Transportation, Passenger Vehicles, (accessed March 22, 2013).*

Design strategies that complement the building's location are also rewarded in the LT section. For example, by limiting parking, a project can encourage building users to take alternative transportation. By providing bicycle storage, alternative-fuel facilities, and preferred parking for green vehicles, a project can support users seeking transportation options.

CONSISTENT DOCUMENTATION

WALKING AND BICYCLING DISTANCE

Walking and bicycling distances are measurements of how far a pedestrian and bicyclist would travel from a point of origin to a destination, such as the nearest bus stop. This distance, also known as shortest path analysis, replaces the simple straight-line radius used in LEED 2009 and better reflects pedestrians' and bicyclists' access to amenities, taking into account safety, convenience, and obstructions to movement. This in turn better predicts the use of these amenities.

Walking distances must be measured along infrastructure that is safe and comfortable for pedestrian: sidewalks, all-weather-surface footpaths, crosswalks, or equivalent pedestrian facilities.

Bicycling distances must be measured along infrastructure that is safe and comfortable for bicyclists: on-street bicycle lanes, off-street bicycle paths or trails, and streets with low target vehicle speed. Project teams may use bicycling distance instead of walking distance to measure the proximity of bicycle storage to a bicycle network in LT Credit Bicycle Facilities.

When calculating the walking or bicycling distance, sum the continuous segments of the walking or bicycling route to determine the distance from origin to destination. A straight-line radius from the origin that does not follow pedestrian and bicyclist infrastructure will not be accepted.

Refer to specific credits to select the appropriate origin and destination points. In all cases, the origin must be accessible to all building users, and the walking or bicycling distance must not exceed the distance specified in the credit requirements.

TOTAL VEHICLE PARKING CAPACITY

When determining total parking capacity, include all the off-street spaces available to the project building's users. This may include spaces both inside and outside the project boundary.

If parking spaces are shared among two or more buildings ("pooled" parking), determine the share of this parking allocated to the project. Include this number of spaces in the total parking capacity and provide rationale for the parking distribution, if necessary.

If no off-street parking is allocated to the project building's users, the team is eligible to pursue LT Credit Reduced Parking Footprint but is not eligible for LT Credit Green Vehicles.

The following parking spaces must be included in total parking capacity:

- New and existing surface parking spaces
- New and existing garage or multilevel parking spaces
- Any off-street parking spaces outside the project boundary that are available to the building's users

The following parking spaces should not be included in total parking capacity:

- On-street (parallel or pull-in) parking spaces on public rights of way
- Parking spaces for fleet and inventory vehicles, unless these vehicles are regularly used by employees for commuting as well as business purposes
- Motorbike or bicycle spaces

PREFERRED PARKING

Preferred parking spaces have the shortest walking distance to the main entrance of the project, exclusive of spaces designated for people with disabilities.

If parking is provided on multiple levels of a facility, locate preferred spaces on the level closest to the main entrance to the building.

If the parking area is subdivided for different kinds of building users (e.g., customers and employees, staff and students, ranking military officials), a project may distribute the required preferred parking spaces proportionally across each parking area. This also applies to the provision of fueling stations in LT Credit Green Vehicles.

Alternatively, a project that subdivides its parking area may provide one general preferred parking area with enough spaces for all user types (based on total parking capacity). In this case, parking areas outside the preferred parking zone would still be separated by user type. This also applies to the provision of fueling stations in LT Credit Green Vehicles.

The reservation of preferred parking spaces is required both for carpool and vanpool vehicles in LT Credit Reduced Parking Footprint and for green vehicles in LT Credit Green Vehicles. Projects pursuing both credits will need to reserve a higher proportion of preferred parking spaces.

Carpool and vanpool spaces and green vehicle spaces may be placed at the discretion of the project team (i.e., green vehicle spaces can be closer to the main entrance than carpool and vanpool spaces, or vice versa), provided the number of spaces reserved for each type meets credit requirements.

Although not encouraged, preferred parking areas and signage for carpool and vanpool vehicles and green vehicles may be combined if 10% of total parking capacity is reserved with this signage and both Reduced Parking Footprint and Green Vehicles credits are achieved.

LOCATION AND TRANSPORTATION CREDIT

LEED for Neighborhood Development Location

This credit applies to:

New Construction (8–16 points)
Core and Shell (8–20 points)
Schools (8–15 points)
Retail (8–16 points)
Data Centers (8–16 points)
Warehouses and Distribution Centers (8–16 points)
Hospitality (8–16 points)
Healthcare (5–9 points)

INTENT

To avoid development on inappropriate sites. To reduce vehicle distance traveled. To enhance livability and improve human health by encouraging daily physical activity.

REQUIREMENTS

Locate the project within the boundary of a development certified under LEED for Neighborhood Development (Stage 2 or Stage 3 under the Pilot or 2009 rating systems, Certified Plan or Certified Project under the LEED v4 rating system).

Projects attempting this credit are not eligible to earn points under other Location and Transportation credits.

TABLE 1. Points for LEED ND location

Certification Level	Points BD+C	Points BD+C (Core and Shell)	Points BD+C (Schools)	Points BD+C (Healthcare)
Certified	8	8	8	5
Silver	10	12	10	6
Gold	12	16	12	7
Platinum	16	20	15	9

BEHIND THE INTENT

The LEED for Neighborhood Development (LEED ND) rating system combines principles of smart growth, new urbanism, and green building design and construction to promote sustainable, healthy, and equitable places for neighborhood residents, workers, and visitors. Neighborhoods following the program must exhibit a wide range of sustainability features, such as walkability, transit access, sensitive land protection, connectivity, and shared infrastructure.

Project teams that select a project site in a LEED ND–certified neighborhood or plan have demonstrated a commitment to the fundamental goals of the Location and Transportation credit category: excellent building location and linkages with the surrounding community. The requirement for this credit is that the project be certified (not just registered) under LEED ND, to ensure that all the goals of the LT category are addressed. This credit thereby provides a streamlined alternative to the pursuit of the individual LT credits

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY LEED ND NEIGHBORHOOD OR CERTIFIED PLAN AREA FOR POTENTIAL DEVELOPMENT

Identify a potential project site that is located fully within a LEED ND–certified neighborhood or certified plan area.

- Check the USGBC website for up-to-date lists of LEED ND projects.
- Local USGBC chapters in the United States or other green building councils in other countries may also serve as valuable resources for identifying certified or soon-to-be-certified LEED ND neighborhoods.

STEP 2. CONFIRM ELIGIBILITY OF LEED ND PROJECT

Confirm that the LEED ND neighborhood or plan area in which the project is located meets credit criteria by collecting the following information:

- Rating system and rating system version
- Certification designation (Table 2; note differing terminology)
- Certification level and certification date

TABLE 2. Eligibility by LEED ND certification designation

Version	Eligible	Ineligible
LEED ND Pilot	Stage 2 LEED for Neighborhood Development Certified Plan Stage 3 LEED for Neighborhood Development Certified Project	Stage 1 LEED for Neighborhood Development Pre-reviewed Plan
LEED 2009	Stage 2 Pre-certified LEED for Neighborhood Development Plan Stage 3 LEED ND Certified Neighborhood Development	Stage 1 Conditional Approval of LEED ND Plan
LEED v4	LEED for Neighborhood Development Certified Plan LEED for Neighborhood Development Certified Built Project	LEED for Neighborhood Development Conditional Approval

The LEED ND project must have achieved certification to earn this credit. LEED ND projects that have only been registered or submitted for certification review do not qualify.

Project teams must consider the certification timelines of related BD+C and ND projects:

- If an associated neighborhood project is certifying to LEED ND Plan, be sure that the individual building projects are registered before the LEED ND project submits its application for certification.
- If an associated neighborhood project is certifying to LEED ND Plan and all building designs are substantially complete, it is recommended to complete the building design review phase first, then the LEED ND Plan certification. Major overlap exists between building water and energy prerequisites. Completing the building certifications first will greatly streamline the LEED ND Plan review process.
- If the associated neighborhood project is certifying to LEED ND, both certifications need to be submitted at approximately the same time, since each depends on the certification (not just registration) of the other.

Delays or appeals of one or both certification reviews could complicate matters if submission timelines are not coordinated. Alert USGBC as early in the documentation process as possible when simultaneous certifications are expected for advice on how to proceed.

STEP 3. DETERMINE POTENTIAL POINTS AVAILABLE FOR LEED ND LOCATION CREDIT AND INDIVIDUAL LT CREDITS

If the LEED ND project is certified and eligible for this credit, compare the available points offered by the other LT credits and the LEED ND Location credit.

STEP 4. DETERMINE FINAL CREDIT ACHIEVEMENT PATHWAY

Select the preferred credit achievement pathway. Projects achieving the LEED ND Location credit are ineligible to pursue additional LT credits.

- LEED ND Location credit is appropriate if the points available for LT Credit LEED for Neighborhood Development Location exceed the potential points available for individual LT credits. The compliance path offered by this credit will likely save a project team time in documentation.
- Individual LT credits are appropriate if the project is in an eligible LEED ND project or certified plan area but can achieve more points by pursuing multiple LT credits. Evaluate the trade-off between additional points and the level of effort required to document them.
- If the prospective LEED ND area is ineligible (Table 2), pursue individual LT credits.

STEP 5. GATHER AND CONFIRM LEED ND PROJECT INFORMATION

Contact members of the LEED ND project team to gather the following information:

- Project name and ID number
- Map of certified LEED ND neighborhood or plan boundary

FURTHER EXPLANATION

CAMPUS

Group Approach
All buildings in the group may be documented as one. The entire group boundary must be within the LEED ND project boundary to earn credit.

Campus Approach
Eligible. The entire campus boundary must be within the LEED ND project boundary to use the campus credit approach.

REQUIRED DOCUMENTATION

Documentation	All projects
LEED ND project information (name, ID number, rating system and version, certification level, and certification date)	X
Vicinity base map with LEED project boundary and LEED ND certified neighborhood or plan boundary	X

RELATED CREDIT TIPS

Project teams achieving this credit are not eligible to pursue other LT credits.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

LOCATION AND TRANSPORTATION CREDIT

Sensitive Land Protection

This credit applies to:

New Construction (1 point)
Core and Shell (2 points)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To avoid the development of environmentally sensitive lands and reduce the environmental impact from the location of a building on a site.

REQUIREMENTS

OPTION 1.

Locate the development footprint on land that has been previously developed.

OR

OPTION 2.

Locate the development footprint on land that has been previously developed or that does not meet the following criteria for sensitive land:

- **Prime farmland.** Prime farmland, unique farmland, or farmland of statewide or local importance as defined by the U.S. Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (or local equivalent for projects outside the U.S.) and identified in a state Natural Resources Conservation Service soil survey (or local equivalent for projects outside the U.S.).
- **Floodplains.** A flood hazard area shown on a legally adopted flood hazard map or otherwise legally designated by the local jurisdiction or the state. For projects in places without legally adopted flood hazard maps or legal designations, locate on a site that is entirely outside any floodplain subject to a 1% or greater chance of flooding in any given year.

- **Habitat.** Land identified as habitat for the following:
  - species listed as threatened or endangered under the U.S. Endangered Species Act or the state's endangered species act, or
  - species or ecological communities classified by NatureServe as GH (possibly extinct), G1 (critically imperiled), or G2 (imperiled), or
  - species listed as threatened or endangered specifies under local equivalent standards (for projects outside the U.S.) that are not covered by NatureServe data.
- **Water bodies.** Areas on or within 100 feet (30 meters) of a water body, except for minor improvements.
- **Wetlands.** Areas on or within 50 feet (15 meters) of a wetland, except for minor improvements.

Minor improvements within the wetland and water body buffers may be undertaken to enhance appreciation of them, provided such facilities are open to all building users. Only the following improvements are considered minor:

- Bicycle and pedestrian pathways no more than 12 feet wide (3.5 meters), of which no more than 8 feet (2.5 meters) may be impervious;
- Activities to maintain or restore native natural communities and/or natural hydrology;
- One single-story structure per 300 linear feet (90 linear meters) on average, not exceeding 500 square feet (45 square meters);
- Grade changes necessary to ensure public access;
- Clearings, limited to one per 300 linear feet (90 linear meters) on average, not exceeding 500 square feet (45 square meters) each;
- Removal of the following tree types:
  - Hazardous trees, up to 75% of dead trees
  - Trees less than 6 inches (150 millimeters) diameter at breast height
  - Up to 20% of trees more than 6 inches (150 millimeters) diameter at breast height with a condition rating of 40% or higher.
  - Trees under 40% condition rating
- The condition rating must be based on an assessment by an arborist certified by the International Society of Arboriculture (ISA) using ISA standard measures, or local equivalent for projects outside the U.S.
- Brownfield remediation activities.

BEHIND THE INTENT

Ecologically sensitive areas provide a variety of human health and environmental benefits. Agricultural areas produce food and assist with rainwater management; floodplains support diverse flora and fauna, supply rich agricultural soil, and provide flood protection; imperiled or endangered species habitat supports biodiversity; and wetlands and water bodies can buffer against flooding, sequester carbon, and manage rainwater runoff.

The ecosystem services and benefits these sensitive land types provide need to be effectively managed. Development of this land not only harms the ecology of the area but also places people and property in danger. For instance, locating a building in a floodplain or close to a marsh increases its risk of damage from floods or rising sea levels, and the conversion of agricultural land limits local opportunities for producing food.

One strategy for lessening the environmental consequences of a building is to select a site that has previously been developed and then to limit the building's footprint to the previously developed area. Building on a previously developed site also encourages the reuse of existing built infrastructure and investment in existing neighborhoods. If developing entirely on previously developed land is infeasible, project teams can achieve compliance by not disturbing sensitive land types.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY PREVIOUSLY DEVELOPED LAND ON SITE

Determine which portions of the site have been previously developed, if any, and map these areas (see *Getting Started, Previous Development*).

STEP 2. PRIORITIZE DEVELOPMENT OF PREVIOUSLY DEVELOPED LAND

Compare the project's proposed development footprint with the previously developed land. Where possible, locate the development footprint only on portions of the site that have been previously developed.

- If the development footprint does not extend beyond the previously developed portions of the site, or if the entire site is previously developed, the project has met the requirements of Option 1. No further action is necessary.
- If the development footprint extends to any land that has not been previously developed, follow Steps 3–8 below (for land that has not been previously developed only) to determine compliance with Option 2.

STEP 3. DETERMINE LOCATION OF PRIME FARMLAND

Confirm that the project's proposed development footprint does not encroach on prime farmland, unique farmland, or farmland of statewide or local importance, as identified in the Natural Resources Conservation Service (NRCS) soil survey for the area, or a local equivalent for projects outside the U.S. (see *Further Explanation, NRCS Soil Surveys* and *International Tips*).

STEP 4. DETERMINE LOCATION OF FLOOD HAZARD AREAS

Consult legally adopted flood hazard maps of the project site area.

- In the U.S., most local governments, flood management agencies, or other local entities maintain flood hazard maps, which may include flood hazard areas designated by both the Federal Emergency Management Agency (FEMA) and a local agency. For FEMA flood hazard zone definitions and map designations, see *Referenced Standards*.
- Projects outside the U.S. may use equivalent standards or determine the flood hazard area with a qualified professional (see *Further Explanation, International Tips*).

STEP 5. DETERMINE LOCATION OF THREATENED OR ENDANGERED SPECIES HABITAT

Project teams in the U.S. should contact the state Natural Heritage Program and state wildlife agency to determine whether any habitat for threatened or endangered species has been or is likely to be found on the project site.

- Qualifying species include threatened or endangered species under the U.S. Endangered Species Act, those listed by a state endangered species act, or those classified by NatureServe as GH, G1, or G2 (see *Referenced Standards)*.
- Projects teams have several options for gathering imperiled species and communities information from NatureServe. County-level data is available on the NatureServe website. Team members can reference the results of the website query as they determine whether ecological communities exist or if there is habitat necessary to support threatened or endangered species, located on the project site. Teams can also work with NatureServe directly to find more site-specific information if results are inconclusive or a more detailed survey is necessary.
- Project teams outside the U.S. should use local equivalents to these agencies. If an equivalent to the U.S. Natural Heritage Program or the state wildlife agency cannot be determined, see *Further Explanation, International Tips*.

STEP 6. DETERMINE LOCATION OF WETLANDS AND WATER BODIES

Use project site maps to locate any wetlands or water bodies.

- Include land within 50 feet (15 meters) of wetlands or land within 100 feet (30 meters) of water bodies.
- U.S. project teams should consult the U.S. Army Corps of Engineers' Wetlands Delineation Manual for further guidance on delineating wetlands.

STEP 7. LOCATE DEVELOPMENT FOOTPRINT TO AVOID ANY SENSITIVE AREAS

If the previous steps reveal any prime farmland, flood hazard zone, imperiled species habitat, or wetlands or water bodies and their surrounding buffers, design the project such that the development footprint does not encroach on the sensitive areas.

STEP 8. UNDERTAKE ONLY APPROVED MINOR IMPROVEMENTS AROUND WETLANDS AND WATER BODIES

Ensure that any necessary improvements to enhance appreciation of the wetland or water body and its buffer are considered minor, per the credit requirements. Project teams should evaluate the trade-offs between access to the wetlands or water bodies and the ecological consequences of the access for those areas.

FURTHER EXPLANATION

EXAMPLE

A project site has had no previous development. In consulting with agencies identified in the credit, the project team determines that an adjacent wetland extends across the project boundary and also finds a small habitat area for an endangered species within the project boundary.

The project team designs the development footprint such that it does not overlap with the sensitive habitat area and is not within 50 feet (15 meters) of the wetland. The project team provides an impervious pedestrian pathway within the wetland buffer that meets the credit requirements. The project earns the credit.

PRIME FARMLAND EXPLANATION

In the U.S., prime farmland (as well as unique farmland and farmland of statewide or local importance) is defined by the U.S. Code of Federal Regulations, as specified in the credit requirements. The definition has multiple parts that indicate the characteristics necessary for the farmland to be considered prime, unique, or of statewide or local importance. The complete definition can be found at gpo.gov/fdsys/pkg/CFR-2001-title7-vol6.

This definition is built into NRCS soil surveys; project teams do not need to conduct their own soil surveys unless seeking local equivalency for a site not covered by NRCS (see *International Tips*). See below for more information on obtaining the results of those soil surveys.

NRCS SOIL SURVEYS IN U.S.

Project teams may determine site soil types by visiting the Natural Resources Conservation Service (NRCS) website (see *Referenced Standards*) and downloading GIS data for the appropriate state and county.

NRCS keeps detailed surveys and maps for every county in the U.S. and provides most of this information online. The information can be downloaded to GIS mapping programs or may be viewed without GIS directly through the NRCS website, at websoilsurvey.nrcs.usda.gov/app/.

If NRCS soils data for the project site are unavailable online, contact the state or regional office to determine whether the site's soil type is considered prime, unique, or of state significance. It may be necessary to consult with an agricultural scientist if the soil type for the project site is unclear.

IDENTIFYING SENSITIVE HABITAT

To determine the presence of sensitive habitat, work with the state Natural Heritage Program and/or state fish and wildlife agencies (or a local equivalent outside the U.S.) to see whether species in any of the listed criteria are found on the project site. This will ensure that the most comprehensive and accurate data are used and eliminates the need for the project team to conduct a site survey.

Scientists from the aforementioned agencies specialize in wildlife information and can therefore determine whether the site has any sensitive habitat.

INTERNATIONAL TIPS

A qualified biologist or ecologist may be helpful in determining which local laws and regulations are the most equivalent to U.S. measures in scope and rigor. A qualified ecological or biological specialist is defined as an individual who has the following qualifications:

- Holds a degree in biology, ecology, or a related subject
- Is a practicing biologist or ecologist with a minimum of three years' experience in, for example, ecological impact assessments, habitat surveys, and habitat restoration
- Understands how construction and the built environment affect ecology and can make recommendations for ecological protection, enhancement, and mitigation measures
- Is covered by a professional code of conduct

Organizations likely to have qualified members include the Chartered Institution of Water and Environmental Management, the Institute of Ecology and Environmental Management, and the Institute of Environmental Management and Assessment.

Prime farmland. A local equivalent for identifying prime farmland is acceptable. Reference the U.S. Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5, to ensure that the local equivalent definition is similar. Use a soil survey with equivalent methodology to the NRCS soil survey that identifies land with characteristics similar to the definition of prime farmland.

Flood hazard areas. If the project area is covered in flood hazard maps, include the criteria used to delineate flood hazard area and the name of the authority that produced the maps. If no flood hazard maps are available, work with an engineer, hydrologist, or other qualified professional to map the flood hazard areas subject to credit requirements. Flood hazard maps must delineate areas with a 1% or greater chance of flooding in any given year. The professional hydrologist should also produce a report or an executive summary of findings and supporting documentation, such as site elevations or topographic maps and sections identifying the flood risk of the project site.

Sensitive habitat. If an equivalent to a U.S. fish and wildlife agency or Natural Heritage Program cannot be determined, review national or international sources for endangered species or protected habitat to determine what imperiled species might occur in the area. Global resources include the International Union for Conservation of Nature Red List (iucnredlist.org). In addition, engage a qualified local biologist or ecologist to conduct a biological survey.

Tree condition. A local equivalent to an arborist certified by the International Society of Arboriculture (ISA) must be consulted to determine the condition ratings of any trees that might be removed.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Site map(s) showing project boundary, development footprint, any previous development, any sensitive areas, and any minor improvements in required buffers	X	X
Explanation of the previous development on the site	X	
Description of how the project team verified prime farmland, flood hazard, and sensitive habitat criteria were met		X

RELATED CREDIT TIPS

LT Credit High-Priority Site. Locating the project on any of the site conditions listed in the related credit increases the likelihood of avoiding the sensitive areas protected under this credit. Brownfield remediation activities pursued as part of Option 3 of the related credit are considered acceptable minor improvements in wetland and water body buffers.

LT Credit Surrounding Density and Diverse Uses. Siting the project building away from sensitive areas increases the likelihood of locating in areas with surrounding building density or near diverse uses.

LT Credit Reduced Parking Footprint. By limiting the area allowed for development, this credit may reduce the amount of available land for parking and help teams achieve the related credit.

SS Credit Site Assessment. During an assessment, a project team may find features such as vegetation, land use, or hydrology that require protection to achieve this credit. The same assessment may be used to identify protection measures in the related credit.

SS Credit Rainwater Management. Sensitive land or previously undeveloped land on the project site that is left undisturbed may be used to manage runoff and help achieve Option 2 of the related credit.

SS Credit Site Development—Protect or Restore Habitat. Sensitive land or previously undeveloped land on the project site that is left undisturbed may be counted toward the 40% greenfield protection requirement in the related credit.

CHANGES FROM LEED 2009

- Floodplain requirements now refer to "flood hazard area shown on a legally adopted flood hazard map" instead of specifically referencing the 100-year floodplain. Projects must now avoid the flood hazard area instead of being at least 5 feet (1.5 meters) above the 100-year floodplain.
- The sensitive habitat requirements have been expanded to include species or ecological communities listed by NatureServe (in additional to local equivalents for projects outside the U.S. or outside areas covered by NatureServe).

- The water body buffer has been changed from 50 feet (15 meters) to 100 feet (30 meters).
- The wetland buffer has been changed from 100 feet (30 meters) to 50 feet (15 meters).
- A list of allowable minor improvements in wetland or water body buffers has been added.

REFERENCED STANDARDS

U.S. Department of Agriculture, United States Code of Federal Regulations Title 7, Volume 6, Parts 400 to 699, Section 657.5: soils.usda.gov/technical/handbook/contents/part622.html

U.S. Fish and Wildlife Service, List of Threatened and Endangered Species: fws.gov/endangered

NatureServe Heritage Program, GH, G1, and G2 species and ecological communities: natureserve.org

FEMA Flood Zone Designations: msc.fema.gov

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

brownfield real property or the expansion, redevelopment, or reuse of which may be complicated by the presence or possible presence of a hazardous substance, pollutant, or contaminant

development footprint the total land area of a project site covered by buildings, streets, parking areas, and other typically impermeable surfaces constructed as part of the project

previously developed altered by paving, construction, and/or land use that would typically have required regulatory permitting to have been initiated (alterations may exist now or in the past). Land that is not previously developed and landscapes altered by current or historical clearing or filling, agricultural or forestry use, or preserved natural area use are considered undeveloped land. The date of previous development permit issuance constitutes the date of previous development, but permit issuance in itself does not constitute previous development.

water body the surface water of a stream (first-order and higher, including intermittent streams), arroyo, river, canal, lake, estuary, bay, or ocean. It does not include irrigation ditches.

wetland an area that is inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas, but exclude irrigation ditches unless delineated as part of an adjacent wetland.

LOCATION AND TRANSPORTATION CREDIT

High-Priority Site

This credit applies to:

New Construction (1-2 points)
Core and Shell (2-3 points)
Schools (1-2 points)
Retail (1-2 points)
Data Centers (1-2 points)
Warehouses and Distribution Centers (1-2 points)
Hospitality (1-2 points)
Healthcare (1-2 point)

INTENT

To encourage project location in areas with development constraints and promote the health of the surrounding area.

REQUIREMENTS

OPTION 1. HISTORIC DISTRICT (1 POINT BD+C EXCEPT CORE AND SHELL, 2 POINTS CORE AND SHELL)

Locate the project on an infill location in a historic district.

OR

OPTION 2. PRIORITY DESIGNATION (1 POINT BD+C EXCEPT CORE AND SHELL, 2 POINTS CORE AND SHELL).

Locate the project on one of the following:

- a site listed by the EPA National Priorities List;
- a Federal Empowerment Zone site;
- a Federal Enterprise Community site;
- a Federal Renewal Community site;
- a Department of the Treasury Community Development Financial Institutions Fund Qualified Low-Income Community (a subset of the New Markets Tax Credit Program);
- a site in a U.S. Department of Housing and Urban Development's Qualified Census Tract (QCT) or Difficult Development Area (DDA); or
- a local equivalent program administered at the national level for projects outside the U.S.

OR

OPTION 3. BROWNFIELD REMEDIATION (2 POINTS BD+C EXCEPT CORE AND SHELL, 3 POINTS CORE AND SHELL)

Locate on a brownfield where soil or groundwater contamination has been identified, and where the local, state, or national authority (whichever has jurisdiction) requires its remediation. Perform remediation to the satisfaction of that authority.

BEHIND THE INTENT

Many communities and governments have identified high-priority redevelopment sites. Putting these sites back into productive use has many environmental advantages over development in greenfields and environmentally sensitive areas. Building a project on a high-priority redevelopment site can revitalize the neighborhood and bring social and economic benefits to the surrounding community. Such projects also achieve savings because they are served by existing infrastructure.

Option 1 rewards investing in historic areas, a proven strategy for maintaining and enhancing community character. Underutilized properties can have a rich history. The redevelopment of sites in historic districts can also reduce urban sprawl through adaptive reuse.

Many low-income communities have sites that are vacant or underutilized because of perceived stigmas or economic barriers. Option 2 promotes the social and economic revitalization of economically depressed or disadvantaged neighborhoods by rewarding the location of certain appropriate projects on such sites.

Option 3 promotes the redevelopment of contaminated sites, where hazardous materials are removed from a site's soil or groundwater, thereby reducing[2] the exposure of humans and wildlife to environmental pollution and improving environmental health. Contaminated site redevelopment often reduces the footprint of the project's elements, with a redevelopment site using an average of 78% less land than the same project would if it were built on a greenfield.[1]

STEP-BY-STEP GUIDANCE

Option 1. Historic District

STEP 1. CONFIRM INFILL STATUS

Confirm that the project site under consideration is an infill site.

- To determine infill status, first identify all land within 1/2 mile (800 meters) of the project boundary that has been previously developed, excluding streets and other rights of way (see *Getting Started, Previous Development*).
- Determine the percentage of land that is previously developed by dividing the previously developed area by the total land area less streets and rights-of-way within 1/2 mile (800 meters) of the project boundary. Water bodies are not included in land area. If this percentage is 75% or greater, the location is considered an infill site.

STEP 2. IDENTIFY AND CONFIRM HISTORIC DISTRICT STATUS

Consult the local planning or permitting agency to identify any historic preservation entity that designates local historic districts. Work with that entity to determine whether the proposed project site is in a historic district.

- Projects in a historic preservation district must often meet additional design or construction criteria. These restrictions may include use of specific exterior building materials, limitations on total building height, and restrictions on demolition.
- Work with the historic preservation entity to determine these restrictions and gain approval through the local review board where required.

Option 2. Priority Designation

STEP 1. IDENTIFY PRIORITY DEVELOPMENT AREA

Review the high-priority designations identified in the credit requirements and consult each program's website to review the areas identified under the program. The priority designations listed most often overlap with economically disadvantaged areas. These programs are administered in the U.S.; for information on equivalency, see *Further Explanation, International Tips*.

- National Priority Sites are designated by the U.S. Environmental Protection Agency. They release

1. *Deason, J.P., G.W. Sherk, and G.A. Carroll, Public Policies and Private Decisions Affecting the Redevelopment of Brownfields (Environmental and Energy Management Program, George Washington University, 2001).*

or threaten to release hazardous substances, pollutants, or contaminants. Projects on the National Priority List are targets for the federal Superfund program, which cleans up uncontrolled hazardous waste sites around the country.

- Empowerment Zone, Enterprise Community, and Renewal Community sites, identified by the U.S. Department of Housing and Urban Development, offer various tax incentives to encourage businesses to open or expand and hire local residents.
- The Community Development Financial Institutions Fund is a federal grant program that seeks to expand affordable credit, capital, and financial services for underserved populations through grants and tax credits. It is a subset of the Treasury's New Markets Tax Credit Program, which provides a tax credit for investing in designated "community development entities."
- A qualified census tract has a certain percentage of low-income households, as defined under Section 42 of the U.S. Internal Revenue Code. Difficult development areas are determined annually by Housing and Urban Development. Owners of rental properties in qualified census tracts and difficult development areas qualify for the low-income housing tax credit, as defined under Section 42 of the Internal Revenue Code.

STEP 2. CONFIRM THAT SITE IS IN AREA WITH PRIORITY DESIGNATION

Work with the local economic development, planning, community development, housing, or redevelopment agency or department to determine whether the specified priority designation applies to the project site.

- A project site qualifies even if only a portion is in the high-priority designated area.
- Indicate the site boundaries and priority area on a site map and provide confirmation of the designation.

Option 3. Brownfield Remediation

STEP 1. IDENTIFY CONTAMINATION

As early as possible in the development process, determine the presence of any on-site soil or groundwater contamination.

- To identify contamination, consult local records, conduct a Phase 1 or Phase 2 environmental site assessment (or a local equivalent), or work with a biologist or environmental scientist.
- The credit explicitly applies to soil or groundwater contamination. Asbestos and other contaminants inside buildings (whether demolished or remaining) or in debris do not count as contamination under this credit requirement. However, it is recommended that project teams consider these factors in an overall site assessment.
- If the project is located on a site that has already been completely assessed and remediated, the results of that assessment and remediation may be used toward achievement of this option if complete documentation is provided.

STEP 2. DETERMINE APPLICABLE REMEDIATION REQUIREMENTS

Obtain a declaration from the authority having jurisdiction indicating the presence of contamination, and work with that authority to determine the remediation requirements for the contaminated site.

- If part of the site is found to have contamination, then the entire area within the LEED project boundary is considered a contaminated site.
- In the U.S., the authority having jurisdiction may be the U.S. Environmental Protection Agency or a state or local government regulatory agency responsible for identification of contaminants and remediation protocols.

STEP 3. COMPLETE REMEDIATION

Remediate the project site to the satisfaction of the authority having jurisdiction. Completing remediation typically involves working with a remediation specialist.

- Remediation can be a long process. Identifying any contamination and beginning remediation is often just the first step; a site undergoing remediation may therefore receive credit at the time of certification.
- Many local governments or other authorities will not grant entitlement or other planning approvals until remediation has made the site safe for human occupancy and intended use.

FURTHER EXPLANATION

INTERNATIONAL TIPS

Option 1 Historic District. Projects may attempt this option if a local, national, or international designation indicates that the project site's neighborhood has significant historic or cultural value.

Option 2 Priority Designation. Most of the priority designations are intended to encourage investment in economically disadvantaged or low-income areas. Projects outside the U.S. should demonstrate that the site is in a priority area, as designated by an equivalent, nationally administered program with similar goals and operation.

Option 3 Brownfield Remediation. Identify site contamination by using a government registry or by following a procedure similar to Phase 1 and Phase 2 Environmental Site Assessments, as specified by ASTM E1527-05 and ASTM E1903–11. In all cases the authority having jurisdiction must require remediation for this option to be achieved. The scope of Phase I and II assessments includes determining the likelihood of contamination and identifying potential contaminants on the site (by such methods as reviewing historical records and interviewing those with knowledge of the site) as well as collecting and testing samples of soil, soil vapor, ground water and structural materials for contamination.

CAMPUS

Group Approach

All buildings may be documented as one.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3
Vicinity map indicating previously developed land within ½ mile (800 meters) of project boundary	X		
Document from historic preservation entity confirming location in historic district	X		
Vicinity map or other documentation confirming priority site designation		X	
Documentation from authority having jurisdiction declaring existence of specific contamination and confirming that remediation has been or will be completed to its satisfaction			X

RELATED CREDIT TIPS

MR Credit Building Life-Cycle Impact Reduction. Projects reusing the structure, envelope, and interior nonstructural elements of a historic building may be eligible for Option 1 of the related credit. Projects renovating or reusing at least half of the structure, enclosure, and interior structural elements of an abandoned or blighted building may be eligible for Option 2 of the related credit.

SS Prerequisite Environmental Site Assessment: If a Phase 1 environmental site assessment (required for School and Healthcare projects under the related prerequisite) reveals brownfields or contamination that will be remediated, the project qualifies for Option 3 of this credit.

LT credit category (**all credits**): Locating a building on any of the high-priority site types addressed in this credit significantly increases the likelihood that the project will be in a dense area served by transit and diverse uses, making other LT credits more achievable.

CHANGES FROM LEED 2009

- This credit adapts many of the concepts formerly found in SS Credit 3 Brownfield Redevelopment.
- Projects now have options for infill location in a historic district and for locating in a priority redevelopment area.
- Projects are no longer limited to officially designated brownfields. Contaminated sites requiring remediation, as deemed by the authority having jurisdiction, can qualify a project for this credit.

REFERENCED STANDARDS

U.S. Environmental Protection Agency, National Priority List: epa.gov/superfund/sites/npl

U.S. Housing and Urban Development, Federal Empowerment Zone, Federal Enterprise Community, and Federal Renewal Community:
portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/economicdevelopment/programs/rc

U.S. Department of Treasury, Community Development Financial Institutions Fund: cdfifund.gov

U.S. Department of Housing and Urban Development, Qualified Census Tracts and Difficult Development Areas: qct.huduser.org/index.html

EXEMPLARY PERFORMANCE

For exemplary performance, pursue Option 2 or 3 in addition to Option 1. Otherwise, only one option is allowed.

DEFINITIONS

brownfield real property or the expansion, redevelopment, or reuse of which may be complicated by the presence or possible presence of a hazardous substance, pollutant, or contaminant

historic district a group of buildings, structures, objects, and sites that have been designated or determined to be eligible as historically and architecturally significant, and categorized as either contributing or noncontributing to the historic nature of the district.

infill site a site where at least 75% of the land area, exclusive of rights-of-way, within 1/2 mile (800 meters) of the project boundary is previously developed. A street or other right-of-way does not constitute previously developed land; it is the status of property on the other side of right-of-way or the street that matters.

previously developed site a site that, prior to the project, consisted of at least 75% previously developed land

LOCATION AND TRANSPORTATION CREDIT

Surrounding Density and Diverse Uses

This credit applies to:

New Construction (1-5 points)
Core and Shell (1-6 points)
Schools (1-5 points)
Retail (1–5 points)
Data Centers (1–5 points)
Warehouses and Distribution Centers (1–5 points)
Hospitality (1–5 points)
Healthcare (1 point)

INTENT

To conserve land and protect farmland and wildlife habitat by encouraging development in areas with existing infrastructure. To promote walkability, and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging daily physical activity.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, DATA CENTERS, HOSPITALITY

OPTION 1. SURROUNDING DENSITY (2–3 POINTS BD+C EXCEPT CORE AND SHELL, 2-4 POINTS CORE AND SHELL).

Locate on a site whose surrounding existing density within a 1/4 mile (400-meter) radius of the project boundary meets the values in Table 1. Use either the “separate residential and nonresidential densities” or the “combined density” values.

TABLE 1A. Points for average density within 1/4 mile of project (IP units)				
Combined Density	**Separate Residential and Nonresidential Densities**		**Points BD+C (except Core and Shell)**	**Points BD+C (Core and Shell)**
Square feet per acre of buildable land	**Residential Density (DU/acre)**	**Nonresidential Density (FAR)**		
22,000	7	0.5	2	2
35,000	12	0.8	3	4

TABLE 1B. Points for average density within 400 meters of project (SI units)				
Combined Density	**Separate Residential and Nonresidential Densities**		**Points BD+C (except Core and Shell)**	**Points BD+C (Core and Shell)**
Square meters per hectare of buildable land	**Residential Density (DU/hectare)**	**Nonresidential Density (FAR)**		
5 050	17.5	0.5	2	2
8 035	30	0.8	3	4

DU = dwelling unit; FAR = floor-area ratio.

SCHOOLS ONLY

Physical education spaces that are part of the project site, such as playing fields and associated buildings used during sporting events only (e.g., concession stands) and playgrounds with play equipment, are excluded from the development density calculations.

AND/OR

OPTION 2. DIVERSE USES (1–2 POINTS)

Construct or renovate a building or a space within a building such that the building's main entrance is within a 1/2 mile (800-meter) walking distance of the main entrance of four to seven (1 point) or eight or more (2 points) existing and publicly available diverse uses (listed in Appendix 1).

The following restrictions apply.

- A use counts as only one type (e.g., a retail store may be counted only once even if it sells products in several categories).
- No more than two uses in each use type may be counted (e.g. if five restaurants are within walking distance, only two may be counted).
- The counted uses must represent at least three of the five categories, exclusive of the building's primary use.

WAREHOUSES AND DISTRIBUTION CENTERS

OPTION 1. DEVELOPMENT AND ADJACENCY (2–3 POINTS)

Construct or renovate the project on a previously developed site that was used for industrial or commercial purposes (2 points).

OR

Construct or renovate the project on a site that is both a previously developed and an adjacent site. The adjacent sites must be currently used for industrial or commercial purposes (3 points).

AND/OR

OPTION 2. TRANSPORTATION RESOURCES (1–2 POINTS)

Construct or renovate the project on a site that has two or three (1 point) or four (2 points) of the following transportation resources:

- The site is within a 10-mile (16 kilometer) driving distance of a main logistics hub, defined as an airport, seaport, intermodal facility, or freight village with intermodal transportation.
- The site is within a 1-mile (1 600-meter) driving distance of an on-off ramp to a highway.
- The site is within a 1-mile (1 600-meter) driving distance of an access point to an active freight rail line.
- The site is served by an active freight rail spur.

In all cases, a planned transportation resource must be sited, funded, and under construction by the date of the certificate of occupancy and complete within 24 months of that date..

HEALTHCARE

OPTION 1. SURROUNDING DENSITY (1 POINT)

Locate on a site whose surrounding existing density within a 1/4-mile (400-meter) radius of the project boundary is:

1. At least 7 dwelling units per acre (17.5 DU per hectare) with a 0.5 floor-area ratio. The counted density must be *existing* density, not zoned density, or
2. At least 22,000 square feet per acre (5 050 square meters per hectare) of buildable land.

For previously developed existing rural healthcare campus sites, achieve a minimum development density of 30,000 square feet per acre (6 890 square meters per hectare).

OR

OPTION 2. DIVERSE USES (1 POINT)

Construct or renovate a building on a site such that the building's main entrance is within a 1/2-mile (800-meter) walking distance of the main entrance of at least seven operational and publicly accessible uses (listed in Appendix 1).

The following restrictions apply.

- A use may be counted as only one type (e.g., a retail store may be counted only once even if it sells products in several categories).
- No more than two uses in each use type may be counted (e.g., if five restaurants are within walking distance, only two may be counted).
- The counted uses must represent at least three of the five categories, exclusive of the building's primary use.

BEHIND THE INTENT

Because most people prefer to walk no more than a quarter of a mile (400 meters) or five minutes to casual destinations and no more than half a mile (800 meters) for regular trips such as a daily commute,[1] locating different kinds of destinations close to each other achieves a long list of documented environmental and social benefits. For example, doubling residential and nonresidential density reduces the length of vehicular trips and total air pollution by 30 percent.[2] Air particulate levels go down along with greenhouse gas emissions, reducing transportation's climate change effects.[3] Furthermore, per capita pedestrian and bicycle injuries and deaths tend to be fewer in denser neighborhoods with more pedestrians and cyclists, since motorists must drive more slowly and carefully in these areas. The rate of car collision fatalities goes down, too, as the average length of vehicular trips grows shorter. Moreover, density improves community members' health. As neighborhoods become more compact, residents who frequently walk, bike, or use transit are more physically fit and less likely to be overweight.[4] One study found that the probability of being overweight falls around 5% for every half-mile (800 meters) walked per day.[5] Finally, compact development capitalizes on existing infrastructure, saving money and resources while more efficiently using land and preserving habitat, farmland, and open space on the urban fringe.

For all those reasons, this credit rewards a project location that is surrounded by existing built density and within walking distance of a variety of services ("uses"). The density thresholds correspond to the minimum densities needed to support bus transit (seven dwelling units per acre, 17.5 DU per hectare) and fixed-rail transit (12 DU per acre, 30 DU per hectare). Two threshold types are listed, one combining residential and nonresidential densities, the second separating them. Project teams therefore have flexibility in calculating the surrounding built density based on the information available to them.

The credit restricts which uses can and cannot count to ensure a diversity of destinations. The more diverse types of services within walking distance of the project, the more opportunities occupants have to combine their trips when meeting daily needs—for example, stopping at a dry cleaner on the way to the bank.

In this credit, warehouses and distribution centers have different requirements, reflecting the needs of buildings devoted to housing goods (and not people). For such projects, proximity to transportation infrastructure matters more.

STEP-BY-STEP GUIDANCE

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, DATA CENTERS, HOSPITALITY, HEALTHCARE

STEP 1. SELECT PROJECT SITE

Use the criteria in the credit requirements to evaluate potential sites for development. Follow these suggestions to maximize the chances of identifying an appropriate site:

- Limit site selection to areas within the central business district of a city or town center.
- Give preference to areas of development that include residential uses.
- Identify both infill sites and existing buildings that can meet the needs of the project.

1. *Interview with Dan Burden, Walkable Communities, cited in How to Create and Implement Healthy General Plans (Raimi + Associates and Public Health Law and Policy, 2008), p. B2, changelabsolutions.org/sites/default/files/Healthy_General_Plans_Toolkit_Updated_20120517_0.pdf (accessed June 10, 2013).*
2. *Raimi, Matthew, and Sarah Patrick with Design Community & Environment, in association with Reid Ewing, Lawrence Frank, and Richard Kreutzer, Understanding the Relationship between Public Health and the Built Environment, Report prepared for the U.S. Green Building Council LEED-ND Core Committee and Congress for the New Urbanism (2006), p. 116, usgbc.org/Docs/Archive/General/Docs3901.pdf (accessed June 10, 2013)*
3. *Ewing, R., et al., Growing Cooler: The Evidence on Urban Development and Climate Change. (Urban Land Institute, 2007), postcarboncities.net/files/SGA_GrowingCooler9-18-07small.pdf (accessed June 10, 2013).*
4. *Frank, L., et al., Linking Objectively Measured Physical Activity with Objectively Measured Urban Form: Findings from SMARTRAQ, American Journal of Preventive Medicine (February 2005): 117–1255.*
5. *Frank, L. et al., Obesity Relationships with Community Design, Physical Activity, and Time Spent in Cars, American Journal of Preventive Medicine 27(2) (August 2004): 87–96.*

STEP 2. IDENTIFY ELIGIBLE OPTIONS

Select the appropriate option(s) for the project.

- Option 1 is for projects in dense locations. Spot-check density on an aerial map to determine whether calculations can demonstrate credit achievement.
- Option 2 is for projects that are close to a variety of amenities and services. If the main entrance is within easy walking distance of diverse uses, investigate this option in addition to Option 1.
- Projects except Healthcare may pursue both options; Healthcare projects are eligible for only a single option.

Option 1. Surrounding Density

STEP 1. IDENTIFY BUILDING SITES AND BUILDABLE LAND WITHIN REQUIRED RADIUS OF PROJECT SITE

On a map, plot a 1/4 mile (400-meter) radius around the project site from the project boundary.

- Indicate building site types as residential, nonresidential, or mixed-use.
- Indicate buildable land (see *Getting Started, Previous Development*). Do not include project buildings or nonhabitable space, such as parking garages.

STEP 2. COLLECT INFORMATION ON DENSITY

For each building site location within the radius, determine whether sufficient information is available to calculate residential and nonresidential building densities separately.

- If the project team cannot determine the number of dwelling units in the surrounding land, use the combined density calculation.
- It might not be necessary to determine the total number of dwelling units or building floor area for all properties within the radius. If the area features a few extremely dense buildings, start with these first to see whether the threshold can be met without further calculations.
- Provided that all land area within the radius is accounted for, project teams must collect only enough density information to demonstrate that values in Table 1 are met or exceeded.

STEP 3. PERFORM SEPARATE RESIDENTIAL AND NONRESIDENTIAL DENSITY CALCULATIONS, IF APPLICABLE

If the information is available, calculate the density for each building type within the 1/4-mile (400-meter) radius. Designate each building and its associated land area as residential, nonresidential, or mixed use (see *Getting Started, Density*).

- Calculate total dwelling units per acre or hectare for all residential buildings.
- Calculate the total floor-area ratio for all nonresidential buildings.
- For mixed-use buildings within the radius, use Equations 1 and 2 to apply a weighted average of the residential and nonresidential components.

EQUATION 1. Weighted average applied to residential land use for mixed-use projects

$$\text{Mixed-use residential land} = \text{\% residential floor area} \times \text{Total mixed-use land area (acres or hectares)}$$

EQUATION 2. Weighted average applied to nonresidential land use for mixed-use projects

$$\text{Mixed-use nonresidential land} = \text{\% nonresidential floor area} \times \text{Total mixed-use land area (acres or hectares)}$$

Add the mixed-use buildings' dwelling units, nonresidential floor area, residential land, and nonresidential land to the values determined when calculating the densities of purely residential or nonresidential areas (see *Further Explanation, Example 1*).

STEP 4. CALCULATE COMBINED DENSITY, IF APPLICABLE

When separate residential or nonresidential density calculations cannot be performed for all areas, use Equation 3 instead to determine the combined density within the prescribed radius.

- Exclude parking garages.
- For buildings with simple, rectilinear footprints, estimate floor area by measuring the building footprint area and multiplying it by the number of floors.

EQUATION 3. Combined density

$$\text{Combined density (ft}^2\text{/acre or m}^2\text{/hectare)} = \text{Total floor area (ft}^2\text{ or m}^2\text{)} \div \text{Total buildable land (acres or hectares)}$$

STEP 5. DETERMINE POINTS EARNED

Refer to Table 1 in the credit requirements to determine points earned, based on the combined or separate residential and nonresidential densities.

For separate calculations, if the point values for the residential and nonresidential densities are different, the lowest performing land use is used to determine the number of points achieved.

Option 2. Diversity of Uses

STEP 1. DOCUMENT NEARBY USES

Survey the eligible existing uses in or near the project and classify the use types according to Appendix 1.

- To be eligible, uses that are planned but not currently operating must be occupied within one year of the date of the LEED project's initial certificate of occupancy.
- Use the credit requirements to determine the number and category of uses that contribute to credit achievement. Note the restriction on the number of uses of each type (see *Further Explanation, Example 2*).

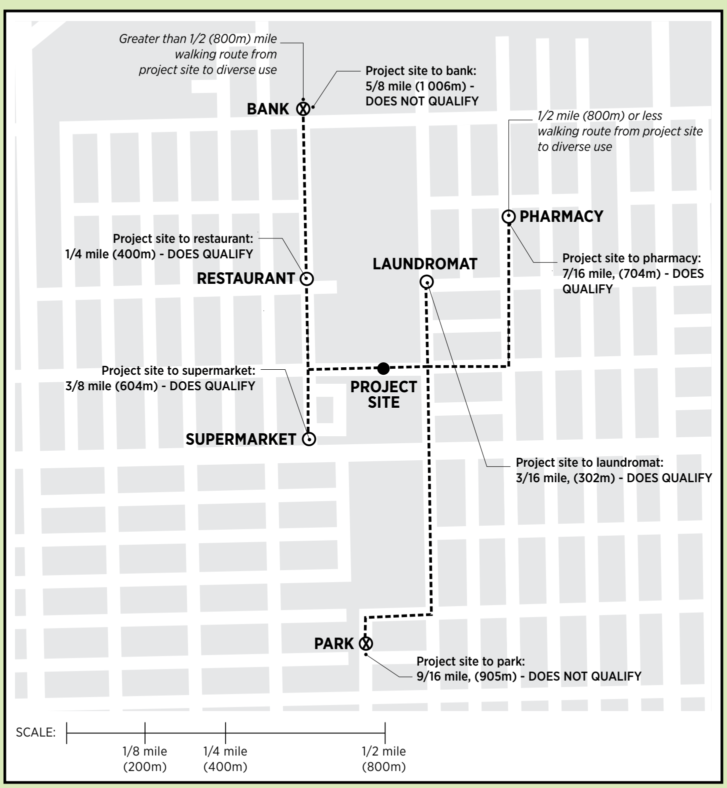


Figure 1. Example walking routes to diverse uses

STEP 2. MAP WALKING ROUTES TO USES

On a map, label the eligible uses and plot walking routes from the project's main entrance.

- Measure the distance along each walking route to determine whether it meets the credit's distance requirements (see Figure 1 and *LT Overview, Walking and Bicycling Distances*).

WAREHOUSES AND DISTRIBUTION CENTERS

STEP 1. CHOOSE PROJECT LOCATION

Select a project location that is a previously developed site used for industrial or commercial purposes, is adjacent to sites currently used for industrial or commercial purposes, or is close to transportation as outlined in the credit criteria. Determine whether planned transportation will be applicable to the project.

STEP 2. SELECT ONE OR BOTH OPTIONS

Select the appropriate option(s) for the project.

- Option 1 is for projects located on a previously developed site, with or without adjacency to previous development.
- Option 2 is for projects sited near transportation resources as identified in the credit criteria.

Option 1. Development and Adjacency

STEP 1. CONFIRM PREVIOUS DEVELOPMENT AND USE

Map the project site, indicating previous development. Calculate the percentage of the site that is previously developed; to be considered a previously developed site, the land area must be 75% previously developed (see *Getting Started, Previous Development*).

Confirm that the site was previously used for commercial or industrial purposes.

STEP 2. DETERMINE ADJACENT SITE STATUS, IF APPLICABLE

For an additional point, confirm that the project site is located on an adjacent site (see *Definitions*). Adjacent sites must be currently used for industrial or commercial purposes. If necessary, identify the uses of adjacent parcels using zoning maps, parcel maps, or similar resources to confirm their status.

Option 2. Transportation Resources

STEP 1. MEASURE DRIVING DISTANCES

On a map, plot driving routes from the project to any of the applicable transportation resources identified in the credit criteria. Indicate driving distances to each resource.

STEP 2. CONFIRM COMPLETION OR CONSTRUCTION OF EXISTING AND PLANNED TRANSPORTATION RESOURCES

Confirm that any transportation resource counted for Option 2 (such as a seaport, off-ramp to a highway, or freight rail line) is completed or will be under construction within 24 months of project completion.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

EXAMPLES

Example 1. Residential and nonresidential density calculations

A new commercial building is surrounded by a variety of residential, nonresidential, and mixed-use buildings within a 1/4 mile (400-meter) radius of the project boundary.

The project developer does not know the size of many of the residential buildings and therefore chooses to do a separate density calculation for residential and nonresidential densities. A survey of the area provides the following information:

TABLE 2. Land area

Building type	All Types	Residential	Nonresidential	Mixed-Use
Land Area	130 acres (53 hectares)	60 acres (23 hectares)	60 acres (23 hectares)	10 acres (4 hectares)

The project determines that 80% of the total mixed-use building floor area is residential and the other 20% is nonresidential, and allocates the land area proportionally according to Equations 1 and 2:

Mixed-use residential land = 80% x 10 acres = 8 acres

Mixed-use nonresidential land = 20% x 10 acres = 2 acres

TABLE 3. Adjusted land area

Building Type	Total	Residential	Nonresidential
Land Area	130 acres (53 hectares)	60 acres + 8 acres = 68 acres (28 hectares)	60 acres + 2 acres = 62 acres (25 hectares)

There are 680 dwelling units within 1/4 mile (400 meters) (including all residential units in mixed-use buildings). The project team calculates density in dwelling units (DU) as follows:

Residential density = 680 DU / 68 acres = 10 DU / acre (24 DU / hectare)

Nonresidential space (including all nonresidential buildings and nonresidential space in mixed-use buildings) within the radius totals 1,600,000 square feet (148 645 square meters), and the total nonresidential land area is 2,700,720 square feet (250 905 square meters). The team calculates the nonresidential density in floor-area ratio (FAR) as follows:

Nonresidential density = 1,600,000 / 2,700,720 = 0.59 FAR

(Nonresidential density = 148 645 / 250 905 = 0.59 FAR)

TABLE 4. Summary of densities			
Building Type	**Total**	**Residential**	**Nonresidential**
Land Area	130 acres (53 hectares)	68 acres (28 hectares)	62 acres (25 hectares) 2,700,720 ft^2 (250 905 m^2)
Dwelling Units		680 DU	
Nonresidential Building Space			1,600,000 ft^2 (148 645 m^2)
Density		10 DU/acre (24 DU/hectare)	FAR 0.59

Since the density within 1/4 mile (400 meters) is 10 dwelling units per acre (24 dwelling units per hectare) and the nonresidential FAR is 0.59, the number of points the project earns based on either value would be 2 points (Table 1).

Example 2. Diversity of uses
A multistory apartment building is within a 1/2-mile (800-meter) walking distance of eight uses in three categories (Appendix 1).

TABLE 5. Summary of uses

	Category				**Total**
	Service	**Food Retail**	**Civic and Community Facilities**		
Use Type	**Restaurant**	**Grocery**	**Child Care**	**Library**	
Number of Uses	3	2	1	2	8
Eligible Uses	2	2	1	2	7

Only two uses from any one type are eligible, however. Thus, the project team can count only two of the three restaurants. This leaves seven allowable uses, so the project scores 1 point.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

All BD+C except Warehouses and Distribution Centers	Option 1	Option 2
Area plan or map showing project site and location of existing residential and non-residential buildings within ¼-mile (400-meter) radius of project site	X	
Area plan or map showing project site, location and type of each use, and walking routes		X
Warehouses and Distribution Centers	**Option 1**	**Option 2**
Area plan or map showing project site, its previous development, and (if applicable) industrial or commercial properties adjacent to project site	X	
Area plan or map showing project site, location and type of transportation resources, and driving distance to each		X
If planned transportation resources are counted, verification that they will be funded and under construction by date of certificate of occupancy and complete within two years of that date		X

RELATED CREDIT TIPS

LT Credit High-Priority Site. Projects located in an infill site to meet Option 1 of the related credit may have better access to nearby uses and may find it easier to meet the densities required for this credit. Projects located in a priority designation site to meet Option 2 of the related credit may find high surrounding density, since the priority sites are often in urban locations.

LT Credit Access to Quality Transit. High-density areas are more likely to be served by transit. Density levels required to support transit services correspond to each density threshold in Option 1 of this credit.

CHANGES FROM LEED 2009

- Points have been redistributed such that the credit's full value can be earned only if the requirements for both Options 1 and 2 are met.
- For all rating systems except Healthcare, there are now two thresholds for each option.
- There are now thresholds for separate residential and nonresidential densities.
- Specific requirements for warehouses and distribution centers have been added.
- The radius for building density calculation is now specified as 1/4 mile (400 meters) from the project boundary.
- Proximity to the diverse uses is now based on walking distance instead of a radius.
- Additional restrictions have been added to stipulate how diverse uses can be counted.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

adjacent site a site having at least a continuous 25% of its boundary bordering parcels that are previously developed sites. Only consider bordering parcels, not intervening rights-of-way. Any fraction of the boundary that borders a water body is excluded from the calculation.

buildable land the portion of the site where construction can occur, including land voluntarily set aside and not constructed on. When used in density calculations, buildable land excludes public rights-of-way and land excluded from development by codified law.

density a measure of the total building floor area or dwelling units on a parcel of land relative to the buildable land of that parcel. Units for measuring density may differ according to credit requirements. Does not include structured parking.

diverse use a distinct business or organization that provides goods or services intended to meet daily needs and is publicly available. Automated facilities such as ATMs or vending machines are not included. For a full list, see the Appendix.

floor-area ratio (**FAR**) the density of nonresidential land use, exclusive of parking, measured as the total nonresidential building floor area divided by the total buildable land area available for nonresidential structures. For example, on a site with 10,000 square feet (930 square meters) of buildable land area, an FAR of 1.0 would be 10,000 square feet (930 square meters) of building floor area. On the same site, an FAR of 1.5 would be 15,000 square feet (1395 square meters), an FAR of 2.0 would be 20,000 square feet (1860 square meters), and an FAR of 0.5 would be 5,000 square feet (465 square meters).

freight village a cluster of freight-related businesses that include intermodal transfer operations. Freight villages may offer logistics services, integrated distribution, warehousing capabilities, showrooms, and support services. Such support services may include security, maintenance, mail, banking, customs and import management assistance, cafeterias, restaurants, office space, conference rooms, hotels, and public or activity center transportation.

highway a transportation thoroughfare intended for motor vehicles with limited access points, prohibitions on human-powered vehicles, and higher speeds than local roads. A highway generally connects cities and towns.

intermodal facility a venue for the movement of goods in a single loading unit or road vehicle that uses successively two or more modes of transportation without the need to handle the goods themselves

previously developed altered by paving, construction, and/or land use that would typically have required regulatory permitting to have been initiated (alterations may exist now or in the past). Land that is not previously developed and landscapes altered by current or historical clearing or filling, agricultural or forestry use, or preserved natural area use are considered undeveloped land. The date of previous development permit issuance constitutes the date of previous development, but permit issuance in itself does not constitute previous development.

previously developed site a site that, prior to the project, consisted of at least 75% previously developed land

LOCATION AND TRANSPORTATION CREDIT

Access to Quality Transit

This credit applies to:

New Construction (1–5 points)
Core and Shell (1–6 points)
Schools (1–4 points)
Data Centers (1-5 points)
Warehouses and Distribution Centers (1-5 points)
Hospitality (1-5 points)
Retail (1-5 points)
Healthcare (1-2 points)

INTENT

To encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, RETAIL

Locate any functional entry of the project within a 1/4-mile (400-meter) walking distance of existing or planned bus, streetcar, or informal transit stops, or within a 1/2-mile (800-meter) walking distance of existing or planned bus rapid transit stops, light or heavy rail stations, commuter rail stations, or commuter ferry terminals. The transit service at those stops and stations in aggregate must meet the minimums listed in Tables 1 and 2. Planned stops and stations may count if they are sited, funded, and under construction by the date of the certificate of occupancy and are complete within 24 months of that date.

Both weekday and weekend trip minimums must be met.

- Qualifying transit routes must have paired route service (service in opposite directions).
- For each qualifying transit route, only trips in one direction are counted towards the threshold.
- If a qualifying transit route has multiple stops within the required walking distance, only trips from one stop are counted towards the threshold.

TABLE 1. Minimum daily transit service for projects with multiple transit types (bus, streetcar, rail, or ferry)			
Weekday Trips	**Weekend Trips**	**Points BD+C (except Core and Shell)**	**Points BD+C (Core and Shell)**
72	40	1	1
144	108	3	3
360	216	5	6

TABLE 2. Minimum daily transit service for projects with commuter rail or ferry service only		
Weekday Trips	**Weekend Trips**	**Points (All Projects)**
24	6	1
40	8	2
60	12	3

Projects served by two or more transit routes such that no one route provides more than 60% of the documented levels may earn one additional point, up to the maximum number of points.

If existing transit service is temporarily rerouted outside the required distances for less than two years, the project may meet the requirements, provided the local transit agency has committed to restoring the routes with service at or above the prior level.

SCHOOLS

OPTION 1. TRANSIT-SERVED LOCATION (1–4 POINTS)

Locate any functional entry of the project within a 1/4-mile (400-meter) walking distance of existing or planned bus, streetcar, or informal transit stops, or within a 1/2-mile (800-meter) walking distance of existing or planned bus rapid transit stops, light or heavy rail stations, commuter rail stations or commuter ferry terminals. The transit service at those stops and stations must meet the minimums listed in Tables 1 and 2. Planned stops and stations may count if they are sited, funded, and under construction by the date of the certificate of occupancy and are complete within 24 months of that date.

- Qualifying transit routes must have paired route service (service in opposite directions).
- For each qualifying transit route, only trips in one direction are counted towards the threshold.
- If a qualifying transit route has multiple stops within the required walking distance, only trips from one stop are counted towards the threshold.

TABLE 1. Minimum daily transit service for projects with multiple transit types (bus, streetcar, rail, or ferry)	
Weekday Trips	**Points**
72	1
144	2
360	4

TABLE 2. Minimum daily transit service for projects with commuter rail or ferry service only	
Weekday Trips	**Points**
24	1
40	2
60	3

Projects served by two or more transit routes such that no one route provides more than 60% of the prescribed levels may earn one additional point, up to the maximum number of points.

If existing transit service is temporarily rerouted outside the required distances for less than two years, the project may meet the requirements, provided the local transit agency has committed to restoring the routes with service at or above the prior level.

OR

OPTION 2. PEDESTRIAN ACCESS (1–4 POINTS)

Show that the project has an attendance boundary such that the specified percentages of students live within no more than a 3/4-mile (1200-meter) walking distance (for grades 8 and below, or ages 14 and below), and 1 1/2-mile (2400-meter) walking distance (for grades 9 and above or ages 15 and above) of a functional entry of a school building. Points are awarded according to Table 3.

TABLE 3. Points for student population within walking distance

Percentage of Students	Points
50%	1
60%	2
70% or more	4

In addition, locate the project on a site that allows pedestrian access to the site from all residential neighborhoods that house the planned student population.

HEALTHCARE

Locate any functional entry of the project within a 1/4-mile (400-meter) walking distance of existing or planned bus, streetcar, or informal transit stops, or within a 1/2-mile (800-meter) walking distance of existing or planned bus rapid transit stops, light or heavy rail stations, commuter rail stations or commuter ferry terminals. The transit service at those stops and stations in aggregate must meet the minimums listed in Tables 1 and 2. Planned stops and stations may count if they are sited, funded, and under construction by the date of the certificate of occupancy and are complete within 24 months of that date.

Both weekday and weekend trip minimums must be met.

- Qualifying transit routes must have paired route service (service in opposite directions).
- For each qualifying transit route, only trips in one direction are counted towards the threshold.
- If a qualifying transit route has multiple stops within the required walking distance, only trips from one stop are counted towards the threshold.

TABLE 1. Minimum daily transit service for projects with multiple transit types (bus, streetcar, rail, or ferry)

Weekday Trips	Weekend Trips	Points
72	40	1
144	108	2

TABLE 2. Minimum daily transit service for projects with commuter rail or ferry service only

Weekday Trips	Weekend Trips	Points
24	6	1
40	8	2

Projects served by two or more transit routes such that no one route provides more than 60% of the prescribed levels may earn one additional point, up to the maximum number of points.

If existing transit service is temporarily rerouted outside the required distances for less than two years, the project may meet the requirements, provided the local transit agency has committed to restoring the routes with service at or above the prior level.

BEHIND THE INTENT

Compact, walkable communities located near transit provide alternatives to driving that benefit the environment as well as the health and well-being of the community. Access to transit is particularly beneficial for young people, the elderly, and people who cannot afford to own cars.

Nearly all forms of public transit create fewer greenhouse gas emissions per passenger than single-occupancy vehicles. Developments in areas near existing transit also consume less land than low-density, auto-oriented growth, reducing conversion of farmland and open spaces into built development. Investment in transit-oriented development, a proven strategy for revitalizing downtowns and declining urban neighborhoods, brings a city roughly twice the economic benefit as would result from the same monetary investment in highways.[1]

Transit-oriented development locations support transit services by boosting ridership, while project occupants enjoy access to public transportation. Projects that are within walking distance of multiple transit routes will further encourage occupants and visitors to use public transportation. Schools should provide pedestrian and bicycle access to transit or be sited in a neighborhood to reduce busing.

STEP-BY-STEP GUIDANCE

NEW CONSTRUCTION, CORE AND SHELL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, AND HEALTHCARE

STEP 1. IDENTIFY TRANSIT STOPS WITHIN 1/2 MILE (800 METERS)

On a site map, identify the location of any transit stops that appear to be within 1/2 mile (800 meters) of the project.

- Existing, temporarily rerouted, or planned stops may be eligible, provided they meet the credit requirements for each situation.
- Projects counting planned or temporarily rerouted service must provide documentation from the transit authority indicating that the criteria will be met for those stops.

STEP 2. CLASSIFY TRANSIT BASED ON VEHICLE TYPES

Identify the type of transit vehicles that serve each transit stop, which could include bus, streetcar, bus rapid transit (BRT), rail, or ferry.

- Classify the identified transit stops by transit vehicle type (e.g., bus, streetcar, rail).
- Transit stops for bus, streetcar, or informal transit between the 1/4-mile (400-meter) and 1/2-mile (800-meter) distance do not contribute to credit compliance.

STEP 3. CONFIRM WALKABILITY

Plot walking routes and distances from transit stops to the project building's nearest functional entry (see Figure 1 and *LT Overview, Walking and Bicycling Distance*).

- Confirm that each functional entry is located with the required walking distance of one or more transit stops, according to the maximum distances outlined in the credit requirements.
- Each point at which a transit vehicle stops to receive or discharge passengers is considered a separate stop; this includes stops facing each other on opposite sides of a street. If a route has two separate stops to serve each direction (e.g., on opposite sides of a street or on separated, one-way streets), choose one stop from which to measure the distance to that route.
- Any transit stop reaching any functional entry of the project within the specified distance can be counted toward the credit. Therefore, different stops within walking distances of different functional entries may count, provided they meet the credit requirements.

1. *Newman, P., and J. Kenworthy, Sustainability and Cities: Overcoming Automobile Dependence (Washington, DC: Island Press, 1999).*

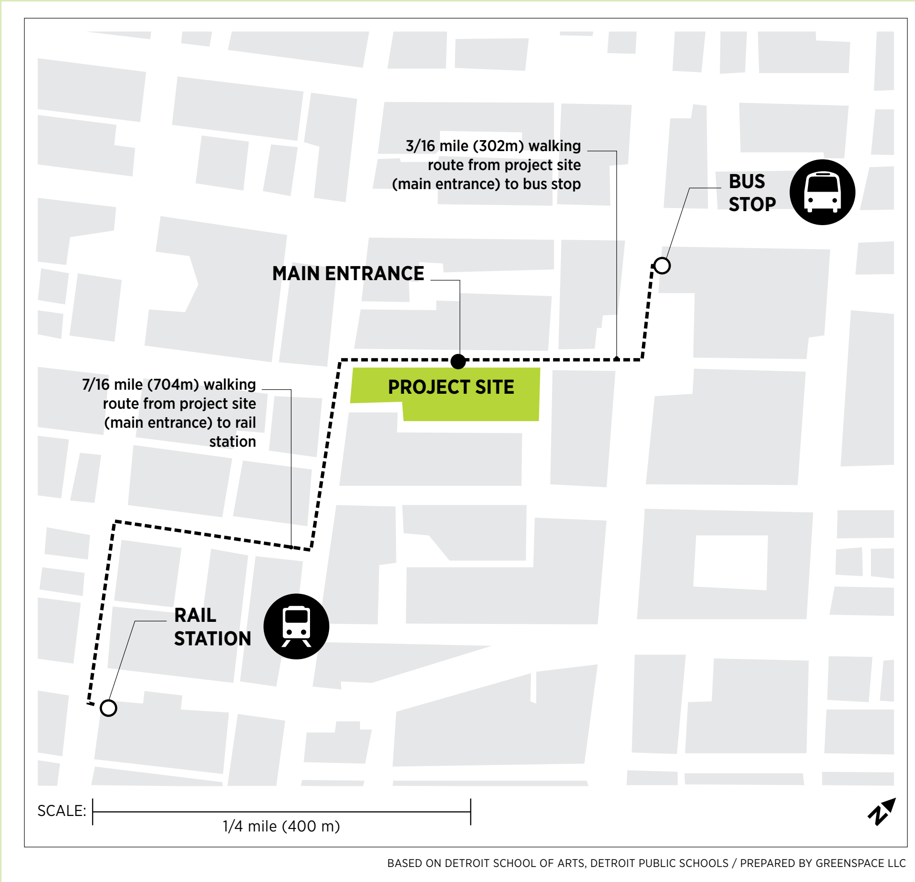


Figure 1. Example walking distance map

STEP 4. COUNT AGGREGATE TRIPS AVAILABLE AT ALL QUALIFYING TRANSIT STOPS

A trip is considered the point at which passengers embark or disembark from a transit vehicle at a stop. For a given route, count trips in only one direction.

For each transit stop within the required walking distance, review transit service schedules to determine the following:

- The number of transit vehicle trips on a weekday. If service varies by weekday, count the weekday with the lowest number of trips.
- The number of transit vehicle rides on a weekend. If weekend counts are different, use an average.
- Schools are not required to evaluate weekend transit service if students do not commute to schools on weekend days (see *Further Explanation*).
- An individual transit stop can be counted only once, regardless of the number of entrances within walking distance of it.

STEP 5. CALCULATE POINTS EARNED

Refer to Table 1 (for multiple transit types) or Table 2 (for commuter rail or ferry only) of the credit requirements to determine the number of points earned.

- If weekday and weekend trips meet different point thresholds, then the lowest performing time period (weekday or weekend) determines the number of points documented.
- Schools should not count weekend transit service or apply the weighted average calculation unless students commute to school on weekend days.
- If there is sufficient diversity of transit service among multiple routes, projects may be eligible to earn 1 bonus point, as outlined in the credit requirements.

SCHOOLS

STEP 1. SELECT ONE OPTION

Select one of the two options.

- Option 1 is for projects whose students primarily live beyond walking distance.
- Option 2 is appropriate for schools whose students live within walking distance, with an attendance boundary clearly demarcated by the school authority.

STEP 2. PROVIDE PEDESTRIAN AND BICYCLE ACCESS TO TRANSIT

Design the site with pedestrian and bicycle paths that extend to at least the school property line to ensure that students, faculty, and staff have safe, direct access to transit facilities (Option 1) or that students can safely travel to and from their homes (Option 2).

Option 1. Transit-Served Location

Follow the steps listed above for the other BD+C rating systems.

Option 2. Pedestrian Access

STEP 1. DELINEATE APPLICABLE WALKSHED BOUNDARY

Create a walkshed boundary using mapping software (GIS or CAD) to indicate the areas within a 3/4-mile (1200-meter) walk (for young students, as defined in the credit requirements) or a 1 1/2-mile (2400-meter) walk (for older students).

STEP 2. DETERMINE SHARE OF STUDENTS WITHIN WALKSHED BOUNDARY

Compare the walkshed boundary with the attendance boundary map for the school. The attendance boundary map or accompanying analysis generally indicates where concentrations of students live (or are anticipated to live), without indicating precise addresses. Using this information, estimate the required percentage of students who live within the particular walkshed boundary.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

EXAMPLE

The project, a 75-unit apartment building pursuing BD+C: New Construction, has two functional building entries. A light rail stop is within a 1/4-mile (400-meter) walking distance of one of the functional building entries. A commuter rail station is within a 1/2-mile (800-meter) walking distance of the other functional building entry. This project meets the walkability requirement.

Both the light rail station and the commuter rail station have service in both directions. To determine the number of trips, the project team counts service in one direction and summarizes the service available at the eligible stops (Table 4).

TABLE 4. Example transit service summary				
	Weekday	Weekend Day A	Weekend Day B	Weekend Average
Light rail	80	60	54	57
Commuter rail	25	10	10	10
Total	105			67
Point threshold	1			1

Because it has both light rail and commuter rail service, the project earns 1 point (Table 1).

The project team determines that the light rail provides more than 60% of the accessible transit (Table 5). The bonus point for having no service that exceeds 60% is therefore unavailable.

TABLE 5. Route diversity			
	Weekday Trips	Average Weekend Trips	Total
Light rail	80	57	137 (80% of trips)
Commuter rail	25	10	32 (20% of trips)
Total service	105	67	172

PROJECT TYPE VARIATIONS

For government projects with security restrictions (e.g., military), on-site mass transit can be used to document credit compliance. Transit service outside secured entrances may contribute to credit compliance, provided it is within the required walking distance (based on mode type) of a stop along the on-site mass transit service.

CAMPUS

Group Approach

Submit separate documentation for each building.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All Projects	Schools Option 1	Schools Option 2
Map showing project, project boundary, transit stop locations, and walking routes and distances to those stops	X	X	
Timetables or other service-level documentation	X	X	
If applicable, documentation of planned transit or restoration of temporarily rerouted service	X	X	
Map showing walkshed boundary			X

RELATED CREDIT TIPS

LT Credit Bicycle Facilities. For schools, bicycle lanes designed to comply with the related credit may be extended to transit facility locations to meet the dedicated lane requirement for this credit.

CHANGES FROM LEED 2009

- Transit service frequency is now included in the credit requirements.
- Access is now measured by walking distance to functional building entries.
- The credit now addresses both weekday and weekend availability.
- Point thresholds are now based on the number of transit trips available within the required walking distance.
- Modes of transportation have been expanded to include ferry, streetcar, bus rapid transit, and informal transit.
- For Schools projects, Option 2 Pedestrian Access now includes a tiered point system based on the percentage of students within the walkable attendance area.
- Private shuttles cannot be used to comply with the requirement.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Double the highest transit service point threshold (except for Schools projects using Option 2).

DEFINITIONS

attendance boundary the limits used by school districts to determine what school students attend based on where they live.

bus rapid transit an enhanced bus system that operates on exclusive bus lanes or other transit rights-of-way. The system is designed to combine the flexibility of buses with the efficiency of rail.

functional entry a building opening designed to be used by pedestrians and open during regular business hours. It does not include any door exclusively designated as an emergency exit, or a garage door not designed as a pedestrian entrance.

light rail transit service using two- or three-car trains in a right-of-way that is often separated from other traffic modes. Spacing between stations tends to be 1/2 mile (800 meters) or more, and maximum operating speeds are typically 40–55 mph (65–90 kmh). Light-rail corridors typically extend 10 or more miles (16 kilometers).

informal transit a publicly available transit service that includes a fixed route service, fare structure, and regular operation. It does not consist of taxi, private shuttles or seasonal, on-call or on-demand transit.

streetcar a transit service with small, individual rail cars. Spacing between stations is uniformly short and ranges from every block to 1/4 mile (400 meters), and operating speeds are primarily 10–30 mph (15–50 kmh). Streetcar routes typically extend 2–5 miles (3-8 kilometers).

walking distance the distance that a pedestrian must travel between origins and destinations without obstruction, in a safe and comfortable environment on a continuous network of sidewalks, all weather-surface footpaths, crosswalks, or equivalent pedestrian facilities. The walking distance must be drawn from an entrance that is accessible to all building users.

LOCATION AND TRANSPORTATION CREDIT

Bicycle Facilities

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Retail (1 point)
Healthcare (1 point)

INTENT

To promote bicycling and transportation efficiency and reduce vehicle distance traveled. To improve public health by encouraging utilitarian and recreational physical activity.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

Bicycle Network

Design or locate the project such that a functional entry or bicycle storage is within a 200-yard (180-meter) walking distance or bicycling distance from a bicycle network that connects to at least one of the following:

- at least 10 diverse uses (see Appendix 1);
- a school or employment center, if the project total floor area is 50% or more residential; or
- a bus rapid transit stop, light or heavy rail station, commuter rail station, or ferry terminal.

All destinations must be within a 3-mile (4800-meter) bicycling distance of the project boundary.

Planned bicycle trails or lanes may be counted if they are fully funded by the date of the certificate of occupancy and are scheduled for completion within one year of that date.

Bicycle Storage and Shower Rooms

Case 1. Commercial or Institutional Projects

Provide short-term bicycle storage for at least 2.5% of all peak visitors, but no fewer than four storage spaces per building.

Provide long-term bicycle storage for at least 5% of all regular building occupants, but no fewer than four storage spaces per building in addition to the short-term bicycle storage spaces.

Provide at least one on-site shower with changing facility for the first 100 regular building occupants and one additional shower for every 150 regular building occupants thereafter.

Case 2. Residential Projects

Provide short-term bicycle storage for at least 2.5% of all peak visitors but no fewer than four storage spaces per building.

Provide long-term bicycle storage for at least 30% of all regular building occupants, but no less than one storage space per residentialunit.

Case 3. Mixed-Use Projects

Meet the Case 1 and Case 2 storage requirements for the nonresidential and residential portions of the project, respectively.

FOR ALL PROJECTS

Short-term bicycle storage must be within 100 feet (30 meters) walking distance of any main entrance. Long-term bicycle storage must be within 100 feet (30 meters) walking distance of any functional entry.

Bicycle storage capacity may not be double-counted: storage that is fully allocated to the occupants of nonproject facilities cannot also serve project occupants.

Core and Shell projects should refer to Appendix 2, Default Occupancy Counts, for occupancy count requirements and guidance.

SCHOOLS

Bicycle Network

Design or locate the project such that a functional entry and/or bicycle storage is within a 200-yard (180-meter) walking distance or bicycling distance of a bicycle network that connects to at least one of the following:

- at least 10 diverse uses (see Appendix 1); or
- a bus rapid transit stop, light or heavy rail station, commuter rail station, or ferry terminal.

All destinations must be within a 3-mile (4800-meter) bicycling distance of the project boundary.

Provide dedicated bicycle lanes that extend at least to the end of the school property with no barriers (e.g., fences) on school property.

Planned bicycle trails or lanes may be counted if they are fully funded by the date of the certificate of occupancy and are scheduled for completion within one year of that date.

Bicycle Storage and Shower Rooms

Provide long-term bicycle storage for at least 5% of all regular building occupants (excluding students grade 3 and younger), but no fewer than four storage spaces per building.

Provide at least one on-site shower with changing facility for the first 100 regular building occupants (excluding students) and one additional shower for every 150 regular building occupants (excluding students) thereafter.

Long-term storage spaces must be easily accessible to occupants and be within 100 feet (30 meters) walking distance of any main entrance.

Bicycle storage capacity may not be double-counted: storage that is fully allocated to the occupants of nonproject facilities cannot also serve project occupants.

RETAIL

Bicycle Network

Design or locate the project such that a functional entry and/or bicycle storage is within a 200-yard (180-meter) walking distance or bicycling distance of a bicycle network that connects to at least one of the following:

- at least 10 diverse uses (see Appendix 1); or
- a bus rapid transit stop, light or heavy rail station, commuter rail station, or ferry terminal.

All destinations must be within a 3-mile (4800-meter) bicycling distance of the project boundary.

Planned bicycle trails or lanes may be counted if they are fully funded by the date of the certificate of occupancy and are scheduled for completion within one year of that date.

Bicycle Storage and Shower Rooms

Provide at least two short-term bicycle storage spaces for every 5,000 square feet (465 square meters), but no fewer than two storage spaces per building.

Provide long-term bicycle storage for at least 5% of regular building occupants, but no fewer than two storage spaces per building in addition to the short-term bicycle storage spaces.

Provide at least one on-site shower with changing facility for the first 100 regular building occupants and one additional shower for every 150 regular building occupants thereafter.

Short-term bicycle storage must be within 100 feet (30 meters) walking distance of any main entrance. Long-term bicycle storage must be within 100 feet (30 meters) walking distance of any functional entry.

Bicycle storage capacity may not be double-counted: storage that is fully allocated to the occupants of nonproject facilities cannot also serve project occupants.

Provide a bicycle maintenance program for employees or bicycle route assistance for employees and customers. Route assistance must be provided in a manner easily accessible to both employees and customers.

For projects that are part of a multitenant complex only: If bicycle storage spaces have been provided in the complex in which the project is located, determine the number of spaces that may be attributed to the project by dividing the project's floor area by the total floor area of the development (buildings only) and multiplying the percentage result by the total number of spaces. If this number does not meet the credit requirement, the project must provide additional bicycle storage.

HEALTHCARE

Bicycle Network

Design or locate the project such that a functional entry and/or bicycle storage is within a 200-yard (180-meter) walking distance or bicycling distance of a bicycle network that connects to at least one of the following:

- at least 10 diverse uses (see Appendix 1); or
- a bus rapid transit stop, light or heavy rail station, commuter rail station, or ferry terminal.

All destinations must be within a 3-mile (4800-meter) bicycling distance of the project boundary.

Planned bicycle trails or lanes may be counted if they are fully funded by the date of the certificate of occupancy and are scheduled for completion within one year of that date.

Bicycle Storage and Shower Rooms

Case 1. Commercial or Institutional Projects

Provide short-term bicycle storage for at least 2.5% of all peak visitors, but no fewer than four storage spaces per building.

Provide long-term bicycle storage for at least 5% of regular building occupants (excluding patients), but no fewer than four storage spaces per building in addition to the short-term bicycle storage spaces.

Provide at least one on-site shower with changing facility for the first 100 regular building occupants (excluding patients) and one additional shower for every 150 regular building occupants thereafter.

Case 2. Residential Projects

Provide secure, enclosed bicycle storage for at least 30% of all regular building occupants (excluding patients) measured at peak periods, but no less than one storage space per residential unit.

FOR ALL PROJECTS

Short-term bicycle storage must be within 100 feet (30 meters) walking distance of any main entrance. Long-term bicycle storage must be within 100 feet (30 meters) walking distance of any functional entry.

Bicycle storage capacity may not be double counted: storage that is fully allocated to the occupants of nonproject facilities cannot also serve project occupants.

BEHIND THE INTENT

Bicycling offers many individual and global benefits. For every mile (1 600 meters) pedaled rather than driven, nearly 1 pound (450 grams) of carbon dioxide (CO_2) emissions is avoided.[1] People who shift from car to bicycle use for short trips extend their lives by an estimated three to 14 months, gaining such health benefits as a lower risk of cardiovascular disease.[2] Planners and developers whose investments support bicycling as a transportation option often win political and popular support.[3]

To promote bicycle-friendly design, this credit rewards two things: the provision of long- and short-term bicycle storage, and access to a "bicycle network" (paths, trails, designated bike lanes, and slow-speed roadways). Short-term and long-term bicycle storage capacity is considered separately because visitors and regular occupants have different bicycle storage needs. For residential spaces, long-term storage must be provided in an area outside individual dwelling units, because having to carry a bicycle into a living space is inconvenient and discourages bicycle use. Finally, being adjacent to a bicycle network means that building occupants can more easily bicycle to and from the building. The route destinations emphasize the role of bicycles for travel to and from home, work, and errands, as well as to other transportation modes such as transit.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY BICYCLE NETWORK AND ELIGIBLE DESTINATIONS

Obtain or create a map of bicycle networks in the area surrounding potential project locations.

- Survey and map schools, employment centers, transit stops, and other eligible uses (Appendix 1).
- A "bicycle network" is defined to include, in any combination, demarcated bike lanes, bike trails, and streets with a maximum speed limit of 25 mph (40 kph). Both bike lanes and bike trails must meet the credit's width requirements.
- For differences in eligible destinations for specific project types, see *Further Explanation, Rating System Variations*.

STEP 2. SELECT BIKE-FRIENDLY PROJECT LOCATION

Locate the project close to an existing or planned bicycle network that meets credit requirements for uses within the specified distance from the project boundary (see Figure 1 and *LT Overview*, *Walking and Bicycling Distance*).

- The bicycle route connecting the project to the qualifying uses may include any combination of trails, bike lanes, and slow-speed streets, provided the total distance traveled is less than 3 miles (5 kilometers).
- For planned bicycle trails or lanes, confirm the schedule for funding and completion.

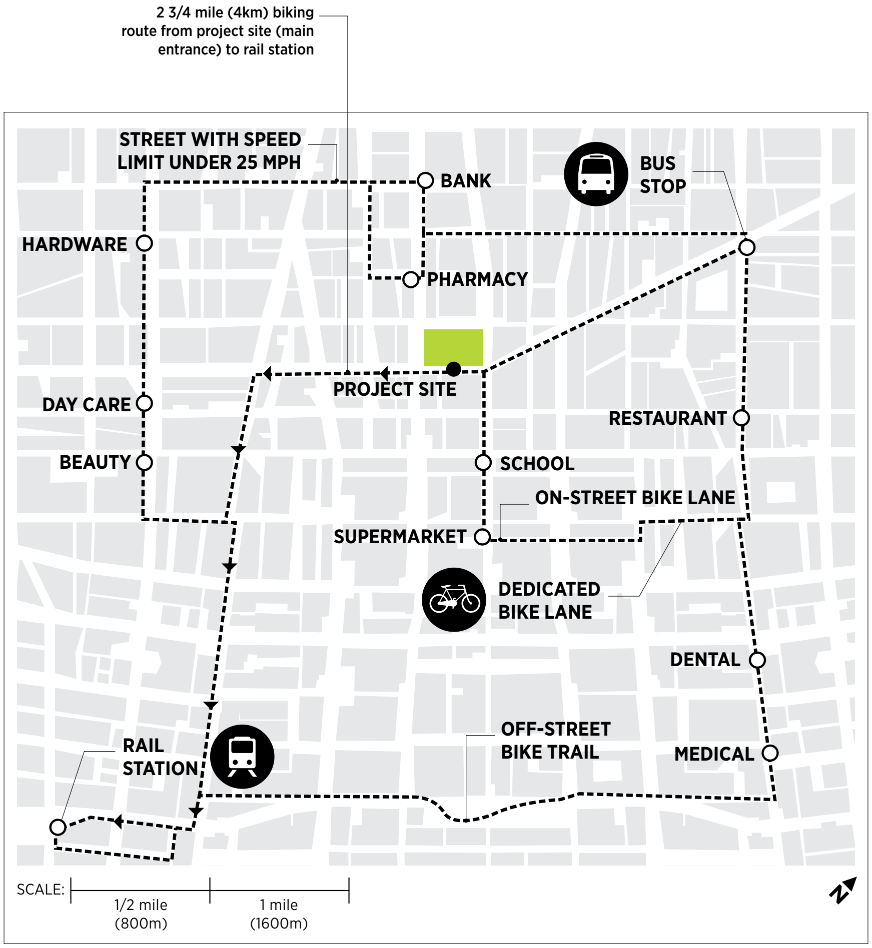
STEP 3. GATHER OCCUPANT COUNT INFORMATION

Determine the number of expected regular occupants in the building (see *Further Explanation, Rating System Variations*, and *Getting Started, Occupancy*, on which building users to include in calculations).

- For all rating systems except Schools and Retail, also determine the number of expected peak visitors.
- For mixed-use projects in all rating systems except Schools, Retail, and Healthcare, identify the project spaces as residential versus commercial or institutional and total the number of regular building occupants in each space type.

Projects with commercial-institutional space or residential space totaling less than 10% of the total building floor area may follow the requirements of the predominant use, at the discretion of the project team.

1. *U.S. Environmental Protection Agency, Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2012, epa.gov/OMSWWW/fetrends.htm#summary (accessed June 10, 2013).*
2. *de Hartog, J.J., H. Boogaard, H. Nijland, and G. Hoek, Do the Health Benefits of Cycling Outweigh the Risks? Environmental Health Perspectives 118(8) (2010).*
3. *Royal, D., and D. Miller-Steiger, National Survey of Bicyclist and Pedestrian Attitudes and Behavior (National Highway Traffic Safety Administration, 2008), nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/.../810972.pdf (accessed June 10, 2013).*



BASED ON DETROIT SCHOOL OF ARTS, DETROIT PUBLIC SCHOOLS / PREPARED BY GREENSPACE LLC

Figure 1. Example bicycle network

STEP 4. DETERMINE NUMBER OF BICYCLE STORAGE SPACES REQUIRED

Calculate the number of required short-term and long-term bicycle spaces, using the following equations. Ensure that the project design includes the minimum bicycle storage spaces specified in the credit requirements (see *Further Explanation, Rating System Variations*).

EQUATION 1. Short-term bicycle storage

Short-term bicycle storage = Peak visitors × 0.025

EQUATION 2. Commercial or institutional long-term bicycle storage (including Retail)

Long-term bicycle storage = Regular building occupants × 0.05

EQUATION 3. Residential long-term bicycle storage

Long-term bicycle storage = (Regular building occupants) x 0.30 OR (# of dwelling units), whichever is greater

EQUATION 4. Retail short-term bicycle storage

$$\text{Short-term bicycle storage} = (2 \times [\text{Building floor area (ft}^2\text{)}/ 5000])$$

OR

$$\text{Short-term bicycle storage} = (2 \times [\text{Building floor area (m}^2\text{)}/ 465])$$

- For all rating systems except Schools and Retail, calculate the number of required short-term and long-term bicycle spaces.
  - For commercial or institutional spaces in the project, follow Equations 1 and 2. At least four short-term storage spaces and four long-term spaces are required.
  - For residential spaces in the project, follow Equations 1 and 3. At least four short-term storage spaces are required per building, and at least one long-term storage space is required per dwelling unit.
- For Schools, calculate the number of required long-term bicycle spaces by following Equation 2 above. Short-term bicycle storage is not required.
- For Retail, calculate the number of required long-term (Equation 2) and short-term (Equation 4) bicycle spaces. Short-term bicycle storage is based on total building floor area.

The following conditions apply to all calculations for short- and long-term bicycle storage:

- Results must be rounded up to the nearest whole number.
- Storage spaces must be devoted to the project pursuing LEED certification and cannot be double-counted. For example, a project team may not count the storage of a nearby building toward its own storage requirements if that storage is already used by the other building's occupants. In addition, if any non-LEED project occupants have access to the storage, then either sufficient spaces must be provided for all occupants with access to amenities or the storage must be designated for the occupants of the LEED project only.
- For mixed-use buildings, identify nonresidential and residential portions of the building and meet the applicable storage requirements for each space type based on prorated occupancy (see *Further Explanation, Example, Mixed-Use Building*).

STEP 5. DETERMINE NUMBER OF SHOWER AND CHANGING FACILITIES REQUIRED

For all rating systems except Schools, use Equation 5 to determine the number of showers with changing facilities required and incorporate these facilities into the project design (see *Further Explanation, Rating System Variations*).

EQUATION 5. Shower facilities

$$\text{If regular building occupants} \leq 100, \text{ Shower facilities} = 1$$

$$\text{If regular building occupants} > 100, \text{ Shower facilities} = 1 + \frac{\text{Regular building occupants} - 100}{150}$$

- Results must be rounded up to the next whole number. For projects with 100 or fewer regular building occupants, only one shower is required.
- Showers are required for commercial or institutional spaces only. For residential spaces, no additional showers are required beyond those provided inside dwelling units.
- Projects with hotel guests may exclude these occupants from shower calculations.
- Shower facilities should be available to all project occupants without cost during the project's hours of operation.
- For mixed-use buildings, identify the nonresidential portions of the building and meet the applicable shower and changing facility requirements for this space type based on prorated occupancy (see *Further Explanation, Example, Mixed-Use Building*).

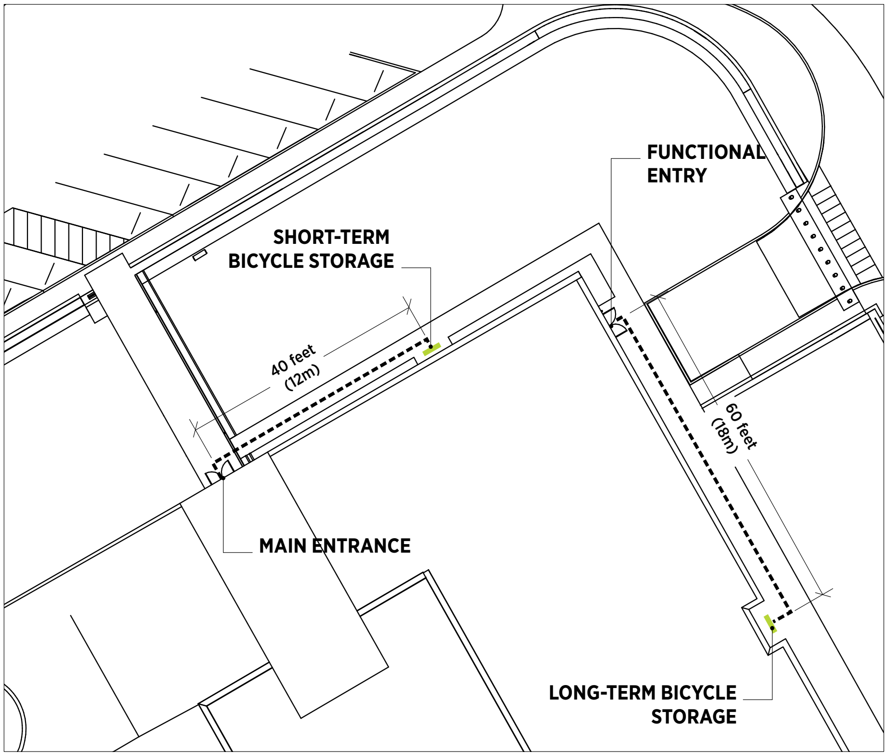


Figure 2. Example bicycle storage locations

STEP 6. INSTALL BICYCLE STORAGE

Locate bicycle storage to meet the credit requirements for the project's rating system. Both short-term and long-term storage facilities are more likely to be used if they are located in a well-lit, safe, and accessible area (see *Further Explanation, Selecting Bicycle Storage*).

- For all rating systems other than Schools, locate short-term and long-term storage within 100 feet (30 meters) of main and functional entrances, respectively.
- For Schools, locate long-term storage within 100 feet (30 meters) of a main entry to the project. Short-term storage is not required.

SCHOOLS

STEP 7. ENSURE SAFE ACCESS TO SCHOOL BUILDINGS

Provide on-site dedicated bicycle lanes that safely connect the edge of school property to school buildings.

RETAIL

STEP 7. INSTITUTE PROGRAMS TO SUPPORT BICYCLING USE

Implement a bicycle maintenance program for retail store employees or provide route assistance for both employees and customers. Consider the best way to promote the bicycling program to create and sustain participation.

- Examples of maintenance programs include coupons for yearly bicycle tune-ups for those who ride to work or on-site supplies for basic self-repairs (e.g., tire pumps, patch kits, basic tools).
- Examples of route assistance include a map identifying bicycle routes to the project site, posted online and in a location on the property that is easily accessible to employees and customers.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

SELECTING BICYCLE STORAGE

Bicycle racks should reflect best practices in design and installation. For example, the rack should support the bicycle in at least two places, to keep it from falling over, and allow the owner to lock both the bicycle frame and one or both wheels with a U-lock. The rack must be securely anchored and resistant to cutting, rusting, bending, and other deformation.

EXAMPLES

Example 1. Large retail building

A 30,000-square-foot (2 800 square-meter) retail building project pursuing Retail has met the bicycle network requirement by being within 3 miles' (5 kilometers') bicycling distance of 10 diverse uses on a bicycle network. The building will have 31 full-time employees plus 18 part-time employees who each work 20 hours per week. To determine the number of bicycle storage and shower and changing facilities required, the team calculates regular building occupants for the building (see *Getting Started, Occupancy*):

$$\text{31 full-time employees} + \frac{\text{(18 part-time employees} \times \text{4 hours per day)}}{\text{8 hours per day}} = \text{40 regular building occupants}$$

The team uses Equation 4 to determine the number of short-term bicycle storage spaces:

$$2 \times [30{,}000 \text{ ft}^2 \; / \; 5{,}000] = 12 \text{ spaces}$$

Equation 2 yields the number of long-term bicycle storage spaces:

$$\text{40 regular building occupants} \times 0.05 = 2 \text{ spaces}$$

Because the project has fewer than 100 regular building occupants, only one shower is required.

Example 2. Residential apartment building

An 80-unit apartment building has 200 residents, no employees, and 150 peak visitors. The building meets the bicycle network requirement by being adjacent to an existing 2.5-mile (4-kilometer) bicycle network that connects to a school and a jobs center. The team uses Equation 1 to determine number of short-term bicycle storage facilities required:

$$\text{150 visitors} \times 0.025 = \text{3.75, rounded to 4 spaces}$$

Equation 3 determines the number of long-term bicycle storage spaces:

$$\text{200 residents} \times 0.30 = 60 \text{ spaces}$$

That result is less than one space for each of the 80 units (80 spaces), however. The credit requires that the project use the greater of the two results, so the team installs 80 long-term storage spaces in addition to the four short-term storage spaces.

Example 3. Mixed-use building with residential, commercial, and retail

A 500,000-square-foot (46 500-square-meter) mixed-use building pursuing BD+C: New Construction includes retail, office, and residential space. The retail component consists of 50,000 square feet (4 650 square meters) and has 10 employees and 30 peak visitors. The office component has 92 regular building occupants with 10 peak visitors. The residential component includes 15 units and has 20 residents with 15 peak visitors. The building meets the bicycle network requirement by being adjacent to an existing 4-mile (6-kilometer) bicycle network that connects to 15 diverse uses within 3 miles' (5 kilometers') bicycling distance of the project boundary.

The project team uses Equation 5 to determine the required number of shower facilities for the nonresidential portion of the building. Following this equation, at least one shower is needed for up to 100 regular building occupants, a second shower is needed from 100 to 250 regular building occupants, and so on. The aggregate nonresidential space in this building has a total of 102 regular building occupants, so two showers are required. These showers are placed so that they are accessible to both retail and office occupants.

The team then uses Equations 1 and 2 to determine short- and long-term bicycle storage spaces for the nonresidential portion of the building:

30 + 10 peak visitors = 40 peak visitors × 0.025 = 1 short-term space

102 regular building occupants × 0.05 = 5.1, rounded to 6 long-term spaces

Equations 1 and 3 determine the number of short- and long-term bicycle storage spaces for the residential portion of the building:

15 peak visitors × 0.025 = 0.375, rounded to 1 short-term space

20 residents × 0.30 = 6 long-term spaces

That result is less than one space for each of the 15 units (15 spaces), however. The credit requires that the project use the greater of the two results, so the team installs 15 long-term storage spaces.

The number of short-term bicycle storage totals two spaces, which is less than the minimum four required for this rating system. Four short-term bicycle storage spaces are installed 80 feet (24 meters) from the main building entrance. Long-term bicycle storage totals 21 spaces and is placed in the parking garage within 100 feet (30 meters) of an entrance to the building.

RATING SYSTEM VARIATIONS

New Construction, Core and Shell, Data Centers, Warehouses and Distribution Centers, Hospitality
At least four short-term and four long-term spaces are required.

Schools
At least four long-term spaces are required; short-term bicycle storage is not required. Regular building occupant calculations for long-term bicycle storage include staff and all full-time students in grade 4 and above (or a local equivalent class year for students aged 10 and older).

Regular building occupant calculations for shower facilities do not include students.

Employment centers and other schools are not qualifying bicycle network destinations.

Bicycle lanes from the school property entrance to school building entrances are required.

Retail
At least two short-term and two long-term spaces are required. Short-term spaces are based on building floor area, per Equation 4.

Regular building occupant calculations include employees only.

Employment centers are not a qualifying bicycle network destination.

A bicycle maintenance or route assistance program is required.

Healthcare
At least four short-term and four long-term spaces are required.

Residential spaces with nonbicycling occupants (e.g., assisted living facilities) may exclude a specified number of occupants from the bicycle storage requirement calculation, provided the team demonstrates that these occupants are physically incapable of bicycling.

Employment centers and schools are not qualifying bicycle network destinations.

INTERNATIONAL TIPS

Bike Path Width
European projects located in historic urban centers may be exempted from bike path width requirements on routes where the requirements cannot be met due to space constraints. Additionally, the bicycle network definition is expanded to include additional criteria on these routes.

CAMPUS

Group Approach
All buildings in the group may be documented as one. Measure distances from the farthest building.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	New Construction, Core and Shell, Data Centers, Warehouses and Distribution Centers, Hospitality, Healthcare	Schools	Retail
Vicinity map showing bicycle network and route and distance along network to eligible destination(s). For planned bicycle networks, capital improvement plan demonstrating completion within one year of certificate of occupancy.	X	X	X
Site plan showing bicycle storage locations	X		X
Site plan showing bicycle storage location with walking route to main entrance and bicycling route to school boundary		X	
Calculations for storage and shower facilities	X	X	X
Description of programs to support bicycle use			X

RELATED CREDIT TIPS

LT Credit Surrounding Density and Diverse Uses. A project in close proximity to 10 diverse uses under the related credit may apply those uses to the requirements for this credit, provided they are located on a bicycle network that meets this credit's requirements.

CHANGES FROM LEED 2009

- Requirements for proximity to a bicycle network have been added.
- Separate short- and long-term bicycle storage requirements have been created.
- The shower room calculation method has changed.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

bicycling distance the distance that a bicyclist must travel between origins and destinations, the entirety of which must be on a bicycle network

bicycle network a continuous network consisting of any combination of the following:

- off-street bicycle paths or trails at least 8 feet (2.5 meters) wide for a two-way path and at least 5 feet (1.5 meters) wide for a one-way path
- physically designated on-street bicycle lanes at least 5 feet (1.5 meters) wide
- designed for a target speed of 25 mph (40 km/h) or less

bus rapid transit an enhanced bus system that operates on exclusive bus lanes or other transit rights-of-way. The system is designed to combine the flexibility of buses with the efficiency of rail.

diverse use a distinct business or organization that provides goods or services intended to meet daily needs and is publicly available. Automated facilities such as ATMs or vending machines are not included. For a full list, see the Appendix.

employment center a nonresidential area of at least 5 acres (2 hectares) with a job density of at least 50 employees per net acre (at least 125 employees per hectare net)

functional entry a building opening designed to be used by pedestrians and open during regular business hours. It does not include any door exclusively designated as an emergency exit, or a garage door not designed as a pedestrian entrance.

light rail transit service using two- or three-car trains in a right-of-way that is often separated from other traffic modes. Spacing between stations tends to be 1/2 mile (800 meters) or more, and maximum operating speeds are typically 40–55 mph (65–90 kmh). Light-rail corridors typically extend 10 or more miles (16 kilometers).

long-term bicycle storage bicycle parking that is easily accessible to residents and employees and covered to protect bicycles from rain and snow

short-term bicycle storage non-enclosed bicycle parking typically used by visitors for a period of two hours or less

walking distance the distance that a pedestrian must travel between origins and destinations without obstruction, in a safe and comfortable environment on a continuous network of sidewalks, all weather-surface footpaths, crosswalks, or equivalent pedestrian facilities. The walking distance must be drawn from an entrance that is accessible to all building users.

LOCATION AND TRANSPORTATION CREDIT

Reduced Parking Footprint

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Retail (1 point)
Healthcare (1 point)

INTENT

To minimize the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff.

REQUIREMENTS

Do not exceed the minimum local code requirements for parking capacity.

Provide parking capacity that is a percentage reduction below the base ratios recommended by the Parking Consultants Council, as shown in the Institute of Transportation Engineers' Transportation Planning Handbook, 3rd edition, Tables 18-2 through 18-4.

Case 1. Baseline Location

Projects that have not earned points under LT Credit Surrounding Density and Diverse Uses or LT Credit Access to Quality Transit must achieve a 20% reduction from the base ratios.

Case 2. Dense and/or Transit-Served Location

Projects earning 1 or more points under either LT Credit Surrounding Density and Diverse Uses or LT Credit Access to Quality Transit must achieve a 40% reduction from the base ratios.

FOR ALL PROJECTS

The credit calculations must include all existing and new off-street parking spaces that are leased or owned by the project, including parking that is outside the project boundary but is used by the project. On-street parking in public rights-of-way is excluded from these calculations.

For projects that use pooled parking, calculate compliance using the project's share of the pooled parking.

Provide preferred parking for carpools for 5% of the total parking spaces after reductions are made from the base ratios. Preferred parking is not required if no off-street parking is provided.

Mixed-use projects should determine the percentage reduction by first aggregating the parking amount of each use (as specified by the base ratios) and then determining the percentage reduction from the aggregated parking amount.

Do not count parking spaces for fleet and inventory vehicles unless these vehicles are regularly used by employees for commuting as well as business purposes.

BEHIND THE INTENT

Inefficient parking systems result in increased congestion and carbon emissions, lost productivity and economic opportunities, and unnecessary paved areas. For example, the United States has roughly two to three times more parking spaces than people. Parking lots' concrete and asphalt cover approximately 2,000 to 6,000 square miles (5 180 to 15 000 square kilometers)[1,2,3] comprising about 35% of the surface area in the average U.S. residential neighborhood and 50% to 70% of the average nonresidential area.[4]

The impervious surface of most parking spaces has environmental and financial downsides. Runoff from impervious surfaces can overwhelm municipal stormwater systems and flushes contaminants into waterways. Dark-colored parking lot surfaces trap heat, raising ambient air temperatures, which in turn necessitate more energy for cooling. Parking is also expensive, costing landowners and developers an average of about $15,000 per space in the U.S.[5]

Parking demand can be reduced by locating projects in high-density, mixed-use areas or in places well served by transit, or by instituting transportation demand management strategies, such as providing preferred parking for carpools. To complement the use of these alternative modes or vehicle-sharing arrangements, vehicular parking itself can be limited by designing fewer spaces. This credit uses the Transportation Planning Handbook base ratios as a baseline against which reductions in parking supply can be compared. When combined with a requirement to provide no more parking than is necessary by code, this baseline ensures that meaningful reductions are achieved.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE LOCAL CODE REQUIREMENTS

Identify the minimum amount of parking required by local code. Confirm that the project's maximum allowable parking is less than or equal to minimum code requirements.

- In some cases, local codes do not establish minimum thresholds. Projects located in areas without a code minimum automatically meet this requirement.
- Projects with no associated off-street parking automatically achieve credit compliance; no calculations or preferred parking spaces are required.

STEP 2. CALCULATE BASE RATIOS AND BASELINE PARKING CAPACITY

Based on the project's space use type(s) and size, determine the parking capacity base ratio using the Transportation Planning Handbook (see *Further Explanation, Base Ratios*).

For projects with multiple space types, calculate and separately track the base ratio for each use. Use the equations provided in the reference table to determine the baseline parking capacity for each space type, and compute the total project baseline capacity.

STEP 3. IDENTIFY APPROPRIATE CASE

Case 2 is appropriate for projects that expect to earn at least 1 point in either LT Credit Surrounding Density and Diverse Uses or LT Credit Access to Quality Transportation. Otherwise, use Case 1.

1. *Chester, Mikhail, Arpad Horvath, and Samer Madanat, Parking Infrastructure: Energy, Emissions, and Automobile Life-Cycle Environmental Accounting, Environmental Research Letters 5(3) (2010), dx.doi.org/10.1088/1748-9326/5/3/034001 (accessed June 10, 2013).*
2. *Ben-Joseph, Eran, ReThinking a Lot: The Design and Culture of Parking (Cambridge, MA: MIT Press, 2012).*
3. *Delucchi, Mark, Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990–1991, vol. 6 (Institute of Transport Studies, 1997), Table 6-A.1, its.ucdavis.edu/?page_id=10063&pub_id=571 (accessed June 10, 2013).*
4. *Akbari, Hashem, L. Shea Rose, and Haider Taha, Analyzing the Land Cover of an Urban Environment Using High-Resolution Orthophotos, Landscape and Urban Planning 63(1) (2003): 1–14, sciencedirect.com/science/journal/01692046 (accessed June 10, 2013).*
5. *Victoria Transportation Policy Institute, Transportation Cost and Benefit Analysis II: Parking Costs (2012), Table 5.4.3-1, vtpi.org/tca/tca0504.pdf (accessed June 10, 2013).*

STEP 4. ESTIMATE PARKING DEMAND

Estimate how many cars are likely to drive to and from the project, and determine whether this number is less than the local code minimum and the capacity calculated from the base ratios.

The Institute of Transportation Engineers' Trip Generation Handbook provides estimates for the number of car trips generated by building type.

STEP 5. DEVELOP AND IMPLEMENT STRATEGIES TO REDUCE PARKING DEMAND

Design the project to reduce parking demand. Consider both new and existing parking. Based on estimated demand, if significant reductions are likely to be necessary, consider implementing multiple strategies for a cumulative effect.

- Choose a project site that maximizes the opportunities for building occupants to travel via transit, walking, bicycle, and other modes that reduce off-street parking demand.
- Integrate transportation demand management (TDM) strategies to reduce parking demand (see *Further Explanation, TDM Strategies)*.

Incorporate the selected strategies into the project design.

- Projects that do not provide additional parking must meet the credit requirements for the existing parking.
- If the project's parking capacity falls below the local code minimum design thresholds, work with the municipality to secure zoning variances. Referencing the requirements of this LEED credit may prove helpful in discussion with local governments.

STEP 6. DETERMINE PROJECT'S REDUCED PARKING CAPACITY

Compute the project's total parking capacity, including both new and existing spaces, and ensure that it does not exceed the local code minimum.

- Use Equation 1 to determine whether the project complies with the credit requirements for the appropriate case, based on the designed capacity and the baseline capacity determined using the base ratio method for each space type (see *Further Explanation, Example*).
- If the project type does not fit any base ratio category or if the tenant is not yet known, select the best approximation and provide a narrative justifying this selection.

EQUATION 1. Percentage of parking capacity reduction

$$\text{Parking reduction} = (\text{Total baseline capacity} - \text{Total provided capacity}) / \text{Total baseline capacity} \times 100$$

- Include pooled parking used by the project building (as a proportionate share of total pooled parking; see *LT Overview, Total Vehicle Parking Capacity*) and any parking used by the project both inside and outside the project boundary, as indicated in the credit requirements.
- Exclude fleet and inventory vehicles and parking in public rights-of-way, as indicated in the credit requirements.

STEP 7. PROVIDE CARPOOL PARKING

Based on the project's reduced parking capacity design, reserve at least 5% as preferred parking for carpools (see *LT Overview, Preferred Parking*).

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

BASE RATIOS

TABLE 1. Base ratios for parking spaces, by building type

Use	Size or condition	Parking spaces
Arena		0.33/seat
Assisted living		0.35/DU
Boarding house, B&B, convent, and other sleeping rooms		1/unit or room plus 2 for owner and staff
Church		0.4/seat
College, university	School population: students, faculty and staff	0.4/school population
Condo, townhouse		Use Owned Apartment ratios
Consumer services (including banks)		4.6/1,000 ft² (5.0/100 m²)
Convention centers not in hotel, or in hotel but exceeding 50 ft² per guest room (4.65 m² per guest room)	< 25,000 ft² (2 325 m²)	30/1,000 ft² (32.29/100 m²)
Convention centers not in hotel, or in hotel but exceeding 50 ft² per guest room (4.65 m² per guest room)	25,000 ft² to 50,000 ft² (2 325 m² to 4 650 m²)	Scaled If x is ft², 30-[10 x (x-25,000)/25,000] spaces per 1,000 ft² If y is m² per room, 32.3-[10.8 x (y-2325)/2325] spaces per 100 m² GLA
Convention centers not in hotel, or in hotel but exceeding 50 ft² per guest room (4.65 m² per guest room)	50,000 ft² to 100,000 ft² (4 650 to 9 300 m²)	Scaled If x is ft², 20-(10 x (x-50,000)/50,000) spaces per 1,000 ft² If y is m² per room, 10.8-[10.8 x (y-4650)/4650] spaces per 100 m² GLA
Convention centers not in hotel, or in hotel but exceeding 50 ft² per guest room (4.65 m² per guest room)	100,000 to 250,000 ft² (9 300 to 23 225 m²)	Scaled If x is ft², 10-(4 x (x-100,000)/150,000) spaces per 1,000 ft² If y is m² per room, 10.8-[4.3 x (y-9300)/13 925] spaces per 100 m² GLA
Convention centers not in hotel, or in hotel but exceeding 50 ft per guest room (4.65 m per guest room)	More than 250,000 ft² (23 225 m²)	6/1,000 ft² (6.5/100 m²)
Data processing, telemarketing		6.0/1,000 ft² (6.5/100 m²)
Day care		0.3/licensed student
Dry cleaners		Use General and Convenience Retail ratio
Elderly housing		0.5/DU
Elementary school		Higher of 0.2/auditorium or gym seat, or 0.25/student
Fast food	With or without drive-through	15/1,000 ft² (16/100 m²)
Free-standing discount super store		5.5/1,000 ft² (5.92/100 m²), including outdoor sales areas
General and convenience retail	Not in shopping center	2.75/1,000 ft² (2.96/100 m²)
General light industrial, industrial park, and manufacturing		1.85/1,000 ft² (1.99/100 m²)
Government office building		Use Office Building radio if general office only; otherwise, parking study prepared for complex
Health, fitness club		7/1,000 ft² (7.5/100 m²)

TABLE 1 (CONTINUED). Base ratios for parking spaces, by building type		
Use	**Size or condition**	**Parking spaces**
Heavy, hard goods, furniture store, carpet store		2.5/1,000 ft² (2.7/100 m²)
High school		Higher of 0.3/auditorium or gym seat, or 0.3/student
High-turnover restaurant	No bar	15/1,000 ft² (16/100 m²)
High-turnover restaurant	With bar	20/1,000 ft² (21.5/100 m²)
Hospital		1.1/employee
Hotel, motel		1.25/room. Add 10/1,000 ft² (10.8/100 m²) for lounge/restaurant. Add conference/banquet at following rates: 1. < 20 ft²/room (1.86 m²/room): none 2. 20 ft²/room (1.86 m²/room) to 50 ft²/room (4.65 m²/room): Scaled If x is ft² per room, 30-[10 x (x-20)/30] spaces per 1,000 ft² GLA conference banquet. If y is m² per room, 32.3-[10.8 x (y-1.86)/2.79] spaces per 100 m² GLA conference banquet 3. > 50 ft²/room (4.65 m²/room): 20/1,000 ft² (21.5/100 m²)
Junior or community college	School population: students, faculty and staff	0.25/school population
Live theater		0.4/seat
Medical, dental office building	Not on hospital campus	4.5/1,000 ft² (4.8/100 m²)
Medical, dental office building	On hospital campus	4/1,000 ft² (4.3/100 m²)
Mini-warehouse		1.75/100 units
Movie theater with matinee	1 screen	0.5/seat
Movie theater with matinee	2 to 5 screens	0.33/seat
Movie theater with matinee	5 to 10 screens	0.3/seat
Movie theater with matinee	More than 10 screens	0.27/seat
Nightclub		19/1,000 ft² (20.5/100 m²)
Nursing home		0.5/bed
Office building	< 25,000 ft² (2 325 m²)	3.8/1,000 ft² (4.1/100 m²)
Office building	25,000 to 100,000 ft² (2 325 to 9 300 m²)	Scaled If x is ft², 3.8-[0.4 x (x-25,000)/75,000] spaces per 1,000 ft² If y is m², 4.1-[0.43 x (y-2325)/6975] spaces per 100 m²
Office building	100,000 ft² (9 300 m²)	3.4/1,000 ft² (3.67/100 m²)
Office building	100,000 to 500,000 ft² (9 300 to 46 500 m²)	Scaled If x is ft²: 3.4-[0.6 x (x-100,000)/400,000] spaces per 1,000 ft² If y is m²: 3.67-[0.67 x (y-9300)/37 200] spaces per 100 m²
Office building	More than 500,000 ft² (more than 46 500 m²)	2.8/1,000 ft² (3.0/100 m²)
Other public assembly		0.25/person in permitted capacity where not seated, or 0.3/seat where seated
Owned accessory dwelling unit		1/Accessory DU. Den must be counted as bedroom if it has closet. Ratios include 0.15 space per unit for visitors.

TABLE 1 (CONTINUED). Base ratios for parking spaces, by building type

Use	Size or condition	Parking spaces
Owned apartment	Efficiency	1/DU for efficiency units. Den must be counted as bedroom if it has closet. Ratios include 0.15 space per unit for visitors.
Owned apartment	With bedroom	1.75/DU for first bedroom plus 0.25 space for each additional bedroom. Den must be counted as bedroom if it has closet. Ratios include 0.15 space per unit for visitors.
Pharmacy	With or without drive-through	Use General and Convenience Retail ratio
Pro baseball stadium		0.35/seat
Pro football stadium		0.31/seat
Quality restaurant		20/1,000 ft² (21.5/100 m²)
Rental apartment	Efficiency	1/DU for efficiency units. Den must be counted as bedroom if it has closet. Ratios include 0.15 space per unit for visitors.
Rental apartment	With bedroom	1.5/DU for first bedroom plus 0.25 space for each additional bedroom. Den must be counted as bedroom if it has closet. Ratios include 0.15 space per unit for visitors.
Rental apartment	In college or university housing district	1/DU for efficiency and 1 bedroom units plus 0.5 space for each additional bedroom. Den must be counted as bedroom if it has closet. Ratios include 0.15 space per unit for visitors.
Shopping center, not more than 10% GLA in nonretail uses	< 400,000 ft² (37 200 m²) GLA	4/1,000 ft² (4.3/100 m²)
Shopping center, not more than 10% GLA in nonretail uses	400,000 to 600,000 ft2 (37 200 m² to 55 750 m²) GLA	Scaled: If x is ft², 4+[0.5 x (x-400,000)/200,000] spaces per 1,000 ft² If y is m², 4.3+[0.5 x (y-37 200)/18 550] spaces per 100 m²
Shopping center, not more than 10% GLA in nonretail uses	More than 600,000 ft² (55 750 m²) GLA	4.5/1,000 ft² (4.8/100 m²)
Shopping center, more than 10% GLA in other uses		Shared parking analysis
Single-family detached residential	< 2000 ft2 (186 m²)	1/DU
Single-family detached residential	2,000 to 3,000 ft² (186 to 279 m²)	2/DU
Single-family detached residential	More than 3,000 ft² (280 m²)	3/DU
Specialty super stores, home improvement		4.5/1,000 ft² (4.8/100 m²), including outdoor sales areas
Supermarket, convenience market		6.75/1,000 ft² (7.3/100 m²)
Video rental		Use General and Convenience Retail ratio
Warehousing		0.67/1,000 ft² (0.72/100 m²)

DU = dwelling unit

GLA = gross leasable area

Adapted from PCC Recommended Zoning Ordinance Provisions (2006), by Parking Consultants Council (PCC), National Parking Association, published by Institute of Transportation Engineers, Transportation Planning Handbook, 3rd edition, Tables 18-2 through 18-4. Use authorized by the Institute of Transportation Engineers,1627 I Street, NW, Suite 600, Washington, DC 20006 www.ite.org

TRANSPORTATION DEMAND MANAGEMENT STRATEGIES

Examples of transportation demand management strategies include the following.

- **Telecommuting.** Allow employees to work remotely on certain days.
- **Shuttles.** Provide shuttle service between transit stops and/or commercial and residential centers. Although shuttles can help reduce parking demand, they cannot be used to earn LT Credit Access to Quality Transit.
- **Shared parking between uses.** Size the parking supply so that surrounding uses with different peak occupancies can all use the parking. For example, a commercial office with daytime peak occupancy can share its parking supply with an adjacent movie theater with evening peak occupancy. Doing so will ensure that the parking is maximized throughout the day.
- **Residential units rented or sold separately from parking.** Conventionally, a dwelling unit's rent or for-sale price includes one or more parking spaces. Instead, rent or sell parking separately so that occupants internalize the cost of parking and those without automobiles can opt not to have parking spaces.
- **Transit subsidy.** Provide building occupants with a subsidy to help pay for transit trips.
- **Compressed workweek schedule.** Structure employees' schedules such that some work longer days in exchange for not working on a particular day every one to three weeks.

EXAMPLE

A 50-unit rental student housing project with one-bedroom apartments is adjacent to a university and within walking distance of a high-frequency light rail line, earning 1 point under LT Credit Access to Quality Transit. The project narrowly missed achieving LT Credit Surrounding Density and Diverse Uses because of a lack of nearby neighborhood uses, but it still must comply with Case 2, since it achieved LT Credit Access to Quality Transit.

Table 1 indicates a baseline of one parking space per dwelling unit for rental apartments in a university housing district, creating a baseline of 50 parking spaces for the project. To comply with the Case 2 requirements, the project needs to provide no more than 30 spaces (a 40% reduction from 50 baseline spaces).

The project reduces overall parking demand by advertising for student residents without cars, providing secure bicycle storage, leasing parking spaces separately from dwelling units; the team has already chosen a location within walking distance to transit and the university that most of its residents attend.

The project secures 15 spaces on one level of an adjacent, off-site, multilevel parking garage that can be leased and used by project occupants, and provides no other parking. This parking reduction of 70% earns the credit under Case 2.

The project also ensures that one of the 15 spaces is preferred parking for carpool use, exceeding the required 5% minimum.

PROJECT TYPE VARIATIONS

Military Installations

Parking for ranking officials may be separated from regular parking, but the proportion of preferred parking for carpools must be applied to each pool of parking.

Separated Employee or Visitor Parking

Projects with separate parking areas for visitors, employees, or students must apply the proportion of preferred parking for carpools to each pool of parking.

INTERNATIONAL TIPS

Preferred Parking for Carpools and Shared-Use Vehicles

For European projects pursuing Case 2, provide preferred parking for carpool or shared-use vehicles for 5% of the total parking spaces after reductions are made from the base ratios. Preferred parking is not required if no off-street parking is provided.

Discounted Parking Rate

For projects pursuing Case 2 which will require payment for parking, a discounted parking rate of at least 20% for carpool vehicles is an acceptable substitute for preferred parking spaces.

CAMPUS

Group Approach
All buildings in the group may be documented as one. All the parking located within the LEED project boundary must be included in the calculations. Submit a site plan that illustrates a reasonable distribution of preferred parking spaces for the buildings or spaces seeking LEED certification.

Campus Approach
Eligible. All the parking located within the LEED campus boundary must be included in the calculations (including parking associated with projects that are not pursuing LEED certification). Submit a site plan that illustrates a reasonable distribution of preferred parking spaces for the projects seeking LEED certification.

REQUIRED DOCUMENTATION

Documentation	All Projects
Site plan indicating parking areas and preferred parking spaces	X
Calculations demonstrating threshold achievement	X
Drawings or photographs of signage or pavement markings indicating reserved status of preferred parking areas	X

RELATED CREDIT TIPS

LT Credit Surrounding Density and Diverse Uses. Projects that earn the related credit are required to further reduce parking to achieve this credit.

LT Credit Access to Quality Transit. Projects that earn the related credit are required to further reduce parking to achieve this credit.

LT Credit Green Vehicles. Reducing the total amount of parking in the project by achieving this credit will result in fewer required total spaces allocated to green vehicles under the related credit. Project teams may choose to aggregate or separately reserve the preferred parking for carpools and green vehicles. If aggregated, the total supply must meet the thresholds for both carpools and green vehicles and be closest to a functional entry (exclusive of spaces designated for disabled persons). If separated, both carpool and green vehicle parking should be in preferred locations (e.g., on either side of a functional entry such that both are closest, excluding parking for the disabled). If this arrangement is not feasible, preferred parking for one vehicle type may be located between the other preferred parking and the functional entry.

CHANGES FROM LEED 2009

- The requirements are now the same for nonresidential and residential, and for New Construction and Core and Shell.
- A baseline reference to a third-party standard (ITE Transportation Planning Handbook, 3rd edition, Tables 18-2 through 18-4) has been added.
- The credit is no longer awarded for providing no new parking. If there is existing parking that will continue to be used by the project, it must also comply with credit requirements.

REFERENCED STANDARDS

Institute of Transportation Engineers, Transportation Planning Handbook, 3rd edition, Tables 18-2 through 18-4: ite.org

EXEMPLARY PERFORMANCE

Case 1. Achieve a 40% parking reduction from the base ratios.

Case 2. Achieve a 60% parking reduction from the base ratios.

DEFINITIONS

preferred parking the parking spots closest to the main entrance of a building (exclusive of spaces designated for handicapped persons). For employee parking, it refers to the spots that are closest to the entrance used by employees.

LOCATION AND TRANSPORTATION CREDIT

Green Vehicles

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Data Centers (1 point)
Hospitality (1 point)
Retail (1 point)
Healthcare (1 point)
Schools (1 point)
Warehouses and Distribution Centers (1 point)

INTENT

To reduce pollution by promoting alternatives to conventionally fueled automobiles.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, DATA CENTERS, HOSPITALITY, RETAIL, HEALTHCARE

Designate 5% of all parking spaces used by the project as preferred parking for green vehicles. Clearly identify and enforce for sole use by green vehicles. Distribute preferred parking spaces proportionally among various parking sections (e.g. between short-term and long-term spaces).

Green vehicles must achieve a minimum green score of 45 on the American Council for an Energy Efficient Economy (ACEEE) annual vehicle rating guide (or local equivalent for projects outside the U.S.).

A discounted parking rate of at least 20% for green vehicles is an acceptable substitute for preferred parking spaces. The discounted rate must be publicly posted at the entrance of the parking area and permanently available to every qualifying vehicle.

In addition to preferred parking for green vehicles, meet one of the following two options for alternative-fuel fueling stations:

OPTION 1. ELECTRIC VEHICLE CHARGING

Install electrical vehicle supply equipment (EVSE) in 2% of all parking spaces used by the project. Clearly identify and reserve these spaces for the sole use by plug-in electric vehicles. EVSE parking spaces must be provided in addition to preferred parking spaces for green vehicles.

The EVSE must:

- Provide a Level 2 charging capacity (208 – 240 volts) or greater.
- Comply with the relevant regional or local standard for electrical connectors, such as SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler or IEC 62196 of the International Electrotechnical Commission for projects outside the U.S.
- Be networked or internet addressable and be capable of participating in a demand-response program or time-of-use pricing to encourage off-peak charging.

OR

OPTION 2. LIQUID, GAS, OR BATTERY FACILITIES

Install liquid or gas alternative fuel fueling facilities or a battery switching station capable of refueling a number of vehicles per day equal to at least 2% of all parking spaces.

SCHOOLS

OPTION 1. GREEN PASSENGER VEHICLES

Designate 5% of all parking spaces used by the project as preferred parking for green vehicles. Clearly identify and enforce for sole use by green vehicles. Distribute preferred parking spaces proportionally among various parking sections (e.g. between short-term and long-term spaces).

Green vehicles must achieve a minimum green score of 45 on the American Council for an Energy Efficient Economy (ACEEE) annual vehicle rating guide (or local equivalent for projects outside the U.S.)

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- Be networked or internet addressable and be capable of participating in a demand-response program or time-of-use pricing to encourage off-peak charging.

OR

Path 2. Liquid, gas, or battery facilities

Install liquid or gas alternative fuel fueling facilities or a battery switching station capable of refueling a number of vehicles per day equal to at least 2% of all parking spaces.

OR

OPTION 2. GREEN BUSES AND SCHOOL-OWNED VEHICLES

Develop and implement a plan for every bus serving the school to meet the following emissions standards within seven years of the building certificate of occupancy:

- nitrogen oxide (NO_x) emissions of 0.50 grams or less per brake horsepower-hour; and
- particulate matter emissions of 0.01 grams or less per brake horsepower-hour.

Emission standards must be met for each bus and not by an average of the entire fleet serving the school.

Develop and implement a plan for 100% of all other (non-bus) vehicles owned or leased to serve the school to be green vehicles. Green vehicles must achieve a minimum green score of 45 on the American Council for an Energy Efficient Economy (ACEEE) annual vehicle rating guide (or local equivalent for projects outside the U.S).

WAREHOUSES AND DISTRIBUTION CENTERS

OPTION 1. ALTERNATIVE-FUEL VEHICLES (1 POINT)

Provide an on-site fleet with at least one yard tractor that is powered by electricity, propane, or natural gas. Provide on-site charging or refueling stations for the vehicles. Liquid or gas refueling stations must be separately ventilated or located outdoors.

OR

OPTION 2. REDUCED TRUCK IDLING (1 POINT)

Provide an electrical connection for at least 50% of all dock door locations to limit truck idling at the dock.

BEHIND THE INTENT

In 2010, transportation accounted for 27% of the total U.S. greenhouse gas emissions from combustion of petroleum-based fuels. More than half of those emissions came from passenger vehicles and light-duty trucks.[1] Globally, greenhouse gas emissions from transportation increased 17.5% from 1990 to 2010.[2]

Beyond climate change effects, conventional-fuel vehicles pose public health risks. Diesel exhaust from idling buses releases fine particulates, which can be especially harmful for children.[3] Idling delivery trucks at warehouse loading docks and diesel-powered yard tractors used to move cargo containers[4] emit nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM).

This credit addresses vehicle emissions by rewarding local and regional infrastructure that incentivizes the purchase of green vehicles. The provision of preferred parking spaces closest to a building's entrance rewards building users who drive green vehicles. To qualify for these spaces, green vehicles must meet third-party standards that comprehensively measure both fuel efficiency and emissions. Projects must also provide infrastructure (e.g., electric charging stations) for alternative-fuel vehicles. Electric vehicle supply equipment must have effective charging speeds, align with local or regional standards, and take advantage of future improvements to the utility grid.

School projects may address employees' and visitors' vehicle use, as in other rating systems, or have the option of meeting emissions and green vehicle standards for their bus and non-bus vehicle fleets. Warehouses and distribution center projects may purchase alternative-fuel yard tractors to move trailers around the facility or provide electrical connections at loading dock doors, a strategy that allows truck drivers to operate in-cab comfort settings and appliances by plugging into grid power rather than by idling their engines unnecessarily.

STEP-BY-STEP GUIDANCE

NEW CONSTRUCTION, CORE AND SHELL, DATA CENTERS, HOSPITALITY, RETAIL, HEALTHCARE

STEP 1. DETERMINE TOTAL VEHICLE PARKING CAPACITY

Total vehicle parking spaces must include all new and existing off-street parking spaces leased or owned by the project, including any parking allocated to the project that is outside the project boundary (see *LT Overview, Total Vehicle Parking Capacity*).

STEP 2. CALCULATE NUMBER OF PREFERRED PARKING SPACES AND ALTERNATIVE-FUEL FUELING STATIONS

Use Equation 1 to determine the number of preferred spaces required for green vehicles. Use Equation 2 for the number of fueling stations required. Projects must provide both preferred parking spaces and alternative-fuel fueling stations. In lieu of preferred parking, projects may provide discounted parking rates for all green vehicles (see *Further Explanation, Discounted Parking Rates*).

EQUATION 1. Required number of preferred parking spaces

$$\text{Preferred spaces} = \text{Total parking spaces} \times .05$$

EQUATION 2. Required number of fueling stations

$$\text{Fueling stations} = \text{Total parking spaces} \times .02$$

STEP 3. INCORPORATE PREFERRED PARKING INTO DESIGN

On the site plan, identify the location of preferred parking spaces for green vehicles (see *LT Overview, Preferred Parking*, and *Further Explanation, Examples*).

1. *epa.gov/climatechange/ghgemissions/sources/transportation.html (accessed June 10, 2013).*
2. *cta.ornl.gov/data/chapter11.shtml, Table 11.7 (accessed June 10, 2013).*
3. *epa.gov/cleanschoolbus/antiidling.htm (accessed June 10, 2013).*
4. *cleanairactionplan.org/civica/filebank/blobdload.asp?BlobID=2516 (accessed June 10, 2013).*

STEP 4. SELECT ALTERNATIVE-FUEL FUELING STATIONS

Consider legal, technical, and safety issues associated with each fuel type. Projects selecting electric vehicle supply equipment (EVSE) must follow Option 1. Projects selecting all other alternative fuel types must follow Option 2.

- Survey future building occupants to determine which alternative fuel is in highest demand. Regional availability of a given fuel type may be a factor.
- Compare the equipment associated with alternative fuels. The cost and complexity of designing and installing the fueling station vary with the type of fuel.
- Learn about the safety and maintenance issues associated with alternative fuels. Building personnel need to be trained to operate and maintain the fueling stations.
- Review local codes and standards for fueling facilities to determine whether other requirements must be met.

STEP 5. CONFIRM COMPLIANCE OF ANY ELECTRIC VEHICLE SUPPLY EQUIPMENT

For Option 1, select EVSE that meets the credit requirements for charge capability, standard compliance, and network features; all three must be documented for credit compliance. This information can often be found on the manufacturer's website.

- Only Level 2 and 3 chargers qualify for this credit.
- The SAE J1772 standard is common among U.S.-based EVSE manufacturers. IEC 62196 of the International Electrotechnical Commission is an equivalent standard that is common outside the U.S.
- The EVSE must have a Wi-Fi, ethernet, cellular modem, or other Internet communication mechanism that allows the device to send usage data to a server. This enables participation in demand response programs (e.g., SmartGrid) or time-of-use pricing. Specifications must demonstrate, at minimum, that the product is IP-addressable.
- A direct connection between the EVSE and on-site renewable energy is acceptable in lieu of network capability if the EVSE will draw solely from that energy source. Documentation must be provided.

STEP 6. INSTALL ALTERNATIVE-FUEL FUELING STATIONS

On the site plan, identify the location of each alternative-fuel fueling station (see *Further Explanation, Examples*).

- For Option 1, EVSE for plug-in electric vehicles or battery switching stations may be located in any area of the parking facility. Parking spaces reserved for EVSE may not contribute toward preferred parking spaces for green vehicles.
- For Option 2, liquid or gas fueling stations should be located outdoors if possible. If a liquid or gas fueling station cannot be located outdoors, provide dedicated exhaust connected directly to the outdoors.

STEP 7. ENSURE EFFECTIVE USE OF PARKING SPACES

Provide clear and permanently installed signage or pavement markings to reserve the preferred parking spaces for green vehicles only (see *Further Explanation, Signage for Green Vehicles*). In addition, clearly indicate the type of fueling station provided. For projects pursuing Option 1, provide signage that the parking space is reserved for plug-in electric vehicles only.

Projects providing discounted parking in lieu of preferred parking must communicate the discounted rate to users (see *Further Explanation, Discounted Parking Rates*).

Work with the property manager or parking management to review the policy for green vehicle parking and alternative-fuel facilities and ensure that the correct vehicles are using these spaces. Enforcement strategies will vary by project but should include consequences for violations by building users.

SCHOOLS

Determine which option the project will pursue.

Option 1 is best for schools whose vehicle fleets are not within reasonable control of the school management, and for those without vehicle fleets.

Option 2 is best for schools that are served by an outdated aged vehicle fleet and if the school management, project team, or owner has reasonable control over the vehicle fleet serving the building.

Option 1. Green Passenger Vehicles

Follow Steps 1 through 6 above; all references to Option 1 and Option 2 equate to Path 1 and Path 2 for Schools, respectively.

Option 2. Green Buses and School-Owned Vehicles

STEP 1. INVENTORY SCHOOL FLEET

Work with the school's fleet manager to identify the make, model, and year of each bus and each non-bus vehicle that serves the project building. All vehicles that serve the project building must be included in the inventory, including privately owned and leased vehicles.

- If the project building is part of a campus with a shared fleet, the inventory must include all buses in the campus bus fleet.
- If the project building has a dedicated bus fleet, inventory only the buses in the dedicated fleet.

STEP 2. EVALUATE BUS FLEET EMISSIONS

- Review manufacturers' data for each vehicle to find the NO_x and PM emissions values and identify each bus that exceeds the emissions in the credit requirements.
- If manufacturers' data are not available or do not include the emissions information, estimate NOx and PM emissions based on the vehicles' engine specifications and model years, using Table 1.
- Project teams outside the U.S. should use a local equivalent table of estimated emissions by model year, if one exists, or refer to manufacturers' data. Include the data source and any supporting calculations with the submittal documentation.

TABLE 1. Estimated emissions, by vehicle model year

Model Year	NO_x (g/bhp-hr)	PM (g/bhp-hr)
1974–1978	10.7	0.60
1979–1984	10.7	0.60
1985–1987	10.7	0.60
1988–1989	10.7	0.60
1990	6.0	0.60
1991–1993	5.0	0.25
1994–1997	5.0	0.10
1998–2003	4.0	0.10
2004–2006	4.0	0.10
2007 ON	0.2	0.01

Source: EPA's historical exhaust emissions standards for heavy-duty highway compression-ignition engines and urban buses: epa.gov/otaq/standards/heavy-duty/hdci-exhaust.htm.

STEP 3. EVALUATE VEHICLES OTHER THAN BUSES

Evaluate each vehicle to determine whether it qualifies as a green vehicle, per the rating system definition.

STEP 4. IDENTIFY PHASE-OUT AND RETROFIT STRATEGIES

If the fleet includes buses or other vehicles that do not meet credit requirements, determine whether to retrofit or phase out these vehicles to meet the emissions standards.

- Buses should be retrofitted using emissions control strategies approved by a relevant third party, such as the California Air Resources Board or a local equivalent. Confirm that each bus will meet credit emissions criteria by applying the emissions control strategies to the manufacturer's data or Table 1 estimates.

- Non-bus vehicles that do not meet green vehicle criteria must be phased out.

STEP 5. DOCUMENT PLANS TO ADDRESS ALL NONCOMPLIANT VEHICLES

Develop a plan to retrofit or phase out all noncompliant vehicles within seven years of the school's certificate of occupancy date. Include the following in the plan:

- Emissions evaluation of each vehicle in the current bus fleet serving the school
- Phase-out strategy or retrofit products for each bus that does not meet the emissions criteria
- Make, model and year of each non-bus vehicle, and whether it meets the green vehicle criteria
- Phase-out strategy for each non-bus vehicle that is not a green vehicle, including types of replacement vehicles
- Timeline and responsible parties for each stage of the plan
- For projects in which bus service is contracted, the policy governing scheduled contact bidding or unscheduled changes to the bus company contract
- Signed commitment from the school (or other entity with control over the fleet) to implement the plan

If bus or non-bus vehicle fleets used by the school already meet the credit requirements, supply the emissions evaluations for buses as well as make, model, and year information for non-bus vehicles.

WAREHOUSES AND DISTRIBUTION CENTERS

Option 1. Alternative-Fuel Vehicles

STEP 1. SELECT ALTERNATIVE-FUEL YARD TRACTOR

Purchase at least one yard tractor to be used at the project site facilities that is powered by electricity, propane, or natural gas.

- Before selecting a model, compare the environmental and economic costs and benefits of each fuel type. Regional availability of a given fuel type may also be a factor.
- Review local codes and standards for the type of fueling station that would be required.
- Compare the equipment associated with alternative fuels. The cost and complexity of designing and installing the fueling station vary with the type of fuel.
- Learn about the safety and maintenance issues associated with alternative fuels. Building personnel need to be trained to operate and maintain the fueling stations.
- If the project owner already owns an alternative-fuel yard tractor that will be dedicated to the facility, it is not necessary to purchase a new yard tractor to comply with the credit requirements.

STEP 2. PROVIDE ALTERNATIVE-FUEL FUELING STATION TO SUPPORT YARD TRACTOR(S)

- Work with the owner, civil engineer, mechanical engineer, and other team members to select an appropriate location for the alternative-fuel fueling station(s).
- Liquid or gas fueling stations should be located outdoors if possible. If a liquid or gas fueling station cannot be located outdoors, provide dedicated exhaust connected directly to the outdoors.

Option 2. Reduced Truck Idling

Install electrical connectors for at least 50% of loading dock doors. Indicate the locations on an electrical plan.

- When identifying the placement of electrical connectors, consider such factors as the frequency with which the door is used, the type of product carried at the door, the length of time trucks are idling, and project design elements that may require a reduction in engine idling (e.g., proximity to places of congregation or building entrances).
- Electrical connectors must allow drivers to shut down truck engines while maintaining use of in-cab heating, air-conditioning, communications, and entertainment systems.
- Although demonstrating this compatibility is not required, vehicles supplying the project will need adapters to take advantage of the electrical connectors. Contact rebate programs such as the Shorepower Truck Electrification Project in the U.S. (the-step-project.org) for potential assistance in subsidizing or supplying adapter kits.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

DISCOUNTED PARKING RATES

Discounted parking rates for green vehicles may be used to achieve this credit in lieu of preferred parking if the following requirements are met:

- The discount must be at least 20%.
- The discount policy must be publicly posted at the entrance to the parking area and any other locations that may serve to inform building users of the discount. The discount must also be included in building policy documents and occupant advertisements.
- Projects cannot limit the discounted parking passes available; the discounted parking rate must be available to all building users who drive green vehicles.
- The discounted rate must be made available to all building users in perpetuity after the project's completion.

This approach is best applied when a large share of the parking capacity is devoted to monthly or yearly parking passes and car owners can receive the discounted rate when buying a pass. The application should ask for the car make and model so that the building operator can verify its compliance with the LEED definition of a green vehicle. Ensure that building personnel responsible for collecting parking fees are aware of the discount policy and the vehicles that are eligible.

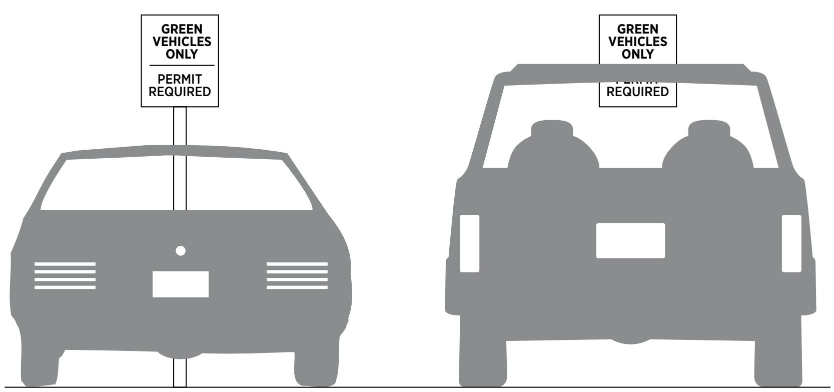
SIGNAGE FOR GREEN VEHICLES

Language used on reserved parking signage must reflect the spirit of the American Council for an Energy Efficient Economy (ACEEE) Green Book methodology (or a local equivalent for projects outside the U.S.).

In addition to this basic language, project teams are encouraged to share the definition of a green vehicle per the ACEEE Green Book (or a local equivalent for projects outside the U.S.). This information may be included with the preferred parking signage, near the preferred parking area, at the parking attendant booth or building entrance, or in educational material readily available to building users.

If a local green vehicle code or standard requires specific signage, this alternative language may be used, provided the standard has been approved by USGBC as equivalent to the ACEEE Green Book (see *International Tips*).

Figure 1. Example signage for green vehicle reserved parking



EXAMPLES

Example 1. Location of preferred parking and alternative-fuel fueling stations (single lot)
A new construction project building has a total parking capacity of 335 spaces. The project calculates 5% of the total to determine the number of preferred parking spaces:

335 total spaces × .05 = 16.75 preferred parking spaces

The result is rounded up to 17 preferred parking spaces. The project team decides to install EVSE in parking spaces reserved for plug-in electric vehicles and calculates the required spaces:

335 total spaces × .02 = 6.7 plug-in spaces

The team must provide seven plug-in spaces. Figure 2 shows the arrangement of preferred parking spaces and alternative-fuel fueling spaces.

Figure 2. Example of preferred parking locations

Example 2. Location of preferred parking in separated parking areas

A new construction project is a mixed-use building with a ground-level grocery store and office floors above. The parking area includes 108 spaces with separate parking areas for long- and short-term parking. Short-term parking, intended for the grocery store customers, numbers 36 spaces; long-term parking for office occupants numbers 72 spaces. The project team calculates the required preferred parking spaces as 5% of the total:

108 total spaces × .05 = 5.4 preferred parking spaces

The result is rounded up to six preferred parking spaces. The project team must proportionally distribute these six preferred parking spaces between the short- and long-term parking areas. Because short-term parking accounts for one-third and long-term for two-thirds of the total parking, two short-term spaces (one-third of six) and four long-term spaces (two-thirds of six) are required. Figure 3 illustrates the result.

In addition, the project is providing natural gas fueling facilities. To determine the number of alternative-fuel vehicles to accommodate per day, the team makes the following calculation:

108 total spaces × .02 = 2.16 vehicles to be supported by refueling facilities

The result is rounded up. Thus the refueling facilities must have sufficient volume and rate to support three vehicles per day.

Figure 3. Example of proportionate distribution of preferred parking spaces

PROJECT TYPE VARIATIONS

Military Installations
Parking for ranking officials may be separated from regular parking, but the proportion of preferred parking for carpools must be applied to each pool of parking.

Separated Employee or Visitor Parking
Projects with separate parking areas for visitors, employees, or students must apply the proportion of preferred parking for carpools to each pool of parking.

INTERNATIONAL TIPS

Local equivalent standards to the American Council for an Energy Efficient Economy's (ACEEE) Green Book must comprehensively address vehicle fuel economy and vehicle emissions ratings, including particulate matter (PM), nitrogen oxides (NO_x), hydrocarbons, and carbon monoxide (CO). Complete and submit a side-by-side comparison of the selected local standard and ACEEE methodologies.

CAMPUS

Group Approach
New Construction, Core and Shell, Data Centers, Hospitality, Retail, Healthcare, Schools
All buildings in the group may be documented as one. All the parking located within the LEED project boundary must be included in the calculations. Submit a site plan that illustrates a reasonable distribution of preferred parking spaces for the buildings or spaces seeking LEED certification.

Warehouses and Distribution Centers
Option 1. All buildings in the group may be documented as one.
Option 2. Submit separate documentation for each building.

Campus Approach
New Construction, Core and Shell, Data Centers, Hospitality, Retail, Healthcare, Schools
Eligible. Submit a site plan that illustrates a reasonable distribution of preferred parking spaces for the projects seeking LEED certification.

Warehouses and Distribution Centers
Option 1. Eligible.
Option 2. Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	New Construction, Core and Shell, Data Centers, Hospitality, Retail, Healthcare		Schools	
	Option 1	Option 2	Option 1	Option 2
Parking or site plan indicating main building entrance, preferred parking spaces, and alternative-fuel fueling stations	X	X	X	
Calculations based on total parking capacity	X	X	X	
For preferred parking spaces, photographs of signage or pavement marking	X	X	X	
For electric vehicle charging spaces, photographs of signage or pavement marking	X		X	
For discounted parking rate, copy of communication to building occupants or photograph of signage	X	X	X	
For electrical connectors, manufacturers' product specifications indicating charge level, compliance with relevant standard, and Internet addressability	X		X	
For liquid or gas fueling stations, manufacturers' product specifications indicating fuel type and refueling rate		X	X	
Phase-in plan for emissions-compliant bus fleet, including emissions evaluation of current fleet, retrofit strategies, timeline, responsible parties				X
Phase-in plan for green non-bus vehicles, including types of vehicles, timeline and responsible parties				X

Warehouses and Distribution Centers		
Documentation	Option 1	Option 2
Manufacturer's documentation of yard tractor model and fuel type	X	
Site plan showing electrical connector locations at loading dock doors		X
Calculations for number of dock doors with electrical connection		X

RELATED CREDIT TIPS

LT Credit Reduced Parking Footprint. Project teams also pursuing the related credit must reserve 12% of total parking capacity for preferred vehicles (with a required 7% for green vehicles in LT Credit Green Vehicles and 5% for carpools or vanpools in LT Credit Reduced Parking Footprint). Guidance for locating preferred parking is the same for both credits.

EA Credit Demand Response. Any electric charging stations should align with the existing demand response program or infrastructure to comply with the related credit.

EQ Prerequisite Minimum Air Quality Performance. Consider separate ventilation for liquid or gas alternative-fuel fueling facilities alongside development of the mechanical plan and indoor air quality strategy to comply with the related prerequisite.

CHANGES FROM LEED 2009

New Construction, Core and Shell, Data Centers, Hospitality, Retail, Healthcare

- The term "low-emitting and fuel-efficient vehicles" has been changed to "green vehicles."
- Options 1 and 2 have been reorganized such that all projects must provide preferred parking for green vehicles and alternative-fuel fueling stations.
- The minimum ACEEE green score, which determines classification as a fuel-efficient vehicle, has been raised to 45.
- The requirement for alternative-fuel stations has been lowered to 2% of total parking capacity.
- Electrical connectors must comply with SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler (or a regional or local equivalent standard) and must also be capable of dynamic interaction with the utility grid.
- Credit can no longer be earned by providing green vehicles or a car-sharing program for building occupants.

Schools

- See section above for changes in Option 1.
- A designated carpool drop-off area for green vehicles (formerly "low-emitting and fuel-efficient vehicles") is no longer required.
- Option 2 now requires an implementation plan to meet NO_x and particulate emissions standards for school buses and green vehicle designation for vehicles other than buses.

Warehouses and Distribution Centers

- Credit requirements specific to warehouses and distribution centers have been added.

REFERENCED STANDARDS

American Council for an Energy Efficient Economy (ACEEE) Green Book: greenercars.org

Society of Automotive Engineers, SAE Surface Vehicle Recommended Practice J1772, SAE Electric Vehicle Conductive Charge Coupler: standards.sae.org/j1772_201001

International Electrotechnical Commission 62196: iec.ch

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

alternative fuel low-polluting, nongasoline fuels such as electricity, hydrogen, propane, compressed natural gas, liquid natural gas, methanol, and ethanol

demand response (DR) a change in electricity use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized

electric vehicle supply equipment the conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle. (National Electric Codes and California Article 625)

grams per brake horsepower hour metric used to communicate how many grams of emissions (e.g., nitrogen oxide or particulate matter) are emitted by an engine of a specific horsepower rating over a one-hour period

preferred parking the parking spots closest to the main entrance of a building (exclusive of spaces designated for handicapped persons). For employee parking, it refers to the spots that are closest to the entrance used by employees.

time-of-use pricing an arrangement in which customers pay higher fees to use utilities during peak time periods and lower fees during off-peak time periods

yard tractor a vehicle used primarily to facilitate the movement of truck trailers and other types of large shipping containers from one area of a site to another. It does not include forklift trucks. Also known as terminal tractor, yard truck, utility tractor rig, yard goat, or yard hustler.

Sustainable Sites (SS)

OVERVIEW

The Sustainable Sites (SS) category rewards decisions about the environment surrounding the building, with credits that emphasize the vital relationships among buildings, ecosystems, and ecosystem services. It focuses on restoring project site elements, integrating the site with local and regional ecosystems, and preserving the biodiversity that natural systems rely on.

Earth's systems depend on biologically diverse forests, wetlands, coral reefs, and other ecosystems, which are often referred to as "natural capital" because they provide regenerative services. A United Nations study indicates that of the ecosystem services that have been assessed worldwide, about 60% are currently degraded or used unsustainably.[1] The results are deforestation, soil erosion, a drop in water table levels, extinction of species, and rivers that no longer run to the sea. Recent trends like exurban development and sprawl encroach on the remaining natural landscapes and farmlands, fragmenting and replacing them with dispersed hardscapes surrounded by nonnative vegetation. Between 1982 and 2001 in the U.S. alone, about 34 million acres (13 759 hectares) of open space (an area the size of Illinois) was lost to development—approximately 4 acres per minute, or 6,000 acres a day.[2] The rainwater runoff from these hardscape areas frequently overloads the capacity of natural infiltration systems, increasing both the quantity and pollution of site runoff. Rainwater runoff carries such pollutants as oil, sediment, chemicals, and lawn fertilizers directly to streams and rivers, where they contribute to eutrophication and harm aquatic ecosystems and species. A Washington State Department of Ecology study noted that rainwater runoff from roads, parking lots, and other hardscapes carries some 200,000 barrels of petroleum into the Puget Sound every year—more than half of what was spilled in the 1989 *Exxon Valdez* accident in Alaska.[3]

Project teams that comply with the prerequisites and credits in the SS category protect sensitive ecosystems by completing an early site assessment and planning the locations of buildings and hardscape areas to avoid harming habitat, open space, and water bodies. They use low-impact development methods that minimize construction pollution, reduce heat island effects and light pollution, and mimic natural water flow patterns to manage rainwater runoff. They also remediate areas on the project site that are already in decline.

1. *UN Environment Programme, State and Trends of the Environment 1987–2001, Section B, Chapter 5, unep.org/geo/geo4/report/05_Biodiversity.pdf.*
2. *U.S. Forest Service, Quick Facts, fs.fed.us/projects/four-threats/facts/open-space.shtml (accessed September 11, 2012).*
3. *Cornwall, W., Stormwater's Damage to Puget Sound Huge, Seattle Times (December 1, 2007), seattletimes.com/html/localnews/2004045940_ecology01m.html (accessed September 14, 2012).*

In LEED v4, the SS category combines traditional approaches with several new strategies, including the backlight-uplight-glare (BUG) method (Light Pollution Reduction credit), working with conservation organizations to target financial support for off-site habitat protection (Site Development—Protect or Restore Habitat credit), replicating natural site hydrology (Rainwater Management credit), and using three-year aged SRI values for roofs and SR values for nonroof hardscape (Heat Island Reduction credit).

SUSTAINABLE SITES PREREQUISITE

Construction Activity Pollution Prevention

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To reduce pollution from construction activities by controlling soil erosion, waterway sedimentation, and airborne dust.

REQUIREMENTS

Create and implement an erosion and sedimentation control plan for all construction activities associated with the project. The plan must conform to the erosion and sedimentation requirements of the 2012 U.S. Environmental Protection Agency (EPA) Construction General Permit (CGP) or local equivalent, whichever is more stringent. Projects must apply the CGP regardless of size. The plan must describe the measures implemented.

BEHIND THE INTENT

This prerequisite promotes environmental protection measures that reduce construction project disturbances to neighboring properties, rainwater systems, and the site itself. Throughout most of the United States and elsewhere, local codes often regulate construction activity pollution; however, some project sites may not be subject to such codes. To ensure that all projects implement erosion and sedimentation control (ESC) measures during construction, LEED applies a U.S.-based national standard, the U.S. Environmental Protection Agency (EPA) construction general permit (CGP).

Local jurisdictions typically look to this standard when writing their own code requirements and adopt ESC measures that are applicable to local soils, weather, natural waterways, and municipal rainwater systems. Therefore, projects that follow local codes derived from the CGP can often demonstrate compliance with the prerequisite. Project teams outside the U.S. can use a local equivalent (see *Further Explanation, International Tips*).

STEP-BY-STEP GUIDANCE

STEP 1. DESIGNATE RESPONSIBLE PARTY

The civil engineer is typically responsible for developing an erosion and sedimentation control (ESC) plan, but in some cases, the landscape architect, project hydrologist, geologist, earthworks contractor, or general contractor will undertake the plan's development.

STEP 2. REVIEW LOCAL CODE AGAINST EPA CGP

Projects within the U.S. should determine whether the local jurisdiction requires an official construction general permit (CGP) based on the National Pollutant Discharge Elimination System (NPDES) program criteria.

- If a permit is required, develop the CGP according to typical regional practices. Projects already using the CGP thus have a streamlined path to compliance.
- If local codes do not reference the CGP, determine whether local code requirements meet or exceed the CGP (see *Further Explanation, About NPDES and the CGP*).

For all projects, conformance to local standards or code is required in lieu of the CGP when the code is equally or more stringent.

- To determine equivalence, compare elements of the local code that cover the requirements in the CGP, Section 2, and ensure that all relevant categories listed are covered by local code. If local codes are less stringent, address gaps by following the CGP.

STEP 3. EVALUATE SITE FOR ESC PLAN NEEDS

Each project site is unique, and not all ESC measures identified in the CGP may be applicable or necessary. Assess which ESC measures are needed based on a simple site evaluation that identifies the following:

- The slope of the project site and where water will drain
- The total area and duration of ground disturbance to identify air quality and rainwater runoff effects on neighboring properties
- The location of existing rainwater management systems that must be protected
- Planned construction sequencing that may require additional ESC measures over time
- Weather and soil conditions that could cause rainwater runoff or generate dust
- Construction entrances and their erosion and sedimentation effects on local roads servicing the project site

STEP 4. CREATE ESC PLAN

During the project's construction documentation phase, develop the plan based on the ESC requirements of the CGP or local equivalent and the unique needs of the project site. This prerequisite applies to all sites, even those smaller than 1 acre (0.4 hectare) (see *Further Explanation, About NPDES and the CGP, and CGP Requirements*).

The ESC plan is generally prepared as part of the project plans, specifications, or a combination of both. The plan includes erosion and sedimentation control measures and activities to be implemented and phased throughout construction.

- All projects must have an ESC plan that meets the prerequisite requirements even if a plan is not required by local code. Teams for such projects must describe the specific situation and how the plan applies.
- Zero lot line projects and projects that cause no exterior site disturbance can instead develop a narrative that describes why no ESC plan is necessary for the site.
- If the team registers for LEED after the project has started, see *Further Explanation, Compliance in Late Design or Early Construction.*

STEP 5. IMPLEMENT ESC PLAN

Establish control measures before construction begins. Implement additional measures as needed based on site conditions and as construction progresses. The establishment and maintenance of ESC measures are generally the responsibility of the general contractor or builder.

- Monitor control measures periodically through site inspections and record maintenance activities taken during construction.
- Inspections must be recorded regularly via date-stamped photographs, inspection reports, or other recording processes.

The following actions are also recommended:

- Any problems identified in site inspections should be resolved in a timely manner.
- Inspections should follow the requirements the CGP, Section 4.1.
- All subcontractors should promptly notify the responsible party if they see damage to an ESC measure.
- Generate and save documentation as the plan is implemented for eventual use in the certification submission (see *Further Explanation, Erosion and Sedimentation Control Plan Narrative*).

FURTHER EXPLANATION

ABOUT NPDES AND THE CGP

The National Pollutant Discharge Elimination System (NPDES) is a U.S. program that regulates stormwater discharges from construction activities that disturb 1 acre (0.4 hectare) or more; it also applies to smaller sites that are part of a larger development or sale. This LEED prerequisite applies to all sites, even those smaller than 1 acre (0.4 hectare). In the U.S., the EPA or a local authority, depending on the project's location, administers the permitting process associated with the NPDES program using the CGP.[1] Projects outside the U.S. may use a local equivalent to NPDES.

Based on the project's location and conditions, some U.S. projects may be required to acquire an NPDES permit. Refer to EPA's CGP website to determine whether a permit is required. A permit is not required to meet this LEED prerequisite, but all projects (regardless of size or NPDES status) must conform to the applicable erosion and sedimentation control requirements of the CGP or a local equivalent.

CGP REQUIREMENTS

Whether they follow the CGP or a local equivalent, all projects must meet the requirements outlined in the CGP, Section 2:

Section 2.1, erosion and sedimentation control

- Providing natural buffers
- Installing perimeter controls
- Minimizing sediment track-out
- Controlling discharges from stockpiled sediment or soil
- Minimizing dust
- Minimizing the disturbance of steep slopes
- Preserving topsoil
- Minimizing soil compaction
- Protecting storm drain inlets
- Maintaining control measures

Section 2.2, stabilization

- Deadlines for initiating and completing stabilization
- Criteria for stabilization

Section 2.3, pollution prevention

- Prohibited discharges
- General maintenance requirements
- Pollution prevention standards
- Emergency spill notification
- Fertilizer discharge restrictions

EROSION AND SEDIMENTATION CONTROL PLAN NARRATIVE

Track implementation of the ESC plan by keeping written records or date-stamped photographs. A narrative description of ESC plan implementation should include the following:

- Timing of the implementation of the plan
- Specific control measures applied on site
- Maintenance protocols used to ensure the proper function of control measures

Example ESC plan documentation narrative and graphic (see Figure 1):

The ESC plan was maintained throughout the duration of the project, from initial site mobilization through project closeout. Specific control measures included site perimeter silt fence maintenance, inlet protection, soil stockpiling, dust

1. This information paraphrased from EPA, https://www.epa.gov/npdes/epas-2012-construction-general-permit-cgp-and-related-documents.

control, visual inspection of all vehicle tires coming to and from the job site, and a designated concrete washout. The implementation of the plan was maintained daily by the general contractor and inspected weekly by the civil engineer for the duration of the project.

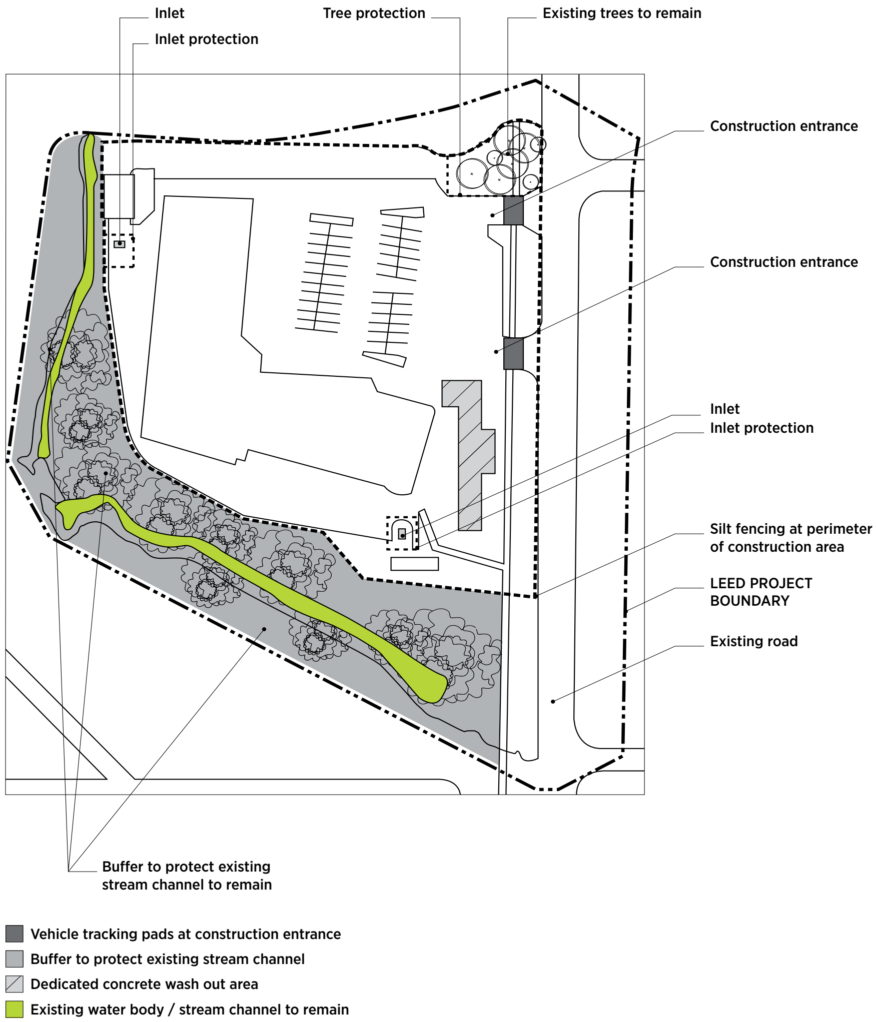


Figure 1. Example ESC measures in plan

COMPLIANCE IN LATE DESIGN OR EARLY CONSTRUCTION

Projects that decide to pursue LEED certification during the design phase may develop or modify the ESC plan at that stage. However, projects that decide to pursue LEED during early construction must have had a compliant ESC plan in place before construction began to meet the prerequisite requirements.

INTERNATIONAL TIPS

Local code requirements may be followed if they are equally stringent or more stringent than the CGP and NPDES. Projects outside the U.S. do not have to comply with the permitting aspects of the CGP.

Construction pollution prevention priorities may differ based on locality or region. Provide information on the issues that are important to the project's region. For example, if rainwater is not a major concern but dust control is, information on dust control should be included in the project's construction activity pollution prevention plan.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Projects Using 2012 EPA CGP	Projects Using Local Standards and Codes
Description of compliance with EPA CGP	X	
For zero lot line projects and projects with minimal or no exterior work: Description of special conditions and compliance with any applicable ESC measures	X	X
Comparison of local standards and codes with EPA CGP		X
Description of how project complies with local standards and codes		X
Drawings depicting erosion and sedimentation control measures implemented		X
Written declaration from general contractor or builder who implemented plan **OR** Date-stamped photos **OR** A description of plan implementation.		X

RELATED CREDIT TIPS

SS Credit Site Development—Protect or Restore Habitat. Implementing an ESC plan that limits site disturbances such as vehicle traffic, grading, equipment storage, erosion, and sedimentation on greenfield areas during construction will contribute to the greenfield requirement in this related credit. Implementing an ESC plan that protects existing soils will make it unnecessary to restore soils to meet Option 1 requirements of the related credit.

SS Credit Rainwater Management. Implementing an ESC plan that minimizes soil compaction where vegetation will be planted or where infiltration measures will be installed will support reducing runoff volumes, in accordance with the related credit's requirements.

CHANGES FROM LEED 2009

The referenced version of the EPA CGP standard has changed from 2003 to 2012.

REFERENCED STANDARDS

Environmental Protection Agency (EPA) Construction General Permit (CGP):
https://www.epa.gov/npdes/epas-2012-construction-general-permit-cgp-and-related-documents

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

greenfield area that has not been graded, compacted, cleared, or disturbed and that supports (or could support) open space, habitat, or natural hydrology.

previously disturbed areas that have been graded, compacted, cleared, previously developed, or disturbed in any way. These are areas that do not qualify as 'greenfield.'

SUSTAINABLE SITES PREREQUISITE

Environmental Site Assessment

This prerequisite applies to:

Schools
Healthcare

INTENT

To protect the health of vulnerable populations by ensuring that the site is assessed for environmental contamination and that any environmental contamination has been remediated.

REQUIREMENTS

Conduct a Phase I Environmental Site Assessment as described in ASTM E1527–05 (or a local equivalent) to determine whether environmental contamination exists at the site. If contamination is suspected, conduct a Phase II Environmental Site Assessment as described in ASTM E1903–11 (or a local equivalent).

If a site is contaminated, remediate the site to meet local, state, or national environmental protection agency region residential (unrestricted) standards, whichever are most stringent.

BEHIND THE INTENT

Many sites may contain contaminants that could harm the health and well-being of future occupants. Soil or groundwater may have been polluted by previous uses, for example, or existing structures might contain hazardous materials, such as lead. Contaminants can harm the health of future users of the site, especially sensitive populations such as children or hospital patients. Children, who are more sensitive to toxic substances than adults are, can be afflicted with learning disabilities, chronic and acute respiratory diseases, cancer, or other illnesses after exposure to toxins. People using health care facilities have greater sensitivity to environmental stressors during their illnesses and treatments. Identifying and remediating contaminated sites can help ensure a safe environment for all occupants.

The American Society for Testing and Materials (ASTM) environmental site assessment (ESA) is a methodology for investigating and identifying a site's environmental contamination. This prerequisite promotes the protection of human health by requiring an ESA (or local equivalent) and, if necessary, remediation of any confirmed site contamination. Project teams may use local assessment standards if they are at least as stringent as ASTM Phase I and II ESAs.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE WHETHER PHASE I ESA (OR LOCAL EQUIVALENT) IS REQUIRED

- ASTM Standard E1527–05, Section 4.8, considers a Phase I ESA valid for 180 days; projects that have a valid assessment should skip to Step 3.
- If a site's Phase I ESA is more than 180 days but less than one year old, the standard requires that updates be made to certain sections.
- If a Phase I ESA is more than one year old, a new assessment is required.

STEP 2. CONDUCT PHASE I ESA (OR LOCAL EQUIVALENT)

- Contract with an environmental professional to complete the Phase I ESA.
- If a local equivalent assessment is being considered, the environmental professional must ensure that any local equivalent assessment is equivalent to ASTM E1527–05 (see *Further Explanation, Local Equivalent Assessments*).
- For projects in the U.S. that are following the All Appropriate Inquiries Final Rule, this regulation is considered consistent with ASTM E1527–05 (see *Further Explanation, Scope of the ESA Phases).*

STEP 3. DETERMINE WHETHER PHASE II ASSESSMENT IS REQUIRED

- If the Phase I (or local equivalent) report indicates that no contamination is suspected, retain the full report, with its findings and conclusions. No further action is necessary.
- If the Phase I report indicates that a "recognized environmental condition" (REC) exists, or the report recommends additional assessment activities (e.g., because of potential or historical conditions, data gaps), then a Phase II ESA (or local equivalent assessment) is required.

STEP 4. CONDUCT PHASE II ASSESSMENT (OR LOCAL EQUIVALENT)

Contract with an environmental professional to complete the Phase II ESA.

- If a local equivalent is being considered, the environmental professional must ensure that it is equivalent to ASTM E1903–11 (see *Further Explanation, Local Equivalent Assessments).*
- Projects with known contamination may wish to move directly to a Phase III ESA (or local equivalent). Although not required for LEED certification, this further assessment helps determine the scope of remediation process and is more extensive than a Phase II ESA. For the purpose of this prerequisite, a Phase III fulfills the requirement for a Phase II ESA. See *Further Explanation, Scope of the ESA Phases*.

STEP 5. DETERMINE WHETHER REMEDIATION IS REQUIRED

- If the Phase II (or Phase III, if the project team chooses) assessment or local equivalent indicates soil or groundwater contaminant levels that exceed regulatory criteria, or the report recommends additional action based on the qualitative or quantitative findings of the investigation, remediation may be necessary.
- An environmental regulatory agency (local or national) may also require remediation based on the findings.

STEP 6. REMEDIATE SITE

- Contract with an environmental professional to prepare and implement a remediation plan. This may include additional investigation and must be completed with the approval of environmental regulatory agencies as necessary.
- Collect documentation indicating that the site is "ready for reuse" from the environmental professional or regulatory agencies as necessary. The site must meet the residential (unrestricted) use standards for the Environmental Protection Agency (EPA) region (or local equivalent) or be otherwise suitable for the project's intended use in the project's EPA region. Proper engineering and institutional use controls, ongoing remediation, and monitoring may be acceptable, provided these activities meet the requirements set forth by the local or national environmental regulatory agency.
- EPA's residential (unrestricted) use standards represent the most rigorous level of cleanup; local equivalent standards must have a similar level of rigor. After remediation, land use must be suitable for residential, school, or hospital use.

FURTHER EXPLANATION

SCOPE OF THE ESA PHASES

A Phase I environmental site assessment (ASTM E1527–05) is a nonintrusive survey that identifies potential or existing site contamination. It determines the likelihood of contamination in the soil, groundwater, and surface water and considers potential contaminants in buildings and structures on the site. A Phase I ESA includes the following:

- A review of historical records (e.g., chain of title, site plans, permits, maps, aerial photographs, previous reports)
- A site visit to visually identify potential contamination sources and signs
- Interviews with individuals who have knowledge of the history of the site
- An executive summary that indicates whether a Phase II ESA is required and a full report documenting the findings

A Phase II ESA (ASTM E1903–11) involves collection and testing soil, soil vapor, groundwater, and building material samples to determine whether and how much contamination exists on the site.

A Phase III ESA (not an ASTM standard) can be a first step in the site remediation process. It includes more extensive sampling and testing than a Phase II ESA to determine the extent of the contamination identified in the Phase II assessment. Because the report includes an evaluation of remediation options, costs, and logistics, it may be more useful than a Phase II ESA for projects with known site contamination.

Any contaminants not typically included in the scope of Phase I and Phase II ESAs should be considered if the site is at risk for such contamination. If non-scope "recognized environmental conditions" (RECs) (asbestos-containing materials, radon, mold, lead, etc) are identified, these contaminants must be addressed in the scope of the Phase I and Phase II ESAs, as applicable.

LOCAL EQUIVALENT ASSESSMENTS

Local equivalents to ESAs are acceptable, provided they are equal to or more stringent than the Phase I ESA and Phase II ESA. The environmental professional must complete a side-by-side comparison of the local standards to the ESA standards.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	No contamination, as confirmed by Phase I ESA (or local equivalent)	No contamination, as confirmed by Phase II ESA (or local equivalent)	Contamination, as confirmed by Phase II or III ESA (or local equivalent)
Phase I ESA or local equivalent assessment	X	X	X
Phase II or III ESA or local equivalent assessment		X	X
Description of contamination and remediation			X
Verification that site has been remediated to residential use standards			X

RELATED CREDIT TIPS

LT Credit High-Priority Site. If the site is classified as a brownfield and remediation is completed to the satisfaction of the authority having jurisdiction, the project is eligible to achieve the related credit.

CHANGES FROM LEED 2009

- The blanket exclusion of former landfill sites has been removed.
- Local equivalent assessments are available to all project teams as an alternative to Phase I and II ESAs.
- Projects are no longer allowed to achieve the prerequisite based on an asbestos sampling plan and remediation report.

REFERENCED STANDARDS

ASTM E1527—05 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process: astm.org

ASTM E1903—11 Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process: astm.org

40 CFR Part 312: Standards and Practice for All Appropriate Inquiries; Final Rule: epa.gov/brownfields/aai

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

site assessment an evaluation of an area's above ground and subsurface characteristics, including its structures, geology, and hydrology. Site assessments typically help determine whether contamination has occurred and the extent and concentration of any release of pollutants. Remediation decisions rely on information generated during site assessments.

SUSTAINABLE SITES CREDIT

Site Assessment

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To assess site conditions before design to evaluate sustainable options and inform related decisions about site design.

REQUIREMENTS

Complete and document a site survey or assessment[1] that includes the following information:

- **Topography.** Contour mapping, unique topographic features, slope stability risks.
- **Hydrology.** Flood hazard areas, delineated wetlands, lakes, streams, shorelines, rainwater collection and reuse opportunities, TR-55 initial water storage capacity of the site (or local equivalent for projects outside the U.S.).
- **Climate.** Solar exposure, heat island effect potential, seasonal sun angles, prevailing winds, monthly precipitation and temperature ranges.
- **Vegetation.** Primary vegetation types, greenfield area, significant tree mapping, threatened or endangered species, unique habitat, invasive plant species.
- **Soils.** Natural Resources Conservation Service soils delineation, U.S. Department of Agriculture prime farmland, healthy soils, previous development, disturbed soils (local equivalent standards may be used for projects outside the U.S.).
- **Human use.** Views, adjacent transportation infrastructure, adjacent properties, construction materials with existing recycle or reuse potential.
- **Human health effects.** Proximity of vulnerable populations, adjacent physical activity opportunities, proximity to major sources of air pollution.

The survey or assessment should demonstrate the relationships between the site features and topics listed above and how these features influenced the project design; give the reasons for not addressing any of those topics.

1. *Components adapted from the Sustainable Sites Initiative: Guidelines and Performance Benchmarks 2009, Prerequisite 2.1: Site Assessment.*

BEHIND THE INTENT

A site assessment evaluates environmental features that the design of a sustainable site and building should take into consideration. It identifies assets, such as favorable climate conditions, good solar access, and healthy plant populations, as well as liabilities, such as unhealthy soils, blighted structures, pollution sources, steep slopes, and extreme climate patterns.

Performing a site assessment is part of an integrative design process that incorporates a site's ecological and historical contexts. A site assessment informs good design decisions, such as locating community gardens in areas with fertile soils, placing outdoor gathering spaces near large trees or desirable water features, orienting buildings to take advantage of prevailing winds and solar access, and optimizing the location of rainwater management features. A well-developed assessment conducted before or during the conceptual design phase may reduce project costs and risks, promote occupants' health, and honor a site's unique characteristics.

Understanding a site's topography, climate, soil types, water availability, and ambient air quality is important because such features can significantly influence a project's design and its ultimate performance.

STEP-BY-STEP GUIDANCE

STEP 1. PREPARE FOR ASSESSMENT

Identify the team that will do the assessment.

- Typically, the team consists of the landscape architect, land planner, and architect. Team members should begin by collecting a wide range of information, such as climate data, topographical maps, nearby building types, and soil survey data.
- Engage local experts and specialists to help inventory any items listed in the credit requirements that extend beyond the core team's expertise (see *Further Explanation, Features to Include in the Site Assessment*).
- Plan to complete the assessment before conceptual design starts because the findings will inform the location and orientation of major program elements. A previous site assessment can be used (including an assessment completed for a campus in which the project is located), provided it accurately reflects the current site and surrounding property conditions.

STEP 2. CONDUCT SITE INVENTORY

Using a variety of data sources, site visits, and local experts, survey and inventory the existing site conditions and surroundings, according to the credit requirements, and compile the information for the site assessment.

- It may be useful to record site elements in a single document as the inventory progresses. See USGBC's site assessment worksheet, a spreadsheet that teams can use to fulfill a portion of the documentation requirements.
- Consider preparing a list of credits that could be influenced by a site assessment, and indicate which site elements are applicable to each credit. For example, SS Credit Rainwater Management may be influenced by topography and the location of existing water bodies on the site.
- Document the site and ecological features (and relevant associated details) that will be important for the design team to understand to meet the project goals. For example, in addition to documenting the location of existing vegetation, consider also collecting information on the size, species, health, root structure, and shade potential of trees so that their attributes can be integrated with planned program elements.
- Consider the proposed initial design to ensure that appropriate features are analyzed (see *Further Explanation, Design Opportunities*).
- If a feature listed in the credit requirements is not relevant for the site, explain why it has been excluded.
- Include such man-made features as buildings, roads, pathways, and existing infrastructure.
- Consider talking to local experts and visiting regional historical societies to collect site information that may not be visible or obvious. For example, Chapman School in Portland, Oregon, has an abandoned

2. *audubonportland.org/local-birding/swiftwatch.*

chimney that provides shelter for tens of thousands of migratory birds every fall.[2]
A design team renovating the school would not know this from property drawings or soil studies but could learn about the chimney's environmental importance from a neighborhood group or community organization.

STEP 3. CONDUCT SITE ANALYSIS

Prepare a site plan that includes the required information gathered during the site inventory. Analyze the effect of the site features on the project design.

- Overlaying the site information on a map will allow the features to be seen in relation to each other so that a site assessment can be conducted (see *Further Explanation, Example)*.
- Various types of information can be differentiated by color, line type, line weight, contrast, icons, and imagery to make the analysis clear and understandable.
- Highlight important relationships between site features and elements that may influence the project design.
- If regional context outside the items listed in the credit requirements is important for understanding the site and evaluating sustainable design options, it may be helpful to develop an assessment at multiple scales.

STEP 4. COMPLETE SITE ASSESSMENT WORKSHEET OR PREPARE SITE ASSESSMENT NARRATIVE

Complete the USGBC site assessment worksheet, or develop a narrative.

- The worksheet or narrative must indicate which site features were evaluated, what was found, and how the findings influenced the project design.
- If certain features were not assessed, describe why they were excluded.

FURTHER EXPLANATION

FEATURES TO INCLUDE IN THE SITE ASSESSMENT

Topography. Include sufficiently detailed site contours to show the general topography of the site and its regional surroundings. Show unique or significant topographic features, such as rock outcroppings (which may help the design team consider views), irregular topography (which could affect grading), and the direction of overland water flows (which will determine drainage). Identify any steep slopes or areas that are at risk for slope failure. Conduct a site visit. Table 1 lists other possible sources of information.

TABLE 1. Topography sources

Source	Description
Site survey	Physical property inspection to determine slopes
U.S. Geological Survey maps usgs.gov	Topographical and historical maps for U.S. projects
UN Educational, Scientific and Cultural Organization (UNESCO) unesco.org	Global mapping sources for projects outside U.S.
Geographic information system data from local governments	GIS files containing many layers of site condition information

Hydrology. A sustainable approach to rainwater management involves finding ways to harvest it on site for irrigation and other water uses, create beneficial water features, prevent rainwater overflows, and recharge the groundwater and aquifers. Show existing surface water resources, such as lakes, streams, estuaries, and delineated wetlands, and their associated buffers. Identify flood hazard areas, coastal hazard zones, or other flood-prone areas of the site. Include existing rainwater infrastructure, collection, and reuse opportunities that support water-use reduction. Estimate the water storage capacity of the site using Urban Hydrology for Small Watersheds Technical Release 55 (TR-55) (or local equivalent for projects outside the U.S). Table 2 lists other possible sources of information.

TABLE 2. Hydrology sources

Source	Description
Site survey	Physical property inspection to determine hydrology
Geographic information system data from local governments	GIS files containing many layers of site condition information
U.S. Geological Survey maps usgs.gov	Topographical and historical maps showing water flow, water bodies, and watersheds for U.S. projects.
U.S. EPA Surf Your Watershed epa.gov	Information on U.S. watersheds, watershed data, and organizations supporting water quality
UN Environmental Program (UNEP) unep.org	Global source of water quality information
National Wetlands Inventory fws.gov	Inventory of U.S. wetland maps and data
Ramsar Convention on Wetlands ramsar.org	Global inventory of protected wetlands and data
Federal Emergency Management Agency fema.gov	Database of U.S. flood maps
Natural Resources Conservation Service TR-55 program nrcs.usda.gov	Computer program with simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs
Food and Agricultural Organization of the United Nations, Aquastat fao.org	Global source of rainfall data

Climate. Understanding the local climate is a first step in designing climate-appropriate outdoor spaces, incorporating effective passive design strategies, and planning for well-integrated mechanical systems. Climate indicators include high, low, and average monthly temperature and relative humidity. Identify the solar exposure using seasonal sun angles, solar access and shading, solar intensity, and amount of direct sun versus ambient light on cloudy days. Determine the seasonal prevailing winds, including range of wind speeds, and average wind speed and direction. Collect the annual and monthly precipitation patterns and determine whether the rain tends to fall in a few large events or in more frequent but smaller events. Survey pavement and roof surfaces to identify the potential heat island effect of any existing structures. Conduct a site visit. Table 3 lists other possible sources of information:

TABLE 3. Climate sources

Source	Description
National Oceanic and Atmospheric Administration (NOAA) noaa.gov	Source for U.S. climate data and future climate trends
U.S. Department of Energy, Energy Efficiency and Renewable Energy (EERE) energy.gov	Historical weather data for more than 2,100 locations around world
Weather Analytics weatheranalytics.com	Global mapping sources for projects outside U.S.
DOE-2 software doe2.com	DOE-2 energy modeling weather files
National Solar Radiation Database rredc.nrel.gov	Database of historical solar radiation for U.S.

Vegetation. Vegetation provides a wide range of environmental services: rainwater management, filtration, groundwater recharge, soil structure, soil organic matter, erosion prevention, carbon storage, and oxygen production. Inventory the location and type (by scientific name) of significant trees, invasive plants, and any threatened or endangered species. Also indicate the location and limits of greenfield areas and habitat corridors that may support local wildlife. Conduct a site visit. Table 4 lists other possible sources of information.

TABLE 4. Vegetation sources

Source	Description
Site survey and basic vegetation survey	Physical property inspection to gather plant information
U.S. Fish and Wildlife Service Endangered species list fws.gov	List of U.S. endangered species
International Union for Conservation of Nature (IUCN) Redlist iucnredlist.org	Global database of endangered species
Geographic information system data from local governments or independent sources	GIS files identifying many layers of site condition information
Google maps maps.google.com Bing maps bing.com/maps	Aerial photographs for determining site vegetation
U.S. EPA ecoregions epa.gov	Maps identifying North American ecoregions and their associated ecosystems and vegetation types
Local land-use and zoning code maps	Local zoning maps showing stream buffers, riparian zones, wetlands, and other vegetated habitat areas

Soils. Healthy soils allow natural rainwater infiltration, which helps prevent runoff, sedimentation, erosion, and flooding. Soils also aid in cleaning, storing, and recharging groundwater. By storing water and making it available to plants, soils play a significant role in vegetation health. Healthy soils also provide habitat, aid in carbon storage, and serve as structural foundations for buildings. Determine whether the site is designated as prime farmland and identify its soil classification by the Natural Resources Conservation Service (projects outside the U.S. can use a local equivalent). Identify the location of healthy soils as well as previously disturbed soils. Develop a soils management plan to improve poor soils and support vegetation. Table 5 lists other possible sources of information.

TABLE 5. Soils sources

Source	Description
Soil survey	Soil map that classifies soil types and properties of project site
Natural Resources Conservation Service usda.gov	Survey of U.S. soil types and classifications

Human use. Document the previous, current, and future known uses surrounding the site to establish a context for human use. Include the location and condition of on-site buildings and infrastructure. Culturally significant resources are not required to be included in the inventory and assessment, but if these elements are an important part of the site, they may be added. If existing structures cannot be easily restored for a new use, inventory the materials that can be reused or recycled. Identify view corridors that can enhance occupants' experience in outdoor gathering spaces and buildings. Also include planned infrastructure adjacent to the site, such as future roadways, bicycle networks, mass transit, and major pedestrian facilities. Conduct a site visit. Table 6 lists other possible sources of information; if public information on past land uses is not readily available, teams can request documents under the Freedom of Information Act (foia.gov) but should know that the FOIA process can take several months.

TABLE 6. Human use sources

Source	Description
Existing site, local, and regional maps	Framework for current human use
Aerial maps maps.google.com Bing maps bing.com/maps	Aerial photographs for determining adjacent uses and infrastructure
Local land-use and zoning code maps	Land uses, open space, habitat areas, density requirements
Sanborn maps	Historical and current maps of town and building information for U.S. cities and towns
Local comprehensive planning documents	Information about planned uses and future development

Human health effects. Research indicates that the natural environment plays a very important role in human health and well-being. Site design, however, sometimes ignores the human benefits of healthful, green environments and fails to provide opportunities for physical activity, restorative and aesthetic experiences, and social interaction. Identify opportunities for physical activity on or adjacent to the site, such as trails, playgrounds, athletic fields, and gyms. Locate major sources of air, water, and noise pollution that may affect future planning. Identify nearby hospitals, rehabilitation facilities, child care centers, schools, and senior centers whose occupants may be vulnerable to on-site pollution. Table 7 lists possible sources of information.

TABLE 7. Human health effects sources

Source	Description
Aerial maps maps.google.com Bing maps bing.com/maps	Aerial photographs for determining land uses and distances to pollution sources
Local land-use and zoning code maps	Land uses, open space, habitat areas, density requirements
Geographic information system data from local governments or independent sources	GIS files identifying many layers of site condition information
U.S. EPA national-scale air toxics assessment (NATA) epa.gov/nata	DOE-2 energy modeling weather files

DESIGN OPPORTUNITIES

The site assessment may yield many considerations for the design team. View corridors, transportation infrastructure, and adjacent properties, for example, may indicate the best orientation of buildings. If incorporated into the design, prevailing winds and seasonal wind patterns may allow natural ventilation to reduce energy use. Occupants can be protected from noise or air-borne particulates if operable windows are on the lee side, away from pollution sources. Annual, seasonal, and daily precipitation trends as well as potential evaporation are inputs for sizing rainwater collection systems. Information on site topography, soil types, precipitation, and vegetation can help optimize on-site rainwater management. If retained, existing trees and landscape features can make outdoor gathering spaces attractive. Soil types and solar access will determine the location of any community gardens.

EXAMPLE

Sample documentation narrative for topography and contours:

> *An assessment of the site topography was conducted using data found on U.S. Geological Survey maps. The results of the slope analysis show that the site is generally sloping to the northeast with slopes of 4% to 6% over most of the site, and some steep slopes located at the southern edge of the property. The project has elected to avoid building near the steep slopes and established a 300-foot (90-meter) buffer for all construction activity. Building structures have been located on slopes less than 5% to minimize site disturbance. Using the information discovered in the slope analysis, rainwater management measures (a rain garden and bioswale) have been placed in low areas on the site.*

INTERNATIONAL TIPS

A local equivalent for the U.S. Natural Resources Conservation Service TR-55 is acceptable, provided it is at least as stringent.

A local equivalent standard for identifying prime farmland is acceptable, provided the definition is equivalent to the U.S. Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5. The soil survey used to identify prime farmland must follow a methodology equivalent to that of the U.S. Natural Resources Conservation Service.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	All Projects
Site survey or assessment plan or map	X
Site assessment worksheet or equivalent narrative	X

RELATED CREDIT TIPS

Integrative Process Credit. Assessing the site will help project teams meet the site condition and building and site program requirements of the related credit.

LT Credit Sensitive Land Protection. Information gathered for the related credit may be used if wetlands, habitat, flood hazard area, or prime soils are investigated on site.

LT Credit Surrounding Density and Diverse Uses. Analyzing the surrounding sites and diverse uses may help meet the human use and human health requirements of the related credit.

LT Credit Access to Quality Transit. Analyzing the surrounding transportation infrastructure will help achieve the human use portion of the related credit.

LT Credit Bicycle Facilities. Analyzing the surrounding bicycle network will help achieve the human use and human health portions of this credit. Assessing existing bicycle facilities and potential future facility needs will aid in the location of bike facilities for the related credit.

SS Credit Site Development—Protect or Restore Habitat. Assessing the site will identify the greenfield areas on site, a portion of which must be protected to meet the criteria for the related credit. Protecting existing soils will make it unnecessary to restore soils to meet the Option 1 requirements for this credit. Protecting habitat and native vegetation will reduce the amount of disturbed, graded, or compacted area that is required to be restored in Option 1 of the related credit.

SS Credit Open Space. Identification and quantification of applicable outdoor spaces can help achieve the requirements of the related credit.

SS Credit Rainwater Management. Studying the climate, rainfall, and hydrology of the site and watershed will help determine applicable strategies to earn the related credit.

SS Credit Heat Island Reduction. Site assessment can lead to identification of paving, shading, or roofing materials that can contribute to requirements of the related credit.

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. An analysis of the climate, including solar access, temperatures, diurnal swings, wind patterns, humidity, and rainfall will support more effective passive and active energy efficiency strategies.

EA Credit Renewable Energy Production. An evaluation of the climate, wind patterns, and solar exposure can influence the siting and orientation of solar panels, wind turbines, and other renewable energy systems.

EQ Credit Daylight. Topography, vegetation, and solar exposure will influence the orientation of the building and location of windows.

EQ Credit Quality Views. An analysis of the available viewsheds may influence the location of windows.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

Natural Resources Conservation Service, Soils: soils.usda.gov

TR-55 initial water storage capacity: nrcs.usda.gov

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

greenfield area that has not been graded, compacted, cleared, or disturbed and that supports (or could support) open space, habitat, or natural hydrology.

Natural Resources Conservation Service (NRCS) soils delineation a U.S.-based soil survey that shows the boundaries of different soil types and special soil features on the site

previously disturbed areas that have been graded, compacted, cleared, previously developed, or disturbed in any way. These are areas that do not qualify as 'greenfield.'

prime farmland land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that is available for these uses, as determined by the U.S. Department of Agriculture's Natural Resources Conservation Service (a U.S.-based methodology that sets criteria for highly productive soil). For a complete description of what qualifies as prime farmland, see U.S. Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5.

Technical Release (TR) 55 an approach to hydrology in which watersheds are modeled to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes, developed by the former USDA Soil Conservation Service.

SUSTAINABLE SITES CREDIT

Site Development—Protect or Restore Habitat

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1 point)

INTENT

To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

REQUIREMENTS

Preserve and protect from all development and construction activity 40% of the greenfield area on the site (if such areas exist).

AND

OPTION 1. ON-SITE RESTORATION (2 POINTS EXCEPT HEALTHCARE, 1 POINT HEALTHCARE)

Using native or adapted vegetation, restore 30% (including the building footprint) of all portions of the site identified as previously disturbed. Projects that achieve a density of 1.5 floor-area ratio may include vegetated roof surfaces in this calculation if the plants are native or adapted, provide habitat, and promote biodiversity.

Restore all disturbed or compacted soils that will be revegetated within the project's development footprint to meet the following requirements[1]:

- Soils (imported and in situ) must be reused for functions comparable to their original function.
- Imported topsoils or soil blends designed to serve as topsoil may not include the following:
  - soils defined regionally by the Natural Resources Conservation Service web soil survey (or local equivalent for projects outside the U.S.) as prime farmland, unique farmland, or farmland of statewide or local importance; or
  - soils from other greenfield sites, unless those soils are a byproduct of a construction process.

1. *Components adapted from the Sustainable Sites Initiative: Guidelines and Performance Benchmarks 2009, Credit 7.2: Restore Soils Disturbed During Construction*

- Restored soil must meet the criteria of reference soils in categories 1–3 and meet the criteria of either category 4 or 5:
  1. organic matter;
  2. compaction;
  3. infiltration rates;
  4. soil biological function; and
  5. soil chemical characteristics.

Project teams may exclude vegetated landscape areas that are constructed to accommodate rainwater infiltration from the vegetation and soils requirements, provided all such rainwater infiltration areas are treated consistently with SS Credit Rainwater Management.

SCHOOLS ONLY

Dedicated athletic fields that are solely for athletic uses are exempted from the soil restoration criteria. These areas may not count toward the minimum required area.

OR

OPTION 2. FINANCIAL SUPPORT (1 POINT)

Provide financial support equivalent to at least $0.40 per square foot (US$4 per square meter) for the total site area (including the building footprint).

Financial support must be provided to a nationally or locally recognized land trust or conservation organization within the same EPA Level III ecoregion or the project's state (or within 100 miles of the project [160 kilometers] for projects outside the U.S.). For U.S. projects, the land trust must be accredited by the Land Trust Alliance.

BEHIND THE INTENT

Preservation and conservation of intact or high-quality native ecosystems, including their soils, native vegetation, sensitive species habitat, wildlife corridors, and hydrology, contributes to maintaining overall ecosystem health. Projects should endeavor to situate buildings in ways that protect undeveloped land.

When building on previously disturbed sites or sites with previously disturbed areas, a project team should consider restoring soils, hydrology, and native plants, all of which improve the viability of ecological communities, manage and filter rainwater, and fulfill other ecosystem functions. This credit encourages project teams to first consider on-site restoration.

When site constraints prevent on-site restoration, consider off-site conservation and restoration. An off-site approach may provide greater total ecosystem benefits than could otherwise be achieved on site. For projects that are unable to provide large, contiguous parcels of on-site land for long-term conservation, providing financial support to a recognized land trust or conservation organization can be an effective tool. Funds may be earmarked for activities that protect or restore habitat, such as acquiring crucial land parcels, restoring habit that is essential to certain species, protecting water bodies, and preserving urban green space.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY GREENFIELD AREA WITHIN PROJECT

Before siting any buildings, work with a landscape architect, restoration ecologist, or other site professional to identify greenfields within the project boundary.

- Greenfield areas are areas that have not been graded, compacted, cleared, or disturbed and that support (or could support) open space, habitat, or natural hydrology.
- All areas within the project boundary must be categorized as either greenfield or previously disturbed, based on their status at the beginning of the project. If no greenfield areas exist on site, continue to Step 4.
- Areas that naturally do not contain vegetation can count toward greenfield or restored area. For example, natural rock outcrops, ponds, and natural desert all qualify under this credit.
- Project teams do not need to vegetate areas that are not naturally vegetated but must submit documentation showing that the area contains naturally existing unvegetated land or water bodies.

STEP 2. DETERMINE GREENFIELD AREA TO PRESERVE AND PROTECT

If greenfield area exists on the site, work with site professionals to identify at least 40% of the total greenfield area to be preserved and protected from all development and construction activity.

- Ideally, prioritize greenfields that are biodiverse (e.g., a shrub thicket) over monoculture plantings (e.g., turf grass) for preservation and protection.
- Consider the project scope, program, and owner's project goals in determining which areas to preserve and protect.
- Preserve and protect greenfield areas for long-term conservation if possible; this credit does not specify the duration of protection (see *Further Explanation, Best Practices for Habitat Protection*).
- If the entire project site is greenfield, preserve 40% of the total project area.

STEP 3. DEVELOP CONSTRUCTION ACTIVITY MANAGEMENT PLAN FOR GREENFIELD PROTECTION

If applicable, establish and clearly delineate construction buffer zones with the project contractors early in the process to avoid soil compaction and other construction damage to greenfields.

- Limiting disturbance during construction helps minimize the need for additional soil and habitat restoration.
- Refer to strategies listed in SS Prerequisite Construction Activity Pollution Prevention.

STEP 4. SELECT OPTION

Select the appropriate option for the project.

- Option 1 may be feasible for projects that have sufficient land to meet the credit requirements for restoration. Project teams must restore both the habitats and soils that will be revegetated. This restoration will likely happen in parallel (see *Further Explanation, Option 1 Timeline*).
- Option 2 is for projects that are 100% greenfield sites, or cannot meet the requirements for on-site restoration, or choose not to conduct restoration. If choosing Option 2, skip to Option 2, Financial Support, below. If unsure, continue with Steps 5 and 6 to gather more information before making a decision.

STEP 5. IDENTIFY ALL PREVIOUSLY DISTURBED SITE AREA

Work with site professionals to determine the total site area that has been graded, compacted, cleared, or disturbed, if any. Include the building footprint if it is located on previously disturbed land.

STEP 6. DETERMINE ANTICIPATED RATIO OF BUILDING GROSS FLOOR AREA (GFA) TO PREVIOUSLY DISTURBED SITE AREA

Determine the density of the project and surrounding areas by estimating the projected size of the building gross floor area (GFA) and comparing it with the site area.

- Building vertically can significantly reduce a building footprint while increasing site density.
- If the project meets the floor-area ratio (FAR) density minimum, vegetated roofs may be considered part of the restored area (see *Further Explanation, Vegetated Roofs*).

Option 1. On-Site Restoration

STEP 1. DETERMINE AREAS FOR RESTORATION

Early in the design process, work with site professionals to determine the portions of the site that are the best candidates for restoration. Use Equation 1 to verify that at least 30% of previously disturbed areas will be restored.

- Restoration and enhancement of natural site elements can include existing ponds, riparian buffers, vegetation, and other natural features.
- Consider restoring areas adjacent to greenfield, bordering natural areas, and contiguous parcels to increase the environmental benefit.

EQUATION 1. Percentage of restoration area

$$\text{Percentage of restoration area} = (\text{Restoration area} / \text{Total previously disturbed site area}) \times 100$$

The total previously disturbed site area includes the building footprint if it is located on previously disturbed land.

- A vegetated roof may be eligible to be included as part of the total restoration area in Equation 1, provided the project density meets the minimum floor-area ratio threshold (see *Further Explanation, Vegetated Roofs*).

STEP 2. DETERMINE RESTORATION STRATEGIES

Develop and prioritize strategies to restore the previously disturbed site areas identified in Step 1. Restoration must use native or adapted vegetation (see *Further Explanation, Best Practices for Habitat Restoration*).

STEP 3. IDENTIFY DISTURBED AREAS TO BE REVEGETATED

Determine which areas have been disturbed or compacted by previous development and will be revegetated.

- Heavy wheeled traffic, previous grading, compacted dirt roads, equipment storage areas, and parking are examples of uses that disturb soils.
- Only soils that will be revegetated need to comply with this requirement.
- Consider the owner's project requirements and work with environmental consultants to help determine which areas to revegetate.

STEP 4. RESEARCH SOIL CONDITIONS AND REFERENCE SOILS

For the areas that will be restored, compile existing information on such characteristics as compaction level, organic matter, infiltration rates, soil biological function, soil chemistry, soil texture, and soil bulk density (see *Further Explanation, Reference Soils*).

STEP 5. RESTORE SOILS IN AREAS TO BE REVEGETATED

- Imported soil may be used as long as it meets all credit requirements (see *Further Explanation, Soil Restoration*).
- Conduct basic soil tests to demonstrate that the restored soils achieve criteria specified in the requirements (see *Further Explanation, Soil Testing Guidelines*).
- Schools projects that exclude athletic fields from the soils requirements must ensure that the fields are dedicated solely for athletic use (see *Further Explanation, Rating System Variations*).

STEP 6. RESTORE PREVIOUSLY DISTURBED SITE AREAS

Carry out the restoration strategies identified in Step 2.

- A project that constructs vegetated landscape areas to accommodate rainwater infiltration may exclude these areas from the vegetation or soil restoration requirements. However, ensure that all such areas are treated consistently between SS Credit Site Development—Protect or Restore Habitat and SS Credit Rainwater Management.
- Lawns (turf grasses) qualify as adapted vegetation only if they are able to survive without mowing, fertilization, pesticides, and irrigation.

Option 2. Financial Support

STEP 1. DETERMINE AMOUNT OF FINANCIAL SUPPORT

Using Equation 2, establish the minimum financial support that must be dedicated to a qualifying land trust or conservation organization.

EQUATION 2. Financial contribution for conservation

$$\text{Minimum financial contribution} = \text{Total site area ft}^2 \times \$0.40/\text{ft}^2$$

OR

$$\text{Minimum financial contribution} = \text{Total site area m}^2 \times \$4/\text{m}^2$$

STEP 2. IDENTIFY QUALIFYING PARTNER ORGANIZATION

Work with an accredited land trust or conservation organization to identify a use for the contribution and establish an agreement with the organization, detailing the use of the funding (see *Further Explanation, Working with Conservation Organizations).*

- The partnering organization must provide financial support to a project that meets the proximity criteria indicated in the credit requirements (see *Further Explanation, Identifying the Project's Ecoregion*).
- Examples of projects include land acquisition or management for natural processes; native habitat restoration; watershed management, restoration, or protection; and public urban green space restoration or revitalization.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

BEST PRACTICES FOR HABITAT PROTECTION

Define the use of the natural habitat. Will it be available to residents or employees only, or will there be public uses, such as birdwatching? Will there be a pathway or route to enable safe use by pedestrians?

Clearly delineate the boundary of the area to be protected on plans that are part of the site or facilities maintenance documents. Also indicate the boundary on the site with signage or markers.

Monitor habitat areas for invasive species and remove them when they are identified.

Do not use protected habitat areas to store equipment or materials or dispose of waste, whether organic or inorganic. Do not harvest live vegetation, fallen trees, or dead standing trees, unless they pose a danger to human safety or create a fire hazard, or as prescribed by a certified forester for the purposes of advancing habitat protection.

Establish a five- to seven-year site management plan that includes fire management, flooding, and invasive species monitoring and management, if necessary.

BEST PRACTICES FOR HABITAT RESTORATION

Have a certified professional perform a preconstruction site assessment of soils, water sources, and vegetation, and wildlife species (native, adapted, invasive) to determine the current site conditions, historical ecological communities, and the preferred restored site condition.

Any wetland that has been destroyed or damaged prior to commencement of construction should be rebuilt or remediated with the help of professionals. Any wetland damaged or destroyed as a result of construction must be rebuilt or remediated.

Cleared land can become a meadow of native grasses and forbs or be planted with native bareroot trees and shrubs. Forests may require removal of invasive plants to allow native species to become reestablished.

Plan for environmental conditions specific to the site (even a native species will not thrive if planted in an inappropriate microclimate). Use local ecotypes for new plantings.

Source plants from reputable nurseries that can attest to the plant origins, ideally nursery-propagated specimens that originated in the same ecoregion as the project site. Ask suppliers about their sources, and avoid plants that are taken from wild areas. Keep records of the origins of the plant material used, which will help with ongoing management of the site.

The Society for Ecological Restoration International provides additional guidance on best practices for restoring degraded habitat.

Select plants that provide habitat and promote biodiversity. When specifying adapted vegetation, choose cultivars of native vegetation that are not considered invasive plants or noxious weeds, and that grow reliably well in the project's locality with minimal maintenance, winter protection, pest protection, irrigation, and fertilization.

OPTION 1 TIMELINE

Restoration of soils and vegetation will likely happen in parallel following the sequence laid out in Table 1.

TABLE 1. Restoration Timeline

Action	Target
Step 1. Identify all previously disturbed areas on project site	Habitat
Step 2. Determine which of those areas to restore	Habitat
Step 3. Identify restoration strategies	Habitat
Step 4. Identify disturbed soils and soil areas to be revegetated	Soils
Step 5. Research soil conditions and site's reference soils for these areas only	Soils
Step 6. Restore soils in areas to be revegetated	Soils
Step 7. Restore previously disturbed site areas	Habitat

VEGETATED ROOFS

If the density of the project and the roof vegetation meet the credit requirements, the vegetated roof may be counted toward the overall restored area calculation.

Determine the density of the project and surrounding areas by calculating the ratio of the anticipated building footprint to the total project area (including both greenfield and previously disturbed areas). This calculation, the floor-area ratio (FAR), is used in many LEED credits.

A vegetated roof is a strategy that can be applied to other SS credits as well. Green roofs count as open space in SS Credit Open Space if the project meets the same density requirement. In SS Credit Rainwater Management, green roofs contribute to water runoff management for zero lot line projects. A vegetated roof is one of the main strategies for achieving Option 1 in SS Credit Heat Island Reduction. Roofs can be either extensive or intensive systems. Maintenance will be needed to keep plants healthy and the structure in good condition. Artificial turf is not an acceptable strategy for vegetated roofs.

REFERENCE SOILS

Reference soils are native to a site, as described in Natural Resources Conservation Service soil surveys (or a local equivalent for projects outside the U.S.), or undisturbed native soils within the project's region that have native vegetation, topography, and soil textures similar to the project site.

For project sites with no existing reference soil, reference soils are defined as undisturbed native soils within the project's region that support appropriate native plant species similar to those intended for the new project. In some cases, reference soils may differ from the existing soils on the site (if soils were imported).

SOIL RESTORATION[2]

In areas that will be revegetated, restore soil characteristics necessary to support the selected native vegetation types (Table 2).

TABLE 2. Soil restoration guidelines

	Soil criterion	Restoration to reference soil conditions	Required
1	Organic matter	Amend soils with mature, stable compost material such that top 12 inches (300 mm) of soil (at minimum) contains at least 3% organic matter OR organic matter levels and organic matter depth are comparable to site's reference soil	Yes
2	Compaction	Ensure bulk densities within 100% of root zone, defined as minimum of 12 inches (300 mm) in depth OR depth comparable to site's reference soil	Yes
3	Infiltration rate	Achieve infiltration rates (inches/hour) or saturated hydraulic conductivity (millimeters/second) comparable to site's reference soil	Yes
4	Biological function	Establish capacity of biotic community to decompose organic matter and release mineral (plant available) nitrogen; potentially mineralizable nitrogen is used as proxy (see Table 7.2-B, SITES Guidelines and Performance Benchmarks 2009)	Meet either or both of 4 or 5
5	Chemistry	Match pH, cation-exchange capacity, and nutrient profiles of original undisturbed soil or site's reference soil; salinity must be suitable for regionally appropriate vegetation	

Example methods to restore soils include stockpiling and reusing topsoil from the site, with organic amendment if needed; amending site soils in place with organic matter and mechanically correcting compaction if needed (e.g., by ripping); and importing a topsoil or soil blend designed to serve as topsoil.

For on-site amendment or blending of imported soils, select organic materials from sources that are renewable within a 50-year cycle. Compost is recommended for its stability, biological qualities, and ability to build soil structure. If mature, stable compost is not locally available, look for locally available organic residuals that can be composted on- or off-site to produce a mature composted organic amendment. Involve a qualified horticultural or soil professional in selecting and balancing amendments for healthy plant growth.

Compost that enhances soil's ability to support vegetation has the following characteristics:

- **A carbon to nitrogen ratio below 25:1.** Higher C:N ratios may be acceptable if specified by a qualified professional as more appropriate for the type of vegetation to be established.
- **Low pollutant concentrations.** Do not exceed the limits established by U.S. EPA in the 40 CFR Part 503 Biosolids Rule, Section 503.13, Table 3, Pollutant Concentrations, or any applicable state or local regulations.
- **No weed seeds.** Compost should not contain viable weed seeds or invasive plant propagules.

SOIL TESTING GUIDELINES

Project teams can take samples of the soils and send them to a laboratory for testing. Local government agencies may offer inexpensive testing of soil samples and guidance around sampling procedures.

Samples must be taken from soils that are disturbed or compacted and will be revegetated. (Soils that will not be revegetated can be excluded from the test.) If the soils test shows that the restored soil meets reference soil attributes, the project meets the requirements.

Typically, multiple samples of the same soil are taken. If a project site has more than one type of soil that will be revegetated, taking multiple samples from each soil type provides a comprehensive picture of the soil condition.

Soil sample test results may include the components listed in Table 3.

2. *SITES Guidelines and Performance Benchmarks 2009, Credit 7.3.*

TABLE 3. Soil components

Soil sample Test result components	Soil sample Test result components
Base	pH Conductivity (measure of soil salinity) Organic matter
Anions	Sulfur Phosphorus Nitrate-N
Cations	Potassium Calcium Magnesium Sodium
Minor elements	Iron Zinc Manganese Copper Boron Aluminum

WORKING WITH CONSERVATION ORGANIZATIONS (OPTION 2)

For U.S. projects, the land trust must be accredited by the Land Trust Alliance and be in the same Level III ecoregion or within the same state as the project.

For projects outside the U.S., the land trust or conservation organization must be located within 100 miles (160 km) of the project.

If there are multiple options for recipients of financial support, project teams may wish to consult with potential recipients to determine the financial need of the organization, the intended use of the contribution, and compatibility with the project's own conservation goals.

IDENTIFYING THE PROJECT'S ECOREGION

Project teams in the U.S. can use the classification system of the Environmental Protection Agency (EPA) to identify their Level III ecoregion and its characteristic native vegetation and soils. Refer to EPA's ecoregion map for more information, at epa.gov/wed/pages/ecoregions/level_iii_iv.htm. If EPA ecoregion information is not available for the project's area, ask the state government's environmental agency for comparable information.

Project teams outside the U.S. should also determine their ecoregion to help inform decisions about habitat protection and restoration.

EXAMPLE

The project illustrated in Figure 1 is pursuing Option 1 by restoring previously disturbed area. Tables 4 and 5 show the team's calculations for demonstration of compliance.

TABLE 4. Example calculation for minimum greenfield and restored area requirements

	Area	Preserved or restored area	Percentage of site area
Total site area (greenfield and previously disturbed)	280,000 ft^2 (26 000 m^2)		
Minimum greenfield area on site	180,000 ft^2 (16 700 m^2)	135,000 ft^2 (12 500 m^2)	**75% (minimum 40% required)**
Total previously disturbed area of site (including building footprint)	100,000 ft^2 (9 290 m^2)		
Rainwater management area (excluded from total previously disturbed)	20,000 ft^2 (1 900 m^2)		
Net previously disturbed area	80,000 ft^2 (7 400 m^2)	30,000 ft^2 (2 800 m^2)	**37.5% (minimum 30% required)**
Greenfield area on site	180,000 ft^2 (16 700 m^2)	135,000 ft^2 (12 500 m^2)	**75% (minimum 40% required)**

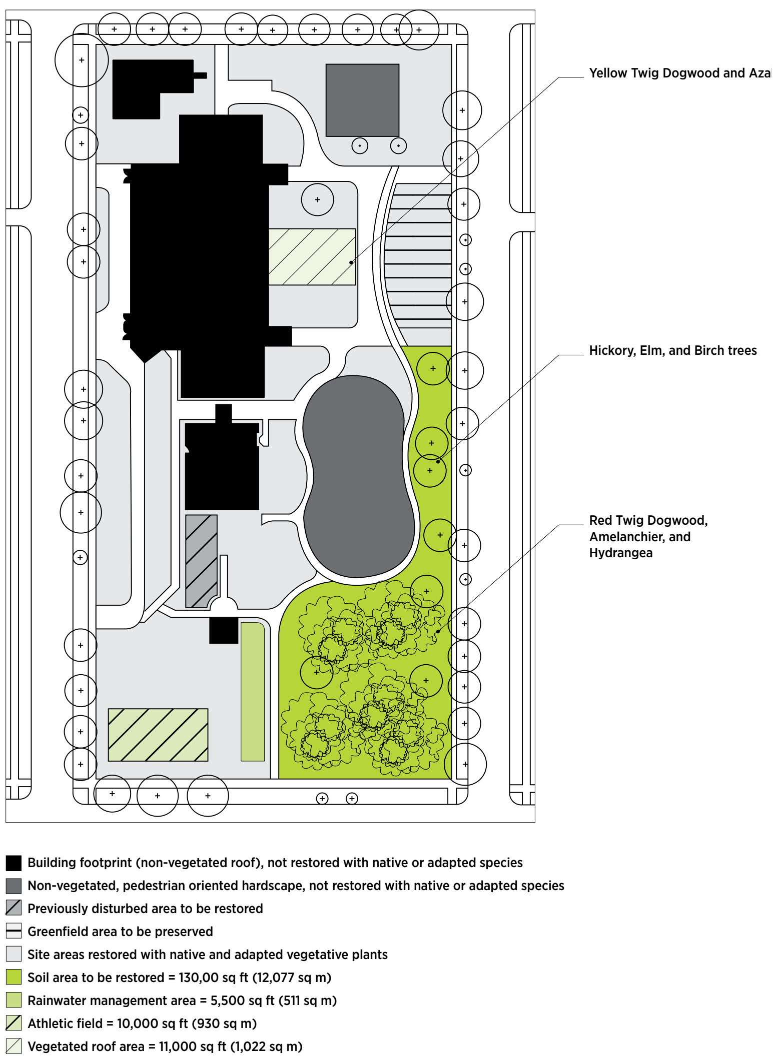


Figure 1. Example protection and restoration site plan

TABLE 5. Example calculation for minimum revegetation and soils restoration requirement

	Area	Notes
Area to be restored	30,000 ft^2 (2 800 m^2)	See Table 4, row 5
Building FAR	1.7	Because FAR > 1.5, vegetated roof can be included in revegetation area
Green roof area	8,000 ft^2 (740 m^2)	Because FAR > 1.5, vegetated roof can be included in revegetation area
Area of soils to be restored	20,000 ft^2 (1 900 m^2)	Area of soils restoration excludes vegetated roof areas

FAR = floor-area ratio

SAMPLE DOCUMENTATION NARRATIVES[3]

Removal and Storage of Topsoil and Duff

Describe strategies employed for the removal of the topsoil and duff to preserve native seed stock and materials for future use. Best practice for the storage of soils for reuse is to store them in shallow piles to allow air movement and protection of soil microorganisms.

> *Prior to disturbance, the Contractor shall salvage existing litter, duff, and upper 3 inches (75 mm) of topsoil from areas to be graded or disturbed on the project site and store until it can be incorporated back into the revegetation project. Litter and duff can be stockpiled together, but must be kept away from topsoil, in piles that are shallow and narrow. Protect stockpiles from precipitation. At no time shall materials be stockpiled for more than 3 months without approval of the engineer. See the attached schedule for specific timing of this treatment.*

Grading and Slope Shaping

Describe what grading or earth moving activities are required for the revegetation project. Soil preparation on slopes may require physical modification or surface roughening. Consider evaluating site complexity of undisturbed areas relative to grades. For example, there may be "microsites" that have depressions or texture changes that can help provide a greater diversity in habitats that need to be mimicked in the restored areas.

> *Areas to be graded or excavated and revegetated include the base of slope to accommodate a retaining wall and installation of the shallow infiltration basin as permitted. For planting areas, scarify the top 6 inches (150 mm) of subgrade before fill placement. Subgrade depths plus specified depth of topsoil should equal finished grade. Contractor shall establish finished grades to blend with existing grades and eliminate uneven areas resulting from rough-grading operations. See the attached schedule for specific timing of these treatments.*

Soil Loosening

Describe physical activities required to restore infiltration capacity and aeration to compacted soil areas.

> *To reduce soil compaction, loosen subgrade of compacted soil areas to an average depth of 12 inches (300 mm). Soil loosening may be performed with hand tools or a mini excavator equipped with backhoe bucket. Soil shall be loosened but not turned or inverted. Soil loosening should be uneven in depth by at least 1–2 inches (25–50 mm) to reduce the chance of soil slumping. Avoid existing plants and tree roots wherever loosening takes place. See the attached schedule for specific timing of this treatment.*

Soil Amendments and Fertilizer

Describe the type, quantity, and application rate of any soil amendments or fertilizers used to improve physical, chemical, or biological properties of the soil.

> *Apply aged wood chips to a depth of 1 inch (25 mm) on the surface of soil loosened areas. Incorporate compost to a depth of 3–4 inches (75–100 mm) and organic phosphorus-free fertilizer at a rate of 270 lbs per acre (50 kg per hectare) into areas where topsoil is to be replaced and into areas compacted during construction activities. Evenly spread compost and*

3. *Example text for soils restoration adapted from tahoebmp.org/Documents/BMPHandbook/Chapter%205/Ch5_2_RevPlnEx.pdf.*

fertilizer on topsoil and incorporate it within using hand tools or mini excavator. After fertilizer application, water area slowly to help incorporate fertilizer into the soil. Water only until soil is moist to avoid runoff of fertilizer off-site. See the attached schedule for specific timing of these treatments.

Soil Stabilization

Describe soil stabilization practices, which may include reapplication of salvaged duff material collected and stored during the site preparation process, bare soil protection using inorganic and organic mulch, and use of tackifiers, soil binders, and hydromulch.

Replace topsoil in disturbed areas (from which topsoil was removed before construction), spread to a uniform depth of 3 inches (75 mm), and gently compact into place. Topsoil shall be dry. This operation shall be conducted during dry weather. All debris, roots, weeds, and other materials in excess of 1 inch (25 mm) in diameter shall be removed while topsoil is being spread. Place wood chips to a 1-inch (25-mm) depth on the surface of loosened areas and incorporate during soil loosening. After seeding, salvaged duff and wood chips shall be evenly applied to the soil surface to a 1-inch (25-mm) depth. Then apply pine needles to increase depth to 2 inches (50 mm). After duff replacement and wood chip and pine needle application, apply tackifier according to manufacturer's specifications in said area on the same working day. Tackifiers shall be chosen with consideration of the sources of these resins: avoid hydro-carbon based products, and prefer organic, natural, and nontoxic materials .

Soil Reuse

Describe how soils have been reused for functions comparable to their original function.

Soil that will be reused on site was collected from the existing site, which contained three main types of uses: vegetation soil in plant beds, structure foundations, and athletic fields. These soils have been preserved separately and will be placed on the project in similar spaces with similar functions. The plant bed soils will be used in planter boxes located throughout the project near the plazas. The foundation soils will be used as part of the material for the foundation of the main project building. Finally, the soils from the former athletic fields will be used in the project's open turf multipurpose area.

RATING SYSTEM VARIATIONS

Schools

- Athletic fields are exempt from the soils requirements if they are used solely for athletic purposes.
- Athletic fields cannot be used toward the 30% restoration requirement.

INTERNATIONAL TIPS

Project teams must identify the agency in their country that is responsible for land conservation issues. U.S. federal agencies may be a good resource to identify counterparts in other countries. Local entities can provide guidance on restoration activities and information regarding land trust projects and conservation organizations within the required distance from the project for teams pursuing Option 2.

Groups that work internationally include NatureServe Natural Heritage Program, Conservation International, and World Land Trust.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	All Projects	Option 1	Option 2
Greenfield area calculations	X		
Description of greenfield area protection (if applicable)	X		
Native or adapted vegetation calculations		X	
Site plan depicting project boundary, building footprint, preserved greenfield area(s) (if applicable), previously disturbed area, restored area, native and adapted vegetation, plant species, other ecologically appropriate features, and any other relevant site conditions		X	
Description of disturbed or compacted soils to be revegetated		X	
Reference soil characteristics and soil test results		X	
Projects with vegetated roofs: provide the floor area ratio (FAR)		X	
Financial support calculations			X
Agreement with land trust or conservation organization			X
U.S. projects: Confirmation that land trust is accredited by Land Trust Alliance			X
Projects outside U.S.: Verification that conservation organization is nationally or locally recognized; description of qualifications and mission of conservation organization			X

RELATED CREDIT TIPS

SS Prerequisite Construction Activity Pollution Prevention. This credit and the related prerequisite have the same purpose: to preserve and protect greenfields during construction activity. Projects may be able to use some of the same techniques for both.

SS Credit Site Assessment. Opportunities identified in the related credit can be used to preserve habitat and soils.

SS Credit Open Space. Greenfield, protected, and restored areas can be counted for both credits.

SS Credit Rainwater Management. Landscaped areas designed for rainwater management can be excluded from soils requirements if the areas use native or adapted vegetation and meet the restoration requirements.

SS Credit Heat Island Reduction. Vegetated roofs can be counted for both credits.

LT Credit High-Priority Site. When planning for habitat restoration on brownfield or contaminated sites, special consideration should be given to the potential interaction and spreading of contaminants through attracted species and site hydrology.

CHANGES FROM LEED 2009

- The setback requirements were replaced with preservation and restoration requirements.
- Soil requirements have been modified to include disturbed or compacted soils.
- The off-site option was replaced with an option for financial support.

REFERENCED STANDARDS

U.S. EPA ecoregions: epa.gov

Land Trust Alliance accreditation: landtrustalliance.org

Natural Resources Conservation Service, web soil survey: websoilsurvey.nrcs.usda.gov

Sustainable Sites Initiative (**SITES™**)**:** sustainablesites.org

EXEMPLARY PERFORMANCE

Option 1. Double the 30% restoration requirement (restore at least 60%).

Option 2. Double the financial donation requirement (provide at least $0.80 per square foot or $8.00 per square meter).

DEFINITIONS

density a measure of the total building floor area or dwelling units on a parcel of land relative to the buildable land of that parcel. Units for measuring density may differ according to credit requirements. Does not include structured parking.

development footprint the total land area of a project site covered by buildings, streets, parking areas, and other typically impermeable surfaces constructed as part of the project

greenfield that has not been graded, compacted, cleared, or disturbed and that supports (or could support) open space, habitat, or natural hydrology.

land trust a private, nonprofit organization that, as all or part of its mission, actively works to conserve land by undertaking or assisting in conservation easement or land acquisition, or by its stewardship of such land or easements (Adapted from Land Trust Alliance)

native vegetation a species that originates in, and is characteristic of, a particular region and ecosystem without direct or indirect human actions. Native species have evolved together with other species within the geography, hydrology, and climate of that region.

previously disturbed areas that have been graded, compacted, cleared, previously developed, or disturbed in any way. These are areas that do not qualify as 'greenfield.'

prime farmland land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and that is available for these uses, as determined by the U.S. Department of Agriculture's Natural Resources Conservation Service (a U.S.-based methodology that sets criteria for highly productive soil). For a complete description of what qualifies as prime farmland, see U.S. Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5.

reference soil a soil native to the project site, as described in Natural Resources Conservation Service soil surveys (or a local equivalent survey outside the United States), or undisturbed native soils within the project's region that have native vegetation, topography, and soil textures similar to the project site. For project sites with no existing soil, reference soils are defined as undisturbed native soils within the project's region that support appropriate native plant species similar to those intended for the new project.

SUSTAINABLE SITES CREDIT

Open Space

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To create exterior open space that encourages interaction with the environment, social interaction, passive recreation, and physical activities.

REQUIREMENTS

Provide outdoor space greater than or equal to 30% of the total site area (including building footprint). A minimum of 25% of that outdoor space must be vegetated (turf grass does not count as vegetation) or have overhead vegetated canopy.

The outdoor space must be physically accessible and be one or more of the following:

- a pedestrian-oriented paving or turf area with physical site elements that accommodate outdoor social activities;
- a recreation-oriented paving or turf area with physical site elements that encourage physical activity;
- a garden space with a diversity of vegetation types and species that provide opportunities for year-round visual interest;
- a garden space dedicated to community gardens or urban food production;
- preserved or created habitat that meets the criteria of SS Credit Site Development—Protect or Restore Habitat and also includes elements of human interaction.

For projects that achieve a density of 1.5 floor-area ratio (FAR), and are physically accessible, extensive or intensive vegetated roofs can be used toward the minimum 25% vegetation requirement, and qualifying roof-based physically accessible paving areas can be used toward credit compliance.

Wetlands or naturally designed ponds may count as open space if the side slope gradients average 1:4 (vertical : horizontal) or less and are vegetated.

FOR PROJECTS THAT ARE PART OF A MULTITENANT COMPLEX ONLY

Open space can be either adjacent to the building or at another location in the site master plan. The open space may be at another master plan development site as long as it is protected from development. If the open space is not adjacent to the building, provide documentation showing that the requirements have been met and the land is in a natural state or has been returned to a natural state and conserved for the life of the building.

BEHIND THE INTENT

When building occupants have opportunities to connect with the outdoors, they exhibit improved well-being and productivity.[1] Open spaces also provide many positive environmental benefits—habitat creation, linked habitat corridors in urban areas, increased rainwater infiltration, and reduced heat island effect.

An open space's features can influence both its use by people and its environmental benefits. For example, turf and paved plazas can encourage group activities that foster social interaction, and including vegetation in at least some portion of the open space offers direct benefits to the environment. Open spaces with qualities that support environmental goals could include community gardens, vegetated roofs, preserved habitats with learning opportunities, and gardens that provide visual interest all year long.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE TOTAL AREA WITHIN PROJECT BOUNDARY

Calculate the total site area within the project's boundary.

STEP 2. CALCULATE OPEN SPACE AND VEGETATED AREA REQUIRED

Use Equation 1 to determine the amount of required open space, and Equation 2 to determine the amount of open space that must be vegetated (see *Further Explanation, Example 1*).

EQUATION 1. Required open space

$$\text{Required open space} \geq 30\% \times \text{Total site area}$$

EQUATION 2. Vegetated space

$$\text{Vegetated space} \geq 25\% \times \text{Required open space}$$

STEP 3. PROGRAM SITE

Identify and designate open space features early in the planning and programming of the site to optimize building placement and landscape design. Ensure that open and vegetated spaces meet or exceed the minimum required areas. Consider the following strategies to optimize open space use:

- Coordinate open space features early in the planning and programming phase to optimize building placement and landscape design. Master planning occurs well before the conceptual design phase of the building development. Facilitating a charrette with the future building occupants, design team, and community members may help in planning for open space that meets the needs of the users.
- Design a compact parking and road footprint layout to preserve open land and provide connections to adjacent ecosystems.
- Tighten program needs and stack floor plans to reduce the building footprint.
- Maximize floor-area ratio (FAR) and accessibility for the greatest range of open space credit options, as outlined in the credit requirements (see *Getting Started, Density,* for an example FAR calculation).

STEP 4. DESIGN OPEN SPACE AREAS

Design each open space area to comply with one or more of the criteria listed in the credit requirements. All open space must be physically accessible and encourage use by occupants of the building and site, but it does not have to be active space (see *Further Explanation, Example 2*).

1. *Parker, D.C., The Corporate Garden, in D. Relf (ed.), The Role of Horticulture in Human Well-Being and Social Development (Portland, Oregon: Timber Press, 1990).*

Turf areas, including areas of turf grass under overhead tree canopies, can be counted in total open space but do not qualify as vegetated open space.

- Extensive or intensive vegetated roofs can be used toward the minimum 25% vegetation requirement. Vegetated roof area can also be counted as open space if it is accessible to the building occupants and the project has a density of 1.5 FAR or greater. Roofs can be either extensive or intensive systems. Maintenance will be needed to keep plants healthy and the structure in good condition. Artificial turf is not an acceptable strategy for vegetated roofs.
- Design open spaces for the specific project location. For example, a xeriscape area might be appropriate in arid locations.
- Open spaces must be usable; a small strip of turf in a parking lot does not meet the intent of the credit. Artificial turf does not count as vegetation or hardscape.
- Determine where overhead vegetation (trees and shrubs), rather than ground cover, would be appropriate.
- Projects may count ponds or wetlands that occur naturally or are designed to function similarly to natural site hydrology and land cover, provided they meet the credit requirements.
- Consider encouraging human interaction with wetlands and natural areas through features such as educational signage, walking trails, and observation stations.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

EXAMPLE 1. REQUIRED SPACE

Equations 1 and 2 (see *Step-By-Step Guidance*) are used to determine the required open space and vegetated area of a 100,000-square-foot (9 295-square-meter) site.

TABLE 1. Example open space summary

Total site area (including building footprint)	100,000 ft^2	
Open space required	30,000 ft^2	= 100,000 x (0.3)
Vegetated area required	7,500 ft^2	= 30,000 x (0.25)
Remaining designated outdoor open space	22,500 ft^2	= 30,000 – 7,500
Total building floor area	175,000 ft^2	FAR 1.75
Vegetated roof counts toward vegetation requirement?	Yes	

EXAMPLE 2. SITE DESIGN

The site illustrated below includes a variety of social gathering spaces and areas that encourage interaction with the environment.

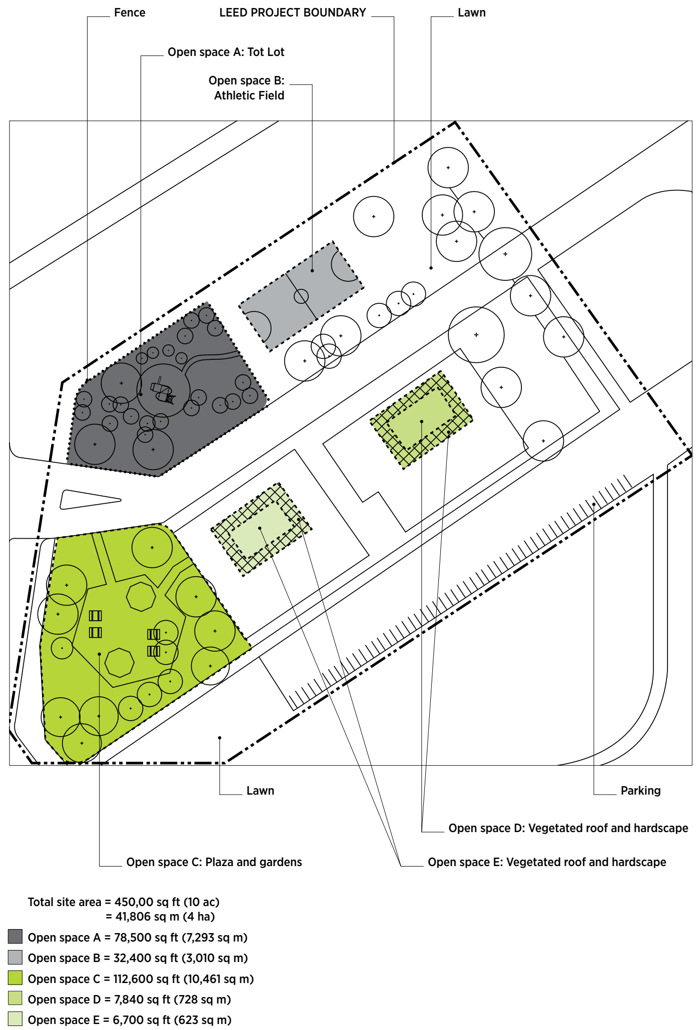


Figure 1. Example site design

PROJECT TYPE VARIATIONS

Multitenant Projects

- A project can follow the multitenant complex approach if it is part of a master plan development, regardless of whether the project is using the LEED Campus Program.
- If the open space is located at a nonadjacent site within the development master plan, it must be protected from development and must be returned to a natural state (e.g., with native vegetation, close to original hydrology).
- A combination of adjacent open space and nonadjacent open space may be used.

CAMPUS

Group Approach

All buildings in the group may be documented as one. The open space does not have to be adjacent to the individual buildings but it must be contained within the LEED project boundary.

Campus Approach

Eligible. The open space does not have to be adjacent to the individual buildings but it must be contained within the LEED campus boundary.

REQUIRED DOCUMENTATION

Documentation	All Projects	Projects with Vegetated Roofs
Site plan that indicates project boundary and campus or master plan boundary (if applicable), highlighting location and size of any open spaces, vegetated areas, plant species, wetlands or naturalistic man-made ponds (with side slopes noted), and vegetated roofs	X	
Open space and vegetated area calculations	X	
Description of how open space is physically accessible and meets area type criteria	X	
Floor-area ratio		X

RELATED CREDIT TIPS

SS Credit Site Development—Protect or Restore Habitat. Preserved or created habitat, including vegetated roofs, that meets the criteria of the related credit and includes elements of human interaction can also count towards this credit.

SS Credit Rainwater Management. Wetlands or naturalistic ponds designed for rainwater collection may count as open space for this credit.

SS Credit Heat Island Reduction. Vegetated roofs and high reflectance paving on roof decks and terraces can contribute to requirements for the related credit. Vegetated roofs can also be counted as open space if the roof areas are accessible and the project has a density of 1.5 FAR or greater.

SS Credit Site Assessment. A site assessment can identify open space opportunities and vegetated areas to preserve, which will support achievement of this credit.

CHANGES FROM LEED 2009

- The credit is no longer tied to presence of a local zoning code; the same open space requirement applies to all projects.
- The credit has been revised to emphasize the quality of the open space in addition to the quantity.
- The intent of the credit has been modified to encourage physical connection to open space and to reduce the focus on biodiversity (which is covered in SS Credit Site Development—Protect or Restore Habitat).

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

extensive vegetated roof a roof that is covered with plants and typically not designed for general access. Usually an extensive system is a rugged green roof that requires little maintenance once established. The planting medium in extensive vegetated roofs ranges from 1 to 6 inches in depth. (Adapted from U.S. Environmental Protection Agency)

floor-area ratio (**FAR**) the density of nonresidential land use, exclusive of parking, measured as the total nonresidential building floor area divided by the total buildable land area available for nonresidential structures. For example, on a site with 10,000 square feet (930 square meters) of buildable land area, an FAR of 1.0 would be 10,000 square feet (930 square meters) of building floor area. On the same site, an FAR of 1.5 would be 15,000 square feet (1395 square meters), an FAR of 2.0 would be 20,000 square feet (1860 square meters), and an FAR of 0.5 would be 5,000 square feet (465 square meters).

intensive vegetated roof a roof that, compared with an extensive vegetated roof, has greater soil volume, supports a wider variety of plants (including shrubs and trees), and allows a wider variety of uses (including human access). The depth of the growing medium is an important factor in determining habitat value. The native or adapted plants selected for the roof should support the site's endemic wildlife populations. (Adapted from Green Roofs for Healthy Cities)

multitenant complex a site that was master-planned for the development of stores, restaurants and other businesses. Retailers may share some services and common areas.

site master plan an overall design or development concept for the project and associated (or potentially associated) buildings and sites. The plan considers future sustainable use, expansion, and contraction. The site master plan is typically illustrated, with building plans (if applicable), site drawings of planned phased development, and narrative descriptions.

SUSTAINABLE SITES CREDIT

Rainwater Management

This credit applies to:

New Construction (2–3 points)
Core and Shell (2–3 points)
Schools (2–3 points)
Retail (2–3 points)
Data Centers (2–3 points)
Warehouses and Distribution Centers (2–3 points)
Hospitality (2–3 points)
Healthcare (1–2 points)

INTENT

To reduce runoff volume and improve water quality by replicating the natural hydrology and water balance of the site, based on historical conditions and undeveloped ecosystems in the region.

REQUIREMENTS

OPTION 1. PERCENTILE OF RAINFALL EVENTS

Path 1. 95th Percentile (**2 points except Healthcare, 1 point Healthcare**)
In a manner best replicating natural site hydrology processes, manage on site the runoff from the developed site for the 95th percentile of regional or local rainfall events using low-impact development (LID) and green infrastructure.

Use daily rainfall data and the methodology in the U.S. Environmental Protection Agency (EPA) Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act to determine the 95th percentile amount.

OR

Path 2. 98th Percentile (**3 points except Healthcare, 2 points Healthcare**)
Achieve Path 1 but for the 98th percentile of regional or local rainfall events, using LID and green infrastructure.

OR

Path 3. Zero Lot Line projects only—85th Percentile (**3 points except Healthcare, 2 points Healthcare**)
The following requirement applies to zero lot line projects in urban areas with a minimum density of 1.5 FAR. In a manner best replicating natural site hydrology processes, manage on site the runoff from the developed site for the 85th percentile of regional or local rainfall events, using LID and green infrastructure.

OR

OPTION 2. NATURAL LAND COVER CONDITIONS (3 POINTS EXCEPT HEALTHCARE, 2 POINTS HEALTHCARE)

Manage on site the annual increase in runoff volume from the natural land cover condition to the postdeveloped condition.

PROJECTS THAT ARE PART OF A MULTITENANT COMPLEX ONLY

The credit requirements may be met using a coordinated approach affecting the defined project site that is within the master plan boundary. Distributed techniques based on a watershed approach are then required.

BEHIND THE INTENT

Conventional site development disrupts natural hydrological systems and watersheds through impervious surfaces, soil compaction, loss of vegetation, and loss of natural drainage patterns. The cumulative effect of these changes is disruption to the natural water balance and a loss of water resources. Typically, a conventional site's rainwater management technique is to address runoff as a byproduct to be disposed of by piping and conveying it as quickly as possible into centralized, large facilities at the base of drainage areas. However, such a strategy, although intended to prevent flooding and promote efficient drainage, can harm watersheds: it increases the volume, temperature, peak flow, and duration of runoff, eroding streams reducing groundwater recharge and stream baseflow, and increasing the amount and types of pollutants discharged to surface waters.

The v4 credit addresses the management of both the quantity and quality of rainwater runoff. This is done through the required use of green infrastructure (GI) and low-impact development (LID) strategies, which improve upon the conventional approach by mimicking a site's natural hydrology and managing water as close to the source as possible. Rainwater is treated as a resource rather than a waste product. The approaches and techniques in this credit involve minimizing disturbed areas on the project site, limiting the amount of impervious cover on a site, and then infiltrating, filtering, storing and reusing, evaporating, or detaining rainwater runoff at or close to its source. The approaches also focus on restoring or designing landscapes to function hydrologically more like the natural, undisturbed landscape of a given location.

This credit's process is iterative in nature, which means that the project will need to conceptualize, calculate, and refine the design until the requirements are achieved to ensure that both the intent of the credit and the project's goals are met. As such, the Step-by-Step Guidance is intended to be a guide only. The steps may need to be repeated or revisited throughout the design process. The rainwater management professional(s) may also have other steps that they typically follow to achieve the requirements.

STEP-BY-STEP GUIDANCE

Select the appropriate option and path (if applicable) for the project. First investigate data sources for natural land cover conditions, and choose Option 1 if information is not available.

- Option 1 is for projects that elect to manage rainfall on their project site such that there is no immediate discharge after development for all rainfall events of a given depth. The specific rainfall depth is based on a statistical analysis of rainfall records for that project location. If the project is zero lot line and meets the credit's required density, Path 3 can be selected. Otherwise, it is recommended that the rainfall values for both the 95th and 98th percentile events are calculated to determine whether Path 1 or Path 2 is more appropriate for the project.
- Option 2 is for projects that elect to evaluate the site hydrologic response based on both natural, undisturbed (i.e. pre-settlement) conditions, and proposed developed conditions. The proposed rainwater management design will implement measures that replicate the natural, undisturbed hydrology for the full range of hydrologic events. This will require hydrologic analysis and comparison of the site under both natural and proposed conditions, using representative rainfall data such as an analysis of all rainfall events during a statistically representative period of time.

Option 1. Percentile of Rainfall Events

STEP 1. DETERMINE IF PROJECT QUALIFIES FOR ZERO LOT LINE PATH (PATH 3)

If the project does not qualify for Path 3, move directly to Step 2.

- Option 1 is for projects that elect to manage rainfall on their project site such that there is no immediate discharge after development for all rainfall events of a given depth. If the project does not exactly meet this definition, but the project team feels that it should be considered zero lot line, provide justification for why it qualifies for this path.
- Calculate the average density of the area within a ¼-mile (400-meter) radius of the project building. If the density, expressed in terms of floor-area ratio (FAR) is less than 1.5, the project is ineligible for the zero lot line path.

STEP 2. OBTAIN RAINFALL DATA FOR PROJECT LOCATION

Obtain at least 10 years of historical rainfall data, or as much historical data as possible, representative of the project climate conditions based on proximity to site, elevation, region, etc. If the team submits less than 10 years' worth of information, explain why additional historical data are not available.

- The rainfall record should be substantially complete, meaning that it is not missing data for extensive periods of time.
- For projects in the U.S., long-term rainfall data for many locations are available through the National Climatic Data Center. Use this database or another source to identify the reference location closest to the project site where similar precipitation patterns are expected (see *Further Explanation, Percentile of Rainfall Events*).
- For project locations outside the U.S. or other locations not covered by the National Climatic Data Center, obtain information from local airports, universities, water treatment plants, or other facilities that maintain long-term precipitation records (see *Further Explanation, International Tips*).
- Data must include the location of the monitoring station, the recording time (usually daily 24-hour time periods), and the total precipitation depth during the time-step.

STEP 3. DETERMINE VALUE FOR CHOSEN PERCENTILE OF RAINFALL EVENTS

Using the historical rainfall data collected, calculate the rainfall value for the 95th, 98th, or 85th percentile (in inches or millimeters). This is the precipitation amount that 95 percent (or 98 percent, or 85 percent) of all rainfall events for the period of record do not exceed and will be represented by a rainfall depth (see *Further Explanation, Percentile of Rainfall Events*).

- Only calculate the 85th percentile if the project meets the criteria in Path 3.
- If the project does not meet the criteria in Path 3, choose which percentile- either the 95th or the 98th- is most appropriate for the project.

STEP 4. ANALYZE EXISTING SITE PERFORMANCE

Prior to calculating the runoff volume from the proposed site design, analyze how the current site is performing relative to the management of precipitation.

- A reduction in the volume of runoff can be achieved by protecting existing natural resources that serve to reduce the generation of runoff.
- The site analysis may reveal existing areas that, with no or minimal alterations, could contribute to the management of rainwater runoff.
- Examples of areas to preserve include healthy un-compacted soils, riparian buffers, tree canopy, etc.
- These areas must be protected from disturbance during the construction period. If protected from disturbance during construction, these natural areas may be excluded from the project area and hence excluded from runoff volume management

STEP 5. DESIGN THE SITE

Conceptually design the site, including rainwater management strategies, using the site performance analysis to inform the design. Include any preserved site features that could contribute to a reduction in, or the management of, runoff volume.

- Roughly locate, layout, and size rainwater management features in relation to the buildings, topography, soils, and other site features and the overall site program.
- It is recommended that a conceptual design be developed first, as projects frequently change and refine the design later after calculating runoff in order to manage the required volume.

STEP 6. CALCULATE RUNOFF VOLUME TO BE MANAGED ON SITE

Use the conceptual design to calculate the total volume of runoff (in cubic feet or cubic meters) corresponding to the chosen percentile of rainfall events for the site in its developed condition. This is the amount of precipitation that the project will need to manage entirely on site through green infrastructure and low-impact development techniques.

- Different methods can be used to calculate the runoff volume. The land use runoff coefficients for small rainfall depths, as developed by Dr. Robert Pitt in Table 5 of Small Storm Hydrology Method, are recommended.
- Runoff volume should be calculated by land use type and depends on the specific developed site conditions of the project, such as amount of paving, permeability of different surfaces, roof area, and vegetated areas (see *Further Explanation, Calculations and Further Explanation, Example*).

STEP 7. MANAGE RUNOFF VOLUME ON SITE

Incorporate green infrastructure and low-impact development strategies into the site design to manage, on site, 100% of the total volume of runoff calculated for the chosen percentile rainfall event and the project's developed conditions (the proposed design).

- Work with the project's civil engineer, landscape architect, or other qualified professionals to choose and size the design strategies (see *Further Explanation, Green Infrastructure and Low-Impact Development Strategies*).
- The chosen GI and LID measures should completely manage the required runoff volume for the chosen rainfall percentile.
- Calculations must account for the site-specific soil characteristics, the soil infiltration rate, and the storage capacity of all GI and LID measures.
- For projects following Path 3, green roofs and rainwater harvesting approaches are the most likely GI and LID strategies to help zero lot line projects meet the credit requirements. Roofs can be either extensive or intensive systems. Maintenance will be needed to keep plants healthy and the structure in good condition. Artificial turf is not an acceptable strategy for vegetated roofs. In some cases, zero lot line projects can also use infiltration planters, porous pavement, and tree boxes.
- For projects that are part of a multitenant complex, see *Further Explanation, Project Type Variations*.

STEP 8. ANALYZE AND REFINE PROPOSED SITE DESIGN

Refine the site design using the calculated runoff and proposed management strategies from the conceptual design. Determine if the proposed design is performing sufficiently enough to manage the required volume of runoff onsite using GI/LID strategies. Continue to tweak and refine the design, by repeating steps 5, 6, and 7 as many times as necessary, in order to achieve the credit requirements and meet project's goals.

- Rainwater management design is an iterative process that involves analyzing schematic designs, roughly calculating runoff volumes managed, and revising the layout and sizing of management strategies multiple times before finalizing the overall site design.
- See *Further Explanation, Examples* for an example of this process.

Option 2. Natural Land Cover Conditions

STEP 1. OBTAIN INFORMATION ABOUT NATURAL CONDITIONS

Gather information about how the site (or the site's immediate region) functioned prior to any alteration or human activity. A sense of the natural conditions can be deduced through an analysis of land cover and general hydrologic function.

- Natural land cover conditions refer to the vegetation and soil conditions that existed in the area prior to development activities.
- Natural hydrology refers to the partitioning of rainfall into components of infiltration, evapotranspiration, and runoff in amounts and patterns that replicate the natural hydrology.
- Examples of alterations, development, and human activities include large-scale tree clearing and grading, industry, agriculture, mining, construction, municipal development, commercial development, and residential development.
- Natural vegetation maps, soil maps, or a description of typical land cover conditions in the project's region may be helpful to evaluate. Determination of the natural land cover conditions can also be based on the historical context of the site (e.g., forested, grassland) and an assessment of the soil conditions.
- For the purposes of this Option, an estimate of the natural conditions is acceptable.
- Sources of information include local governments and state environmental agencies, conservation or water resource organizations, historical societies or historic preservation groups, libraries, colleges and universities, private historical mapping companies, and (in the U.S.) EPA, Department of the Interior, U.S. Geological Survey, Oak Ridge National Laboratory (NASA), National Center for Atmospheric Research, and Department of Agriculture.

STEP 2. CALCULATE NATURAL CONDITIONS

Evaluate the full range of hydrologic rainfall events over a 10-year time period. Alternatively, an "average" representative rainfall year may be developed (continuous modeling simulation is required).

- The goal of this step is to determine the pattern and distribution of natural conditions in order to understand how the site functioned and thus what amount of runoff needs to be managed on site. In other words, to understand hypothetically how the site has performed over a period of record.
- All variables needed to complete this step are estimated based on the historical land cover conditions. For example, runoff curve numbers for the site are estimated based on the historical vegetation cover and soil conditions.

STEP 3. CALCULATE RUNOFF VOLUME TO BE MANAGED ON SITE

Calculate the runoff volume under the developed (proposed design) conditions, and compare it to the runoff volume under the natural conditions. If there is an increase in runoff volume between natural and developed conditions over the time period evaluated, manage the difference on site.

- In rare cases, the natural land cover conditions would manage less than the 95th percentile. In this case, the project is only requiired to manage the runoff volume that the natural land cover conditions would manage.

STEP 4. MANAGE RUNOFF VOLUME ON SITE

Similar to Option 1, incorporate green infrastructure and low-impact development strategies into the site design to manage, on site, the required volume of runoff.

- Portions of the site that are natural or close to natural may mitigate rainwater runoff and supplement other best management practices to achieve the goal of natural hydrologic performance.
- Work with the project's civil engineer, landscape architect, or other qualified professionals to choose and size the design strategies (see *Further Explanation, Green Infrastructure and Low-Impact Development Strategies*).
- Confirm that the chosen GI and LID measures will completely manage the required runoff volume.
- For projects that are part of a multitenant complex, see *Further Explanation, Project Type Variations*.

FURTHER EXPLANATION

CALCULATIONS

The land use runoff coefficients for small rainfall depths in the Small Storm Hydrology Method are recommended (runoff coefficients express the fraction of rainfall which is converted into runoff). The project team may choose the runoff volume calculation methodology most appropriate for the project, provided sufficient documentation and justification to demonstrate that the intent of the credit is being met.

The U.S. EPA Stormwater Management Model (SWMM) and National Stormwater Calculator is a general tool that is available for compliance overview; it is not recommended for use in design. It can be used in the project's conceptual design phase for estimating rainwater and runoff, and choosing initial management strategies.

The use of the Cover Complex Method is not recommended at this time for the calculation of runoff volume from small rainfall events (i.e. less than 2.5 in [63.5 mm] of precipitation in 24 hours).

Many rainwater software programs include calculation methodologies. Computer modeling programs based on the Small Storm Hydrology Method, such as WinSLAMM, are acceptable tools.

Small Storm Hydrology Method[1]

Large impervious areas– This category describes impervious areas with an average dimension greater than 24 feet (7.3 meters) in any direction. Examples of large impervious areas include parking lots with curbs, roads with curbs, highways, etc.

Small impervious areas – This category describes impervious areas with an average dimension no greater than 24 feet (7.3 meters) in any direction. Examples of small impervious areas include roads without curbs, small parking lots without curbs, and sidewalks.

For each land use type, runoff volume is calculated based on land use area and land use coefficient using the following equation:

IP units

$$\text{Runoff Volume} = \frac{P}{12} \times Rv \times A$$

where:

Runoff Volume is from the percentile rainfall event (ft³)

P = percentile rainfall depth (in)

Rv = Small Storm Hydrology Method runoff coefficient (alternatively, Rv can be calculated using the following equation: $Rv = 0.05 + 0.009(I)$, where I = percent impervious area expressed as a whole number)

A = area of land use (ft²)

For a site with multiple land uses, Runoff Volume can be calculated as follows:

$$\text{Runoff volume} = \sum_{i=1}^{n} \left\{ \left(\frac{P}{12} \times Rv_i \times A_i \right) + \left(\frac{P}{12} \times Rv_{i+1} \times A_{i+1} \right) + \ldots + \left(\frac{P}{12} \times Rv_n \times A_n \right) \right\}$$

SI units

$$\text{Runoff Volume} = \frac{P}{1000} \times Rv \times A$$

where:

Runoff Volume is from the percentile rainfall event (m³)

P = percentile rainfall depth (mm)

Rv = Small Storm Hydrology Method runoff (alternatively, Rv can be calculated using the following equation: $Rv = 0.05 + 0.009(I)$, where I = percent impervious area expressed as a whole number)

A = area of land use (m²)

For a site with multiple land uses, Runoff Volume can be calculated as follows:

$$\text{Runoff volume} = \sum_{i=1}^{n} \left\{ \left(\frac{P}{1000} \times Rv_i \times A_i \right) + \left(\frac{P}{1000} \times Rv_{i+1} \times A_{i+1} \right) + \ldots + \left(\frac{P}{1000} \times Rv_n \times A_n \right) \right\}$$

1. *Robert Pitt, P.E., Ph.D., DEE, Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices In: Advances in Modeling the Management of Stormwater Impacts, Volume 7. (Edited by W. James). Computational Hydraulics International, Guelph, Ontario and Lewis Publishers/ CRC Press. 1999.*

PERCENTILE OF RAINFALL EVENTS[2]

A percentile rainfall event represents a precipitation amount that the chosen percent of all rainfall events for the period of record do not exceed. For example, the 95th percentile of rainfall events is the measured precipitation depth accumulated over 24 hours that ranks as the 95th-percent rainfall depth based on the range of all daily event occurrences during the period of record. The 24-hour period is typically defined as 12:00:00 A.M. to 11:59:59 P.M.

Use the following steps to determine the 95th percentile of rainfall events:

1. Obtain a long-term daily precipitation data set for the project location (e.g., for U.S. projects, from the National Climatic Data Center website; for projects outside the U.S., see *International Tips*). In general, a 30-year period of rainfall record is preferred for the analysis. The raw data are collected by most airports. At least 10 years of data must be included if available.
2. Import the data into the USGBC rainfall events calculator or another spreadsheet. If using another spreadsheet, organize daily precipitation records in a single column, in any order.
3. Review the records, looking for anomalies, and identify and remove any erroneous or flagged data points.
4. Remove rainfall events of less than 0.1 inch (2.5 mm). The amount of precipitation from these small events generally produces no measurable runoff because of absorption by permeable surfaces and interception and evaporation by impermeable and vegetated surfaces.
5. The USGBC calculator determines the various percentile rainfall amounts. If using another spreadsheet software, apply a percentile function (or similar) to obtain results.

Detailed explanation regarding calculation of the percentile event using daily rainfall records can be found in EPA 841-B-09-001, December 2009, www.epa.gov/owow/nps/lid/section438.

GREEN INFRASTRUCTURE AND LOW-IMPACT DEVELOPMENT STRATEGIES

The goal of low impact development is to manage water as close to the source as possible using soil and vegetation-based systems. In addition to mimicking natural hydrologic cycle processes, green infrastructure and low-impact development help integrate the site with the surrounding watershed, are appropriate to the local ecosystem and climate, and deliver such other benefits as water reuse, habitat creation, and species diversity.

Prior to calculating the runoff volume from the project area, the project is encouraged to reduce the volume of runoff by protecting existing natural resources that serve to reduce the generation of runoff. Examples include healthy uncompacted soils, riparian buffers, tree canopy, etc. These areas must be protected from disturbance during the construction period in order to be effective. If protected from disturbance during construction, these natural areas can be excluded from runoff volume management.

All runoff from the chosen percentile of precipitation events must be managed such that there is no discharge from the site. Techniques include, but are not limited to, infiltration, storage and re-use, bioretention, open-grid pavement, and the reduction of impervious area. Infiltration may not be feasible in some cases based on the soil or geological conditions of the site. Karst geology and areas where water infiltrates at less than 1/2 inch (25 mm) per hour are two examples of situations that can be unfavorable for infiltration. The engineer, landscape architect, or rainwater professional will ultimately determine the best solution for the project's unique conditions. Continued maintenance of all rainwater management strategies is important in order for them to remain effective over time.

Project teams should consult EPA's *National Menu of Stormwater Best Practices* and consider the following questions when selecting measures for the project:

- Which GI and LID measures will best mimic natural site hydrology?
- How can multiple measures be used together (in a "treatment train" approach) to manage rainwater?
- What are the infiltration rates and capacities of the most practical measures and how might the site's soil conditions affect their efficiency?
- What are the types and infiltration rates of existing soil conditions, and what design modifications might need to be made, if any, to the best management practices to satisfy performance goals?

2. *Components adapted from Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act.*

- How effective are the measures at removing contaminants from the rainwater runoff?
- How will the measures be maintained?

EXAMPLES

Example 1.

Figure 1. Example site plan

The project team has selected Option 1, Path 1, and pulled daily rainfall data from the National Climatic Data Center for the previous 10 years. Based on the historical data, the 95th-percentile storm delivers 1.1 inches (28 mm) of rain.

TABLE 1. Example percentiles of rainfall events

Rainfall amount	Percentile of rainfall events
1.33 inches (34 millimeters)	99
1.29 (33)	98
1.22 (31)	97
1.15 (29)	96
1.1 (28)	95
1.05 (27)	94
1.01 (26)	93
0.96 (24)	92

To supplement the capacity of the pervious landscaped area, the project team has identified several conceptual GI and LID measures- bioretention areas, porous paving, a rain garden, and pervious decking- to capture rainwater from impervious surfaces. To ensure that the designed site manages all the rainwater runoff generated during the 95th percentile storm, the team calculates how the GI and LID measures manage the runoff, and it is verified that all required runoff is managed on site.

Sample documentation narrative describing GI and LID measures:

> *The bioretention facilities incorporated into the site design are soil- and plant-based filtration systems that receive runoff from the developed site areas. They are located at low points on the site, where rainfall collects (see site plan). Rainfall runoff infiltrates into a sandy medium that temporarily holds the rainwater, facilitating numerous physical, biological, and chemical processes. Vegetation planted in the bioretention facilities, including* Andropogon scoparius, *Iris sp., and* Prunus americana, *help filter particles in the runoff, assimilate nutrients and contaminants from the neighboring roadway, degrade engine oil, and oxygenate conditions to promote beneficial microorganisms. Bioretention mimics natural site hydrology by facilitating natural processes such as infiltration and evapotranspiration. The area of bioretention in this project meets the 95th percentile criteria, managing rainwater runoff via natural processes.*

Example 2.
Example 2 follows a project located in Maryland that attempted Option 1, Percentile of Rainfall Events. It gives an overview of the project, and then details the iterative rainwater management design process and calculations used to achieve the credit requirements. It is broken into two modules, both of which are located in the web-based reference guide on the right side of the "Guide" page.

INTERNATIONAL TIPS

If rainfall data for the project location are not available through the National Climatic Data Center database, the databases of the UN Food and Agriculture Organization (FAO) and Aquastat can be good sources of information for country-level rainwater data. Local rainfall data are best; use country-level data if necessary.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Eligible.

PROJECT TYPE VARIATIONS

Multitenant Complex Projects, Master Plan

The requirements may be met using a coordinated approach for multiple-building projects. This could include a group of distributed LID techniques within the boundary of the master plan to manage rainwater generated from the project site (Figure 2).

If a coordinated approach is used for the multitenant or multiple-building areas, distributed LID techniques based on a watershed approach are required. Accordingly, highly centralized approaches such as large ponds or wetlands that manage all of the runoff from the master plan site do not meet the intent of this credit. Instead, design LID strategies to manage runoff as close as possible to the source and in such a way that the strategies best maintain or restore the watershed's hydrological and ecological functions.

There are LID strategies that may be easier to implement for master planned developments with more open space opportunities.

Examples include using swales instead of piping, promoting sheet flow to natural areas, and reducing the width of paved roadways.

REQUIRED DOCUMENTATION

Documentation	All Projects	Option 1, Path 3	Option 2
Rainfall data	X		
Rainfall events calculator or calculations for the chosen percentile storm	X		
Runoff volume calculations	X		
Plans, details, or cross sections depicting site conditions and GI or LID strategies, highlighting topography, soil qualities, direction of water flow, and area of site that each facility addresses	X		
Narrative confirming measures qualifyas GI or LID	X		
Calculations for volume of rainwater managed by GI or LID strategies	X		
Explanation for why 10 years of historic rainfall data are not available for the project location (if applicable)	X		
Description of conditions that make the project zero lot line		X	
Floor area ratio		X	
Documents illustrating natural land cover conditions			X
Multitenant complex projects only:summary of centralized approach and associated distributed techniques	X		

RELATED CREDIT TIPS

Integrative Process Credit. GI and LID measures, such as harvesting and reusing rainwater for indoor and/or outdoor water use, will contribute to the preliminary water budget analysis required for the related credit.

SS Credit Site Development—Protect or Restore Habitat. Vegetated areas used as part of GI and LID approaches can be excluded from the calculations for the related credit.

SS Credit Open Space. Some vegetated GI and LID areas may qualify as open space areas for the related credit. Specifically, wetlands or naturally-designed ponds may count as open space if the side slope gradients are vegetated and average 1:4 (vertical:horizontal) or less.

SS Credit Site Assessment. The assessment of site hydrology and soils conducted for the Site Assessment Credit may inform appropriate GI and LID measures for SS Credit Rainwater Management.

SS Credit Site Master Plan. If project teams have the opportunity to plan the school property's overall rainwater strategy or watershed approach in the master planning phase, the rainwater management option for multitenant complex strategies may be applied to the entire school property area.

WE Prerequisite and WE Credit Outdoor Water Use Reduction. GI and LID measures that harvest and reuse rainwater for irrigation may help achieve the related credit by reducing the potable water demand.

WE Prerequisite and WE Credit Indoor Water Use Reduction. GI and LID measures that harvest and reuse rainwater to supplement plumbing fixture water use may help reduce potable water demand.

SS Credit Heat Island Reduction. Vegetated roofs installed for achievement of this credit will also qualify for the related credit.

CHANGES FROM LEED 2009

- Stormwater quality and quantity management credits have been combined into a single Rainwater Management credit.
- Projects must use GI and LID rainwater management techniques on site.
- A specific path has been created to accommodate reduced rainwater management opportunities in zero lot line urban projects.
- The multitenant complex path has been expanded to all projects types in addition to retail projects.
- The metric by which to test compliance is now the total volume of runoff calculated for the 95th percentile of regional or local storm events, rather than the one-year and two-year storm events.

REFERENCED STANDARDS

U.S. EPA Technical Guidance on Implementing the Rainwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act: epa.gov

EXEMPLARY PERFORMANCE

Manage 100% of rainwater that falls within the project boundary.

DEFINITIONS

green infrastructure a soil- and vegetation-based approach to wet weather management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure management approaches and technologies infiltrate, evapotranspire, capture and reuse stormwater to maintain or restore natural hydrologies. (Adapted from U.S. Environmental Protection Agency)

low-impact development (**LID**) an approach to managing rainwater runoff that emphasizes on-site natural features to protect water quality, by replicating the natural land cover hydrologic regime of watersheds, and addressing runoff close to its source. Examples include better site design principles (e.g., minimizing land disturbance, preserving vegetation, minimizing impervious cover), and design practices (e.g., rain gardens, vegetated swales and buffers, permeable pavement, rainwater harvesting, soil amendments). These are engineered practices that may require specialized design assistance.

manage (**rainwater**) **on site** to capture and retain a specified volume of rainfall to mimic natural hydrologic function. Examples of rainwater management include strategies that involve evapotranspiration, infiltration, and capture and reuse.

master plan boundary the limits of a site master plan. The master plan boundary includes the project area and may include all associated buildings and sites outside of the LEED project boundary. The master plan boundary considers future sustainable use, expansion, and contraction.

natural site hydrology the natural land cover function of water occurrence, distribution, movement, and balance

zero lot line project a plot whose building footprint typically aligns or nearly aligns with the site limits

SUSTAINABLE SITES CREDIT

Heat Island Reduction

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1-2 points)
Healthcare (1 point)

INTENT

To minimize effects on microclimates and human and wildlife habitats by reducing heat islands.

REQUIREMENTS

Choose one of the following options:

OPTION 1. NONROOF AND ROOF (2 POINTS EXCEPT HEALTHCARE, 1 POINT HEALTHCARE)

Meet the following criterion:

$$\frac{\text{Area of Nonroof Measures}}{0.5} + \frac{\text{Area of High-Reflectance Roof}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

Alternatively, an SRI and SR weighted average approach may be used to calculate compliance.

Use any combination of the following strategies.

Nonroof Measures

- Use the existing plant material or install plants that provide shade over paving areas (including playgrounds) on the site within 10 years of planting. Install vegetated planters. Plants must be in place at the time of occupancy permit and cannot include artificial turf.
- Provide shade with structures covered by energy generation systems, such as solar thermal collectors, photovoltaics, and wind turbines.
- Provide shade with architectural devices or structures that have a three-year aged solar reflectance (SR) value of at least 0.28. If three-year aged value information is not available, use materials with an initial SR of at least 0.33 at installation.

- Provide shade with vegetated structures.
- Use paving materials with a three-year aged solar reflectance (SR) value of at least 0.28. If three-year aged value information is not available, use materials with an initial SR of at least 0.33 at installation.
- Use an open-grid pavement system (at least 50% unbound).

High-Reflectance Roof
Use roofing materials that have an SRI equal to or greater than the values in Table 1. Meet the three-year aged SRI value. If three-year aged value information is not available, use materials that meet the initial SRI value.

TABLE 1. Minimum solar reflectance index value, by roof slope

	Slope	Initial SRI	3-year aged SRI
Low-sloped roof	≤ 2:12	82	64
Steep-sloped roof	> 2:12	39	32

Vegetated Roof
Install a vegetated roof.

OR

OPTION 2. PARKING UNDER COVER (1 POINT)

Place a minimum of 75% of parking spaces under cover. Any roof used to shade or cover parking must (1) have a three-year aged SRI of at least 32 (if three-year aged value information is not available, use materials with an initial SRI of at least 39 at installation), (2) be a vegetated roof, or (3) be covered by energy generation systems, such as solar thermal collectors, photovoltaics, and wind turbines.

BEHIND THE INTENT

Dark, nonreflective surfaces used for parking, roads, roofs, walkways, and other hardscapes absorb the sun's warmth and radiate heat, creating heat islands. Urban areas can have temperatures 1.8° to 5.4°F (1° to 3°C) warmer than surrounding suburban and undeveloped areas, and as much as 22°F (12°C) warmer in evenings. These heat islands may contribute to regional average warming trends[1] A study of surface warming resulting from rapid urbanization in east China found urban heat islands responsible for 24.2% of regional warming.[2] Urban heat island effects have numerous negative consequences: plants and animals sensitive to temperature fluctuations may find habitat affected by heat islands inhospitable. Human health may suffer because exposure to ground-level pollution is often worse in places affected by heat islands. Additionally, heat islands increase cooling loads in the summer, necessitating larger, more powerful air-conditioners that use more electricity, in turn increasing cooling costs, producing more greenhouse gases, and generating pollution.

According to a study of the metropolitan areas of Baton Rouge, Chicago, Houston, Sacramento, and Salt Lake City by the Department of Energy's Lawrence Berkeley National Laboratory, the energy savings potential of heat island reduction measures ranges from $4 million to $15 million per year.[3] Efforts to reduce heat islands can have a reasonable payback period when included as part of an integrated systems approach to improving building performance, such as by installing solar panels on shading devices or using a vegetated roof to insulate a building and extend the life of the roof.

The most effective measure of a roofing material's ability to reject solar heat is the solar reflectance index (SRI). However, to measure the solar heat rejection of components that are not roofing materials, or "nonroof"—for example, vegetation, shading devices, and other less reflective components—solar reflectance (SR) is used in this credit instead. SR is a more appropriate way to measure nonroof materials, which have more thermal mass. In addition to a product's initial SRI or SR value, this credit considers a product's three-year-aged SRI or SR values, which measure material performance over time. The credit encourages project teams to adopt a variety of strategies, including reducing hardscape and incorporating high-SRI or high-SR materials such as vegetation and shaded parking, which minimize a project's overall contribution to heat island effects.

STEP-BY-STEP GUIDANCE

Determine which option the project will pursue. Exemplary performance is available to teams that pursue both options and locate 100% of parking under cover.

- Option 1 is for projects with compliant roofs and at-grade (i.e., nonroof) systems, but no covered parking.
- Option 2 is for projects with only covered or underground parking.

Option 1. Nonroof and Roof

STEP 1. MINIMIZE HARDSCAPE

In early design, look for opportunities to limit the amount of hardscape on the project site. Increasing the landscaped portion of the site is the most effective strategy for reducing overall heat island effects and supports achievement of other credits (see *Further Explanation, Heat Island Mitigation Strategies* and *Related Credit Tips*).

STEP 2. IDENTIFY HARDSCAPE AND ROOF AREA

On a site plan, determine the total hardscape area and the total applicable roof area within the project boundary.

1. *U.S Environmental Protection Agency, Heat Island Effect, epa.gov/heatisland/index.htm (accessed May 2013).*
2. *Yang, X., Y. Hou, and B. Chen, Observed Surface Warming Induced by Urbanization in East China, J. Geophys. Res., 116 (2011), D14113, doi:10.1029/2010JD015452.*
3. *U.S Environmental Protection Agency, Heat Island Effect: Urban Heat Island Pilot Project (UHIPP), epa.gov/hiri/pilot/index.html (accessed May 2013).*

- Hardscape area includes all paved roads, sidewalks, courtyards, and parking lots.
- Applicable roof area excludes roof area covered by mechanical equipment, solar energy panels, skylights, and any other appurtenances.
- The top level of multilevel parking structures is considered nonroof surface if it has parking spaces, but roof area if it has no parking spaces.

STEP 3. SELECT ROOFING MATERIALS

To the extent feasible, incorporate vegetated roof systems or high-reflectance roofing materials that comply with Table 1 of the rating system requirements. On the site plan, determine the areas of vegetated and high-reflectance roof. For all applicable roof areas, gather manufacturer's documentation of SRI to verify compliance with credit requirements.

- Roof reflectance is the focus on sites that are designed to minimize hardscape.
- Roofing material selection is typically the most economical way to mitigate heat island effect.
- Consider how roof surfaces will be maintained. For example, regular cleaning will be needed to maintain the reflectivity of high-SRI surfaces.
- Selected materials may meet either the initial SRI threshold or the 3-year aged SRI threshold. They are not required to meet both.

STEP 4. IDENTIFY AREA OF PLANTERS AND SHADED, PERMEABLE, AND REFLECTIVE HARDSCAPE

On the site plan, determine the area of hardscape that is mitigated by one of the eligible nonroof measures listed in the credit requirements. Gather manufacturer's documentation of SR and paving permeability, as applicable, to verify compliance with credit requirements.

- Calculate the area of each nonroof measure in plan view.
- Count each hardscape surface only once, even if it is addressed through multiple strategies (e.g., permeable paving that is also shaded).
- Selected materials may meet either the initial SR threshold or the 3-year aged SR threshold. They are not required to meet both.

STEP 5. EVALUATE COMPLIANCE AGAINST CREDIT REQUIREMENTS

Determine credit compliance using Equation 1 (standard) or Equation 2 (weighted) (see *Further Explanation, Examples 1* and *2*).

- Equation 1 determines the combined compliance of roof and nonroof measures for the whole project.
- Equation 2 weights the SR and SRI for total hardscape and roof area, showing its overall consequence on heat island effect. This equation is useful for projects that have multiple roof angles and nonroof or roof materials that fall both above and below the required SR and SRI values.
- Project teams should first evaluate compliance with Equation 1. If the project does not achieve compliance with Equation 1, the team should move to Equation 2.

EQUATION 1. Standard nonroof or roof calculation

$$\frac{\text{Area of Nonroof Measures}}{0.5} + \frac{\text{Area of High-Reflectance Roof}}{0.75} + \frac{\text{Area of Vegetated Roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

EQUATION 2. Weighted nonroof or roof calculation

$$\frac{\left(\text{Area of high reflectance nonroof A} \times \dfrac{\text{SR of high reflectance nonroof A}}{\text{Required SR}}\right)^{1}}{0.5} + \frac{\text{Area of other nonroof measures}}{0.5} + \frac{\left(\text{Area of high reflectance roof A} \times \dfrac{\text{SRI of high reflectance roof A}}{\text{Required SRI}}\right)^{2}}{0.75} + \frac{\text{Area of vegetated roof}}{0.75} \geq \text{Total Site Paving Area} + \text{Total Roof Area}$$

1. Summed for all high-reflectance nonroof areas.
2. Summed for all high-reflectance roof areas.

STEP 6. INCORPORATE ADDITIONAL MITIGATION STRATEGIES IF NECESSARY

If the project does not meet the credit requirements with either calculation, revise the project design to extend or incorporate additional nonroof or roof mitigation strategies. Then recalculate to confirm compliance.

Once the credit strategy is finalized, include performance requirements in the applicable specification sections, or specify particular systems and products that meet credit requirements.

Option 2. Parking under Cover

STEP 1. DETERMINE TOTAL VEHICLE PARKING SPACES IN PROJECT

Calculate the number of parking spaces within the LEED project boundary. This value must be consistent with the parking spaces used for other credits.

- Do not count motorcycle or bicycle parking spaces as vehicle parking spaces.

STEP 2. LOCATE AT LEAST 75% OF PARKING SPACES UNDER COVER

Where possible, locate parking spaces underground, under a deck, under a roof, or under a building.

- Indicate covered parking on a site map.
- Count uncovered parking at the top level of a multilevel parking structure as uncovered spaces in the credit calculations.

STEP 3. DESIGN PARKING COVER TO MEET CREDIT REQUIREMENTS

Ensure that the roof over the parking area meets the credit requirements for eligible types of parking cover (see *Further Explanation, Heat Island Mitigation Strategies*).

- Uncovered parking at the top level of a multilevel parking structure is not required to meet the prescribed roof criteria because it is considered nonroof surface.
- If there are no parking spaces on the top level of a multilevel parking structure, this area is considered roof area and must comply with the criteria listed in the credit requirements.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

HEAT ISLAND MITIGATION STRATEGIES

TABLE 2. Roof strategies

Strategy	Rules and tips
High-reflectance roof	• Consider effects of glare on traffic, pedestrians, and adjacent buildings, especially if project has steep-sloped roofs • Consider high-reflectance materials' need for maintenance (e.g., regular cleaning) required to keep these materials from losing reflectivity over time
Vegetated roof	• Artificial turf grass does not count • Plants must be in place at occupancy • Extensive or intensive vegetated roofs are eligible; roof planters contribute only if part of a vegetated roof system • Consider maintenance required for both plants and structural integrity

TABLE 3. Nonroof strategies

Strategy	Rules and tips
Shading with new or existing plant material	• Plants must be in place at occupancy • Assume 10-year canopy width at noon (i.e., in plan view, plant canopy width has no extending shadows, regardless of time of year)
Vegetated planters	• Artificial turf grass does not count • Plants must be in place at occupancy
Shading structures with energy generation	Paved area (not roof area) shaded by covering with energy generation equipment (e.g., solar thermal collectors, photovoltaics, wind turbines) is eligible
Shading architectural devices or structures	Materials must have 3-year aged SR value of at least 0.28, or initial SR of at least 0.33
Vegetated shading structures	Plants must be in place at occupancy
High-reflectance paving	• Materials must have 3-year aged SR value of at least 0.28, or initial SR of at least 0.33 • Consider maintenance (e.g., regular cleaning) required to keep these materials from losing reflectivity over time
Open-grid paving	Must be at least 50% unbound

TABLE 4. Covered parking strategies

Strategy	Rules and tips
Undercover parking	• May be underground, under deck, under roof, or under building • Stacked parking is considered covered parking • Any roof used to shade or cover parking must meet criteria listed in credit requirements

EXAMPLES

Figure 1 illustrates a project that is seeking to achieve Options 1 and 2.

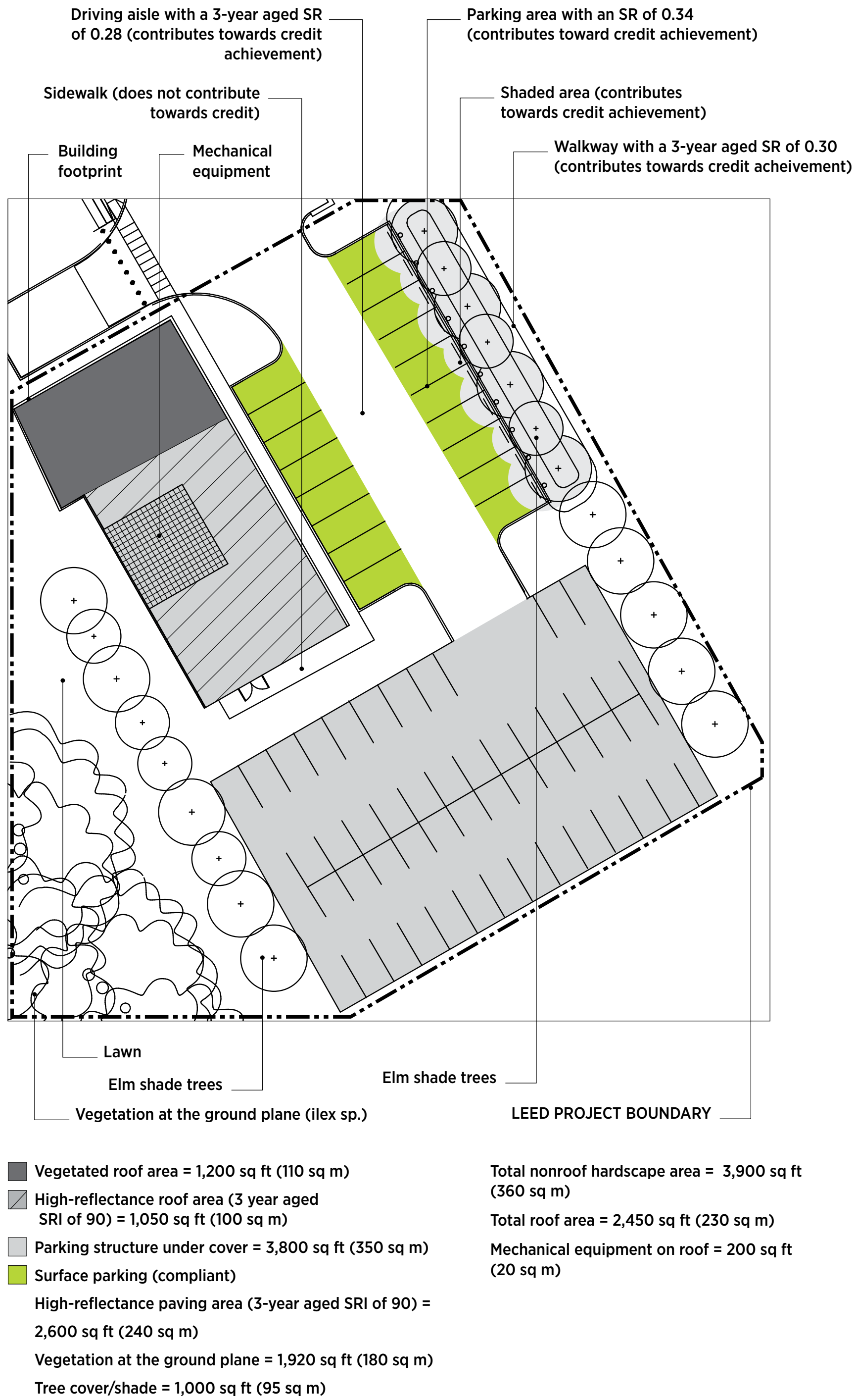


Figure 1. Example site plan

Example 1. Standard nonroof or roof calculation

The project includes 3,900 square feet (360 square meters) of hardscape. The total roof area is 2,450 square feet (230 square meters), of which 200 square feet (20 square meters) is covered by mechanical equipment, making the total applicable roof area 2,250 square feet (210 square meters). The following heat island mitigation strategies have been included in the project design:

- 400 ft^2 (35 m^2) of sidewalk with 3-year aged SR of 0.30
- 600 ft^2 (55 m^2) parking canopy covered with photovoltaic panels
- 1,000 ft^2 (95 m^2) of shading by tree canopy
- 1,200 ft^2 (110 m^2) vegetated roof
- 1,050 ft^2 (100 m^2) of high-reflectance roof with 3-year aged SRI of 90

The project team calculates compliance using Equation 1, as follows:

$$\frac{400\text{ ft}^2\,(35\text{ m}^2) + 600\text{ ft}^2\,(55\text{ m}^2) + 1{,}000\text{ ft}^2\,(95\text{ m}^2)}{0.5} + \frac{1{,}050\text{ ft}^2\,(100\text{ m}^2)}{0.75} + \frac{1{,}200\text{ ft}^2\,(110\text{ m}^2)}{0.75} \geq 3{,}900\text{ ft}^2\,(360\text{ m}^2) + 2{,}250\text{ ft}^2\,(210\text{ m}^2)$$

The total calculated area of nonroof and roof mitigation strategies (7,000 square feet [650 square meters]) exceeds the sum of total site hardscape and total applicable roof area (6,150 square feet [570 square meters]), so the project achieves the credit.

Example 2. Weighted nonroof or roof calculation

The project includes 3,900 square feet (360 square meters) of hardscape. The total roof area is 2,450 square feet (230 square meters), of which 200 square feet (20 square meters) is covered by mechanical equipment, making the total applicable roof area 2,250 square feet (210 square meters). The following heat island mitigation strategies have been included in the project design:

- 400 ft^2 (35 m^2) of permeable sidewalks that are 55% unbound
- 600 ft^2 (55 m^2) parking canopy covered with vegetated roofing system
- 1,000 ft^2 (95 m^2) of shading by tree canopy
- 1,200 ft^2 (110 m^2) vegetated roof
- 400 ft^2 (35 m^2) of steep-sloped roof with initial SRI of 42
- 650 ft^2 (60 m^2) of steep-sloped roof with initial SRI of 34

The project team calculates compliance using Equation 2, as follows:

$$\frac{400\text{ ft}^2\,(35\text{ m}^2) + 600\text{ ft}^2\,(55\text{ m}^2) + 1{,}000\text{ ft}^2\,(95\text{ m}^2)}{0.5} + \frac{\left(400\text{ ft}^2\,(35\text{ m}^2) \times \frac{\text{SRI } 42}{\text{SRI } 39}\right) + \left(650\text{ ft}^2\,(60\text{ m}^2) \times \frac{\text{SRI } 34}{\text{SRI } 39}\right)}{0.75} + \frac{1{,}200\text{ ft}^2\,(110\text{ m}^2)}{0.75} \geq 3{,}900\text{ ft}^2\,(360\text{ m}^2) + 2{,}250\text{ ft}^2\,(210\text{ m}^2)$$

The total calculated area of nonroof and roof mitigation strategies (6,929 square feet, 636 square meters) exceeds the sum of total site hardscape and total applicable roof area (6,150 square feet, 570 square meters), so the project achieves the credit.

INTERNATIONAL TIPS

Projects outside the U.S. can contact manufacturers directly and ask for SRI information. If manufacturers do not provide this information, the project team can identify a similar material from the Cool Roof Rating Council standard for comparison to show that the project's material meets the intent of the credit.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Nonroof and roof area calculations	X	
Site plan(s) with elements and measurements, including LEED project boundary, building footprint, roof and hardscape area, and area of each roof and nonroof measure	X	
Manufacturer's documentation of SRI, SR, and paving permeability	X	X
Parking space calculations		X

RELATED CREDIT TIPS

SS Credit Site Development—Protect or Restore Habitat. Minimizing the amount of hardscape increases the amount of site area available to meet the 30% site restoration threshold for the related credit's Option 1 (On-Site Restoration). Vegetated roofs can also contribute to Option 1 if the plant material meets the criteria for native or adapted.

SS Credit Open Space. Vegetated roofs can be counted as open space if the project has a development density of 1.5 floor-area ratio and the vegetated roofs are extensive or intensive and are accessible to occupants. Qualifying roof-based, physically accessible paving areas can also count toward the related credit if the project has a development density of 1.5 floor-area ratio. The site assessment process in SS Credit Open Space can be used to identify the best opportunities for mitigating heat islands.

SS Credit Rainwater Management. Vegetated roofs can contribute to rainwater management. Reducing a site's hardscape area and/or using open-grid paving will improve infiltration rates.

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. Vegetated roofs help insulate buildings, and the cooler surrounding microclimate may lower a building's cooling load and improve energy performance. High-reflectance roofs experience less solar heat gain and may therefore lower cooling loads (but increase heating loads in low-rise buildings in cold climates).

CHANGES FROM LEED 2009

- The credit combines the roof and nonroof heat island credits from LEED 2009.
- Vegetated roofs and high-reflectance roofs now have equal weight when calculating compliance.
- Tree canopy shade area is now calculated after 10 years of growth rather than five years.
- The initial SRI thresholds for roofing material have increased.
- Credit compliance for nonroof hardscape is now calculated using SR values instead of SRI values.
- The credit now takes into account the three-year aged SRI values for roofing material.

REFERENCED STANDARDS

Cool Roof Rating Council Standard (CRRC-1): coolroofs.org

EXEMPLARY PERFORMANCE

Achieve both Options 1 and 2. Locate 100% of parking under cover.

DEFINITIONS

appurtenance a built-in, nonstructural portion of a roof system. Examples include skylights, ventilators, mechanical equipment, partitions, and solar energy panels.

heat island effect the thermal absorption by hardscape, such as dark, nonreflective pavement and buildings, and its subsequent radiation to surrounding areas. Other contributing factors may include vehicle exhaust, air-conditioners, and street equipment. Tall buildings and narrow streets reduce airflow and exacerbate the effect.

infrared (**thermal**) **emittance** a value between 0 and 1 (or 0% and 100%) that indicates the ability of a material to shed infrared radiation (heat). A cool roof should have a high thermal emittance. The wavelength range for radiant energy is roughly 5 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum and have an emittance of roughly 0.9, or 90%. Clean, bare metals, such as untarnished galvanized steel, have a low emittance and are the most important exceptions to the 0.9 rule. In contrast, aluminum roof coatings have intermediate emittance levels. (Adapted from Lawrence Berkeley National Laboratory)

open-grid pavement system pavements that consist of loose substrates supported by a grid of a more structurally sound grid or webbing. Pervious concrete and porous asphalt are not considered open grid as they are considered bounded materials. Unbounded, loose substrates do not transfer and store heat like bound and compacted materials do.

solar reflectance (**SR**) the fraction of solar energy that is reflected by a surface on a scale of 0 to 1. Black paint has a solar reflectance of 0; white paint (titanium dioxide) has a solar reflectance of 1. The standard technique for its determination uses spectrophotometric measurements, with an integrating sphere to determine the reflectance at each wavelength. Determine the SR of a material by using the Cool Roof Rating Council Standard (CRRC-1).

solar reflectance index (**SRI**) a measure of the constructed surface's ability to stay cool in the sun by reflecting solar radiation and emitting thermal radiation. It is defined such that a standard black surface (initial solar reflectance 0.05, initial thermal emittance 0.90) has an initial SRI of 0, and a standard white surface (initial solar reflectance 0.80, initial thermal emittance 0.90) has an initial SRI of 100. To calculate the SRI for a given material, obtain its solar reflectance and thermal emittance via the Cool Roof Rating Council Standard (CRRC-1). SRI is calculated according to ASTM E 1980. Calculation of the aged SRI is based on the aged tested values of solar reflectance and thermal emittance.

thermal emittance the ratio of the radiant heat flux emitted by a specimen to that emitted by a blackbody radiator at the same temperature (adapted from Cool Roof Rating Council)

three-year aged SR or SRI value a solar reflectance or solar reflectance index rating that is measured after three years of weather exposure

undercover parking vehicle storage that is underground, under deck, under roof, or under a building

SUSTAINABLE SITES CREDIT

Light Pollution Reduction

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and people.

REQUIREMENTS

Meet uplight and light trespass requirements, using either the backlight-uplight-glare (BUG) method (Option 1) or the calculation method (Option 2). Projects may use different options for uplight and light trespass.

Meet these requirements for all exterior luminaires located inside the project boundary (except those listed under "Exemptions"), based on the following:

- the photometric characteristics of each luminaire when mounted in the same orientation and tilt as specified in the project design; and
- the lighting zone of the project property (at the time construction begins). Classify the project under one lighting zone using the lighting zones definitions provided in the Illuminating Engineering Society and International Dark Sky Association (IES/IDA) Model Lighting Ordinance (MLO) User Guide.

Additionally, meet the internally illuminated signage requirement.

Uplight

OPTION 1. BUG RATING METHOD

Do not exceed the following luminaire uplight ratings, based on the specific light source installed in the luminaire, as defined in IES TM-15-11, Addendum A.

TABLE 1. Maximum uplight ratings for luminaires	
MLO lighting zone	**Luminaire uplight rating**
LZ0	U0
LZ1	U1
LZ2	U2
LZ3	U3
LZ4	U4

OR

OPTION 2. CALCULATION METHOD

Do not exceed the following percentages of total lumens emitted above horizontal.

TABLE 2. Maximum percentage of total lumens emitted above horizontal, by lighting zones	
MLO lighting zone	**Maximum allowed percentage of total luminaire lumens emitted above horizontal**
LZ0	0%
LZ1	0%
LZ2	1.5%
LZ3	3%
LZ4	6%

AND

Light Trespass

OPTION 1. BUG RATING METHOD

Do not exceed the following luminaire backlight and glare ratings (based on the specific light source installed in the luminaire), as defined in IES TM-15-11, Addendum A, based on the mounting location and distance from the lighting boundary.

TABLE 3. Maximum backlight and glare ratings

	MLO lighting zone				
Luminaire mounting	LZ0	LZ1	LZ2	LZ3	LZ4
	Allowed backlight ratings				
> 2 mounting heights from lighting boundary	B1	B3	B4	B5	B5
1 to 2 mounting heights from lighting boundary and properly oriented	B1	B2	B3	B4	B4
0.5 to 1 mounting height to lighting boundary and properly oriented	B0	B1	B2	B3	B3
< 0.5 mounting height to lighting boundary and properly oriented	B0	B0	B0	B1	B2
	Allowed glare ratings				
Building-mounted > 2 mounting heights from any lighting boundary	G0	G1	G2	G3	G4
Building-mounted 1–2 mounting heights from any lighting boundary	G0	G0	G1	G1	G2
Building-mounted 0.5 to 1 mounting heights from any lighting boundary	G0	G0	G0	G1	G1
Building-mounted < 0.5 mounting heights from any lighting boundary	G0	G0	G0	G0	G1
All other luminaires	G0	G1	G2	G3	G4

The lighting boundary is located at the property lines of the property, or properties, that the LEED project occupies. The lighting boundary can be modified under the following conditions:

- When the property line abuts a public area that includes, but is not limited to, a walkway, bikeway, plaza, or parking lot, the lighting boundary may be moved to 5 feet (1.5 meters) beyond the property line.
- When the property line abuts a public street, alley, or transit corridor, the lighting boundary may be moved to the center line of that street, alley, or corridor.
- When there are additional properties owned by the same entity that are contiguous to the property, or properties, that the LEED project is within and have the same or higher MLO lighting zone designation as the LEED project, the lighting boundary may be expanded to include those properties.

Orient all luminaires less than two mounting heights from the lighting boundary such that the backlight points toward the nearest lighting boundary line. Building-mounted luminaires with the backlight oriented toward the building are exempt from the backlight rating requirement.

OR

OPTION 2. CALCULATION METHOD

Do not exceed the following vertical illuminances at the lighting boundary (use the definition of lighting boundary in Option 1). Calculation points may be no more than 5 feet (1.5 meters) apart. Vertical illuminances must be calculated on vertical planes running parallel to the lighting boundary, with the normal to each plane oriented toward the property and perpendicular to the lighting boundary, extending from grade level to 33 feet (10 meters) above the height of the highest luminaire.

TABLE 4. Maximum vertical illuminance at lighting boundary, by lighting zone

MLO lighting zone	Vertical illuminance
LZ0	0.05 FC (0.5 LUX)
LZ1	0.05 FC (0.5 LUX)
LZ2	0.10 FC (1 LUX)
LZ3	0.20 FC (2 LUX)
LZ4	0.60 FC (6 LUX)

FC = footcandle

AND

Internally Illuminated Exterior Signage

Do not exceed a luminance of 200 cd/m^2 (nits) during nighttime hours and 2000 cd/m^2 (nits) during daytime hours.

Exemptions from Uplight and Light Trespass Requirements

The following exterior lighting is exempt from the requirements, provided it is controlled separately from the nonexempt lighting:

- specialized signal, directional, and marker lighting for transportation;
- lighting that is used solely for façade and landscape lighting in MLO lighting zones 3 and 4, and is automatically turned off from midnight until 6 a.m.;
- lighting for theatrical purposes for stage, film, and video performances;
- government-mandated roadway lighting;
- hospital emergency departments, including associated helipads;
- lighting for the national flag in MLO lighting zones 2, 3, or 4; and
- internally illuminated signage.

BEHIND THE INTENT

Artificial exterior lighting not only provides human safety and comfort, it enables us to productively use more hours of the day. If done correctly, exterior lighting offers safety, security, building identification, aesthetics, and way finding. However, poor lighting design causes light pollution.

Light pollution is the misdirection or misuse of light, generally resulting from an inappropriate application of exterior lighting. Backlight creates light trespass onto adjacent sites by directing light in the opposite direction of the area intended to be lighted. Uplight causes artificial sky glow. Glare is caused by high-angle front light.

Light pollution creates an abundance of environmental problems. Wildlife species that hunt or forage at night may be unable to feed. Some flora and fauna are unable to adjust to seasonal variations when exposed to light pollution. Migratory birds that rely on stars to guide them during migration may become disoriented. Even human health can be damaged by misuse of light. Studies have shown that overexposure to artificial lighting, particularly at night, may disrupt our circadian rhythms and melatonin production, impair night vision, and lead to sleep disorders.[1] Finally, light pollution directed into the sky or into areas that do not need illumination is a waste of both energy and money.

Good lighting design involves reducing three forms of light pollution: uplight, glare, and light trespass. This credit addresses all three with requirements for specifying only the necessary lighting, selecting the right luminaires (lamp-ballast combinations), locating them appropriately on the project site, and implementing an appropriate control strategy. So that designers have flexibility, this credit offers two compliance options—a calculation method (as in LEED 2009) and a new backlight, uplight, and glare (BUG) rating method.

Thoughtful selection of lighting results in luminaires that are not only aesthetically pleasing but also generate well-shielded, well-directed light. Minimizing direct views of lamps avoids glare, and gradually changing light levels allows the human eye to adapt. Efficient design specifies both luminaire distribution and lighting controls, including motion sensors, photocells, time clocks, and other devices that reduce the amount of light at times and places it is not needed.

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH EXTERIOR LIGHTING PROJECT GOALS

Determine which team members will be responsible for the lighting design, luminaire selection, and overall lighting concept. Prepare a schematic site lighting design by doing the following:

- Identify the desired lighted areas on site.
- Consult the Illuminating Engineering Society (IES) Lighting Handbook recommendations to establish target light levels and uniformities for the identified areas.
- Identify any areas of the site where it may be difficult to meet the credit requirements because of light level needs, proximity to a boundary, or other factors.

STEP 2. DETERMINE LIGHTING ZONE

Identify the project's lighting zone. The lighting designer (or someone with knowledge of the project site and lighting zone classifications) is responsible for classifying the lighting zone.

- Refer to the IES Model Lighting Ordinance (MLO) User Guide for information on determining the project's lighting zone (see *Further Explanation, Lighting Zones*).
- Classify the entire project as one lighting zone.
- Provide justification for the lighting zone chosen for the project.

STEP 3. ESTABLISH LIGHTING BOUNDARY

Determine the lighting boundary for the project and create a lighting boundary site plan. Provide justification for any modification of the lighting boundary (e.g., if the lighting boundary was moved from the project boundary to the center line of an adjacent public street).

1. *American Medical Association, House of Delegates, Report 4 of the Council on Science and Public Health* (A-12), *Light Pollution: Adverse Health Effects of Nighttime Lighting* (2009), *ama-assn.org/resources/doc/csaph/a12-csaph4-lightpollution-summary.pdf* (accessed March 2013).

STEP 4. PREPARE SITE LIGHTING DESIGN

Prepare a site lighting plan based on the lighting zone designation and develop a luminaire schedule for the project, selecting luminaires that eliminate or minimize uplight and light trespass off site (see *Further Explanation, Choosing Luminaires*).

- Designate all exterior luminaires (both exempt and nonexempt) within the project boundary, and indicate locations, including pole heights.
- Depict the project boundary, the property line (if different from the project boundary), the lighting boundary, any additional properties included in the lighting boundary, and any relevant project site conditions.
- Indicate the total number of each luminaire type in the project.
- Identify the manufacturer, model number, lamp type, orientation, tilt angle (if applicable), and input wattage for each luminaire type.

This is only a preliminary design; the project team may need to revisit the design after completing the subsequent steps and determining the uplight and light trespass values.

STEP 5. DETERMINE EXEMPTIONS

- Identify any luminaires that are exempt from the uplight and light trespass requirements and provide justification for the exemptions.
- Examples of exempt lighting include emergency lighting, government-mandated roadway lighting, theatrical lighting, and lighting of the national flag in certain lighting zones.
- If no lighting is required except what is listed in exemptions (see credit requirements) the project achieves the credit, provided the team justifies the exemptions.

STEP 6. SELECT COMPLIANCE OPTION FOR NONEXEMPT LIGHTING

Determine which method of compliance documentation the project team will follow for all nonexempt lighting, and for each of the two sets of requirements (uplight and light trespass). The two compliance options are the BUG Rating Method (Option 1) or the Calculation Method (Option 2). Project teams can also combine the two options.

- Option 1 may be the easier compliance path if BUG ratings are available for all or most project luminaires (see *Further Explanation, About the BUG Method*).
- Option 2 is for projects with some luminaires that would not comply or would be difficult to include under the BUG rating method. Examples include a particular luminaire that, in itself, would not meet the BUG thresholds but when used in concert with other luminaires can pass based on the calculation method; and adjustable luminaires tilted from their nominal position, such that it is difficult to determine the BUG rating.
- A project can pursue different options for the uplight and trespass requirements. For example, Option 1's BUG rating method can be applied to uplight and Option 2's calculation method can be used for light trespass, and vice versa. However, project teams cannot mix compliance paths within uplight or light trespass: only one option may be used to demonstrate uplight, and only one option may be used to demonstrate light trespass.

STEP 7. GATHER DATA ON LUMINAIRES

Option 1

- List the backlight, uplight, and glare ratings of each unique luminaire for the orientation and tilt specified in the project design.
- Ratings for luminaires without published BUG rating can be determined via software (see *Further Explanation, Calculating BUG Values*).

Option 2

- Show the total lumens per luminaire and lumens emitted above horizontal by each luminaire (lamp-ballast combination) for the orientation and tilt specified in the project design.
- Show the performance for each angular position (tilt) if there are multiple angular positions for a luminaire type.
- Identify all auxiliary shielding specified.

STEP 8. EVALUATE UPLIGHT COMPLIANCE

Determine compliance with the uplight requirements and make any necessary adjustments to the preliminary lighting design.

Option 1

Consult Table 1 of the credit requirements for the maximum luminaire BUG uplight rating for the project's lighting zone. Ensure that all luminaires, when positioned in the specified design position, do not exceed this maximum uplight rating (see *Further Explanation, Example 1*).

Option 2

Calculate the percentage of total lumens emitted above horizontal (see *Further Explanation, Example 2*). Ensure that the selected luminaires, cumulatively, do not exceed the maximum allowable uplight percentage listed in Table 2 of the credit requirements, based on the project's lighting zone.

- The requirements apply not to each individual luminaire but to the total uplight generated by all luminaires.
- Use manufacturer's data sheets or IES files for each luminaire to identify the total luminaire lumens emitted plus the total luminaire lumens emitted above 90 degrees (horizontal). This information is typically shown in catalogue cutsheets or in IES files.

STEP 9. EVALUATE LIGHT TRESPASS COMPLIANCE

Determine compliance with the light trespass requirements and make any necessary adjustments to the preliminary lighting design (see *Further Explanation, Calculating Light Trespass*).

Option 1

Consult Table 3 of the credit requirements for the maximum luminaire BUG rating for the project's lighting zone and the luminaire location and angular position. Ensure that all luminaires do not exceed the maximum backlight and glare ratings.

- Consider mounting location, distance from the lighting boundary, and light source when choosing the luminaires that meet the backlight and glare ratings. Luminaires mounted at the highest height and located closest to the lighting boundary constitute the worst-case scenario and may not comply (see *Further Explanation, Mounting Heights*).
- Consider trade-offs when choosing luminaires. Compared with traditional light sources, for example, LEDs are more directional and brighter and can therefore produce more glare, but they are also more controllable.
- Ensure that the luminaires chosen are located appropriately in relation to the lighting boundary, as stipulated in the credit requirements. A building-mounted luminaire with its backlight oriented toward the building can be exempted from the backlight requirement. In this case, the luminaire must meet only the light trespass requirements for glare.

Option 2

Calculate the vertical illuminance at the lighting boundary to ensure that the illuminance does not exceed the maximum allowance shown in Table 4 of the credit requirements (see *Further Explanation, Vertical Illuminance*).

- Calculate the vertical illuminances on all vertical planes as they extend upward from the lighting boundary at grade level to a height at least 33 feet (10 meters) above the tallest luminaire on the project. Calculation points on each plane must be no more than 5 feet (1.5 meters) apart. For each plane, ensure that the greatest vertical illuminance does not exceed the threshold indicated in the credit requirements.
- Retain point-by-point calculation output for the vertical plane containing the greatest vertical illuminance (the worst-case scenario).

STEP 10. SELECT COMPLIANT, INTERNALLY ILLUMINATED EXTERIOR SIGNAGE

Choose luminaires that meet the threshold requirements for light pollution and light trespass given in the credit requirements. If the signage company does not have any data for the manufactured sign, assess compliance in other ways. For example,

- Take a measurement of the sign's maximum luminance.
- Have the lighting consultant construct the sign in calculation software by putting an automatic placement grid on the luminous surface(s) of the object with a transmission assigned to the surface(s) and setting the measurement type to diffuse luminance to get the results.

FURTHER EXPLANATION

LIGHTING ZONES

The Model Lighting Ordinance establishes five lighting zones, ranging from natural environments with no artificial lighting (Lighting Zone 0) to areas of very high ambient lighting, such as Times Square in New York City (Lighting Zone 4).

The MLO lighting zone for the project is based on the lighting zone of the immediately adjacent property at the time construction begins.

TABLE 5. Model Lighting Ordinance lighting zones*

Lighting zone	Definition	Recommended uses
0 **No ambient lighting**	Areas where natural environment will be seriously and adversely affected by lighting. Effects include disturbing biological cycles of flora and fauna and/or detracting from human enjoyment and appreciation of natural environment. Human activity is subordinate in importance to nature. Vision of human residents and users is adapted to darkness, and they expect to see little or no lighting. When not needed, lighting should be extinguished.	Typically includes undeveloped areas of open space, wilderness parks and preserves, areas near astronomical observatories, or any other area where protection of dark environment is critical.
1 **Low ambient lighting**	Areas where lighting might harm flora and fauna or disturb character of area. Vision of human residents and users is adapted to low light levels. Lighting may be used for safety and convenience but is not necessarily uniform or continuous. After curfew, most lighting should be extinguished or reduced as activity levels decline.	Typically includes single- and two-family residential communities, rural town centers, business parks, and other commercial, industrial, orstorage areas with limited nighttime activity. May also include developed areas in parks and other natural settings.
2 **Moderate ambient lighting**	Areas of human activity where vision of human residents and users is adapted to moderate light levels. Lighting may typically be used for safety and convenience but is not necessarily uniform or continuous. After curfew, lighting may be extinguished or reduced as activity levels decline.	Typically includes multifamily residential uses, institutional residential uses, schools, churches, hospitals, hotels, motels, and commercial or businesses areas with evening activities in predominately residential areas. Also includes neighborhood recreational and playing fields, and mixed-use development with predominance of residential uses.
3 **Moderately high ambient lighting**	Areas of human activity where vision of human residents and users is adapted to moderately high light levels. Lighting is generally desired for safety, security and/or convenience and it is often uniform and/or continuous. After curfew, lighting may be extinguished or reduced in most areas as activity levels decline.	Typically includes commercial corridors, high-intensity suburban commercial areas, town centers, mixed-use areas, industrial uses and shipping and rail yards with high nighttime activity. Also includes high-use recreational and playing fields, regional shopping malls, car dealerships, gas stations, and other nighttime active exterior retail areas.
4 **High ambient lighting**	Areas of human activity where vision of human residents and users is adapted to high light levels. Lighting is generally considered necessary for safety, security and/or convenience and it is mostly uniform and/or continuous. After curfew, lighting may be extinguished or reduced in some areas as activity levels decline.	Areas of very high ambient lighting levels, used only for special cases and not appropriate for most cities. May be used for extremely unusual installations such as high-density entertainment districts and heavy industrial uses. (Currently only Times Square has this classification in the U.S.)

* Adapted from Model Lighting Ordinance User Guide.

LIGHTING BOUNDARY

The lighting boundary typically coincides with the property lines of the property that the LEED project occupies. However, in certain situations the lighting boundary may be modified:

- When the property boundary abuts a public area that includes, but is not limited to, a walkway, bikeway, plaza, or parking lot, the lighting boundary may be moved to 5 feet (1.5 meters) beyond the property line.
- When the property boundary abuts a public roadway or public transit corridor, the lighting boundary may be moved to the center line of that roadway or corridor.

- When additional properties owned by the same entity responsible for the LEED project are contiguous to the project site and have the same or a higher lighting zone as the project, the lighting boundary may be expanded to include those properties. In these cases, it is best if a lighting master plan is developed.

CHOOSING LUMINAIRES

Once the appropriate lighting zone and boundaries are established, the project's lighting professional needs to pay close attention to quantity, types, and locations of luminaires and the geometry of the site. The closer the luminaire to the lighting boundary, the more likely it is that light extends beyond the boundary. For a location with a narrow distribution, select a luminaire with a lower pole height, or move it away from the boundary to reduce light trespass.

Use manufacturer's luminaire data or IES files to obtain the necessary information for determining compliance with this credit. Luminaires without photometric distribution data must be assumed to have 100% of their initial lamp lumens at or above 90 degrees. For adjustable tilt luminaires, consider the angular position when determining a BUG rating or calculating compliance. A luminaire in its nominal position may have minimal light trespass and low illumination to the night sky (e.g., a U rating of U1). But if the designer tilts the luminaire to achieve the desired pattern of illuminance, more light may be emitted above the horizon and change the U rating to a U2 or even higher.

Determine the BUG ratings or calculations for each unique combination of luminaire and its angular position in the lighting design. Luminaires with limited field adjustability must be assumed to have maximum tilt applied and lumens at or above 90 degrees must be calculated from maximum tilted orientation. To more easily meet the credit requirements, avoid adjustable luminaire types as a primary lighting source.

The Illuminating Engineering Society has established recommendations for exterior lighting levels for varioush applications. Light source selection has a significant effect on how much light is needed and how comfortable it feels. A cooler (whiter) light source (above 2500 degrees Kelvin color temperature) with higher color rendering index (above 80 CRI) makes it easier for people to see and to distinguish detail. By following the recommendations, projects may be able to use lower light levels. However, to ensure acceptability and minimize liability, light levels lower than recommended should be approved by the owner and possibly by the local jurisdiction.

ABOUT THE BUG METHOD

Backlight, uplight, and glare (BUG) are used to classify luminaires and their likelihood of generating light pollution. This comprehensive system takes into account uplight shielding (Figure 2), glare shielding, and backlight shielding (Figure 1), and it limits lamp lumens to values appropriate for a given lighting zone. The system includes a table of consensus acceptable values against which the photometric data of a luminaire can be compared. BUG ratings provide a much more detailed picture of the overall lumen distribution of a luminaire than cut-off designations.

If BUG values are available for the project's luminaires, the team is likely to find Option 1 the easier compliance path.

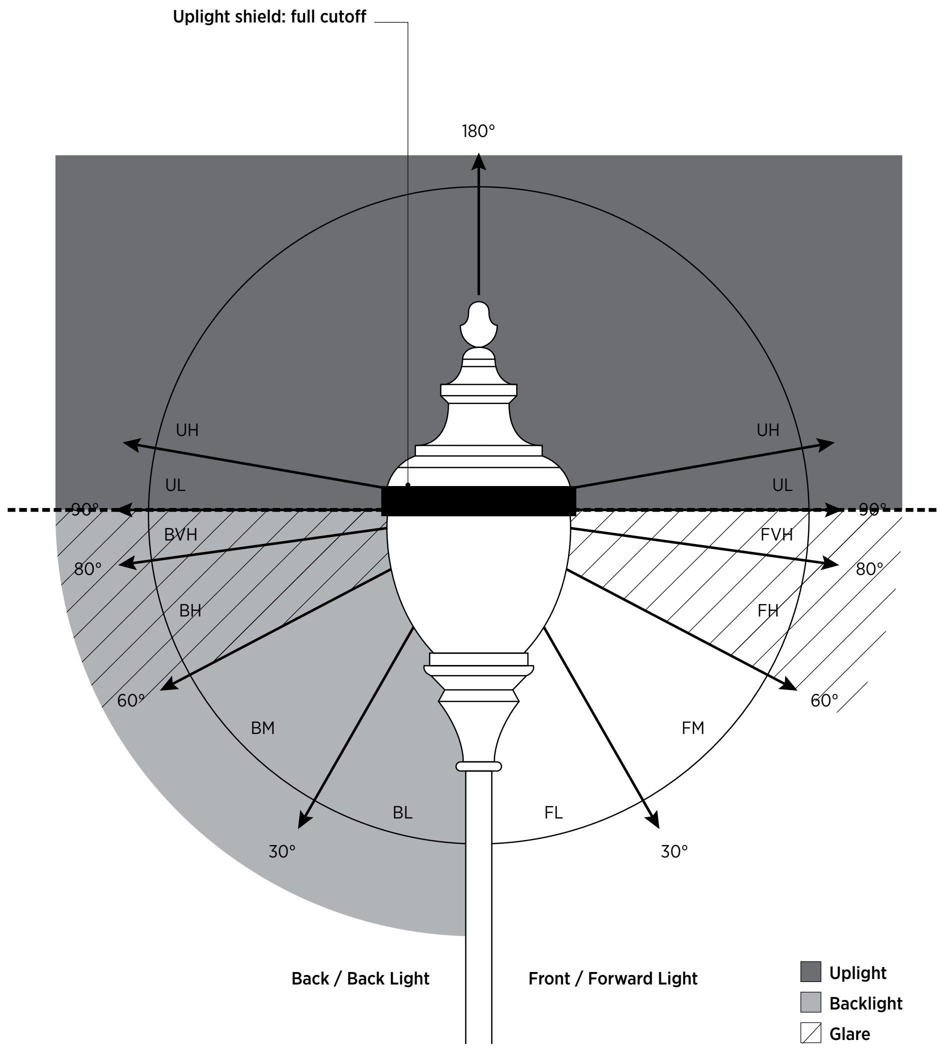


Figure 1. Backlight, uplight, and glare

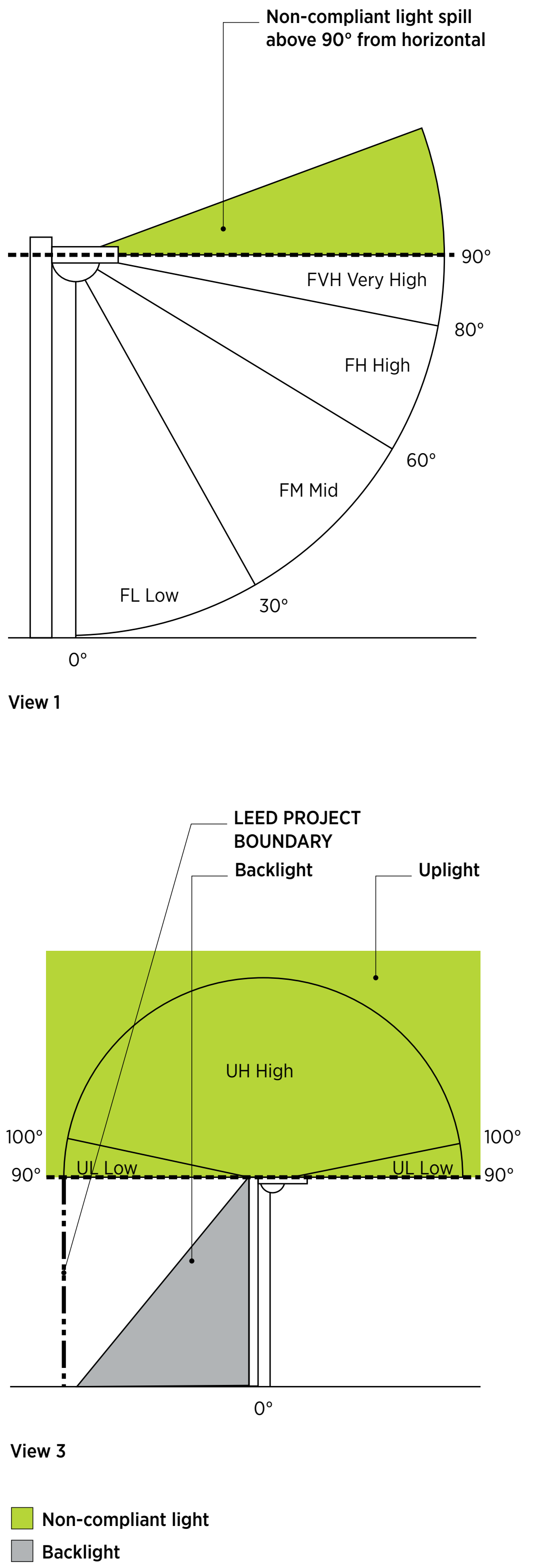


Figure 2. Compliant and noncompliant light

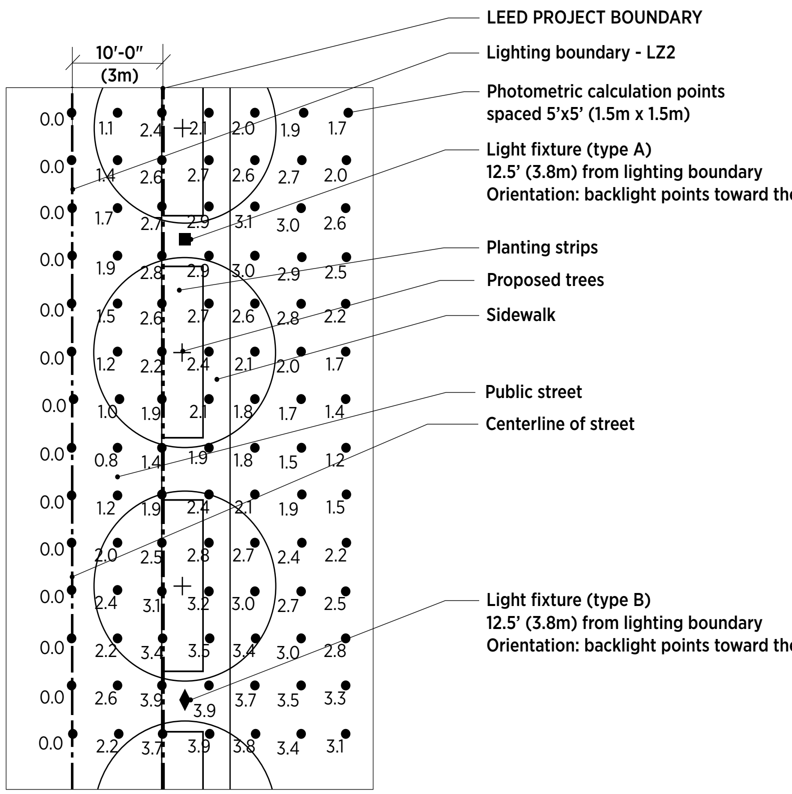
CALCULATING BUG VALUES

BUG values are typically published by product manufacturers. If published BUG data do not address the design position of the luminaire (or are not available at all), ratings can be calculated by reviewing a luminaire's photometric test data and zonal lumen distribution and comparing the data with the maximum zonal lumens for backlight, uplight, and glare established in IES TM-15-11, Addendum A. Software is also available that will calculate the BUG rating using the IES file for the luminaire.

- For the backlight rating, determine the lowest rating where the lumens for all of the secondary solid angles do not exceed the threshold lumens from IES TM-15-11, Addendum A, Table A-1.
- For the uplight rating, determine the lowest rating where the lumens for all secondary solid angles do not exceed the threshold lumens from IES TM-15-11, Addendum A, Table A-2.
- For the glare rating, determine the lowest rating where the lumens for all of the secondary solid angles do not exceed the threshold lumens from IES TM-15-11, Addendum A, Table A-3. For building-mounted luminaires only, the BVH and BH zonal lumens do not need to be considered in determining the G rating.

CALCULATING LIGHT TRESPASS

To calculate light trespass, use lighting design software and develop a photometric site plan (Figure 3) showing all installed exterior lighting luminaires. Set a vertical calculation grid at each segment of the project's lighting boundary and the extent of the lighting zone allowances. The vertical illuminance calculation points must be no more than 5 feet (1.5 meters) apart and extend from grade level up to at least 33 feet (10 meters) above the tallest luminaire in the project (Figure 4).



Plan (NTS)

Figure 3. Photometric site plan

VERTICAL ILLUMINANCE

Illuminance is the total quantity of light, or luminous flux, that falls on a surface, as measured in footcandles or lux. This measurement is usually taken on the horizontal plane, at either the ground or the workplane, but measuring vertical illuminance is helpful for understanding how much light is hitting a building façade, a human face, or the vertical plane at a property boundary. Simply put, vertical illuminance can be explained as standing outside the boundary looking straight into the site at eye level (or horizontal if you are on the ground looking up).

In calculation software, a vertical calculation grid is placed at the location where the measurements need to be taken. In person, measurements are taken using a light meter held vertically. For the purposes of LEED, only the calculation grid for the one vertical plane with greatest vertical illuminance is required to be submitted, and not more. Projects must still assess all of the areas on the boundary for vertical illuminance, but create documentation for only the worst case scenario because all other vertical planes will show lower illuminance values, and thus will comply with the requirements. If there are unique situations, like sensitive areas that require different thresholds, calculation grid documentation for those scenarios should also be submitted.

In Figure 4, the vertical illumination at a point P on a vertical surface parallel to and extending straight up from the lighting boundary is the component of the illumination that is normal to this surface at that point. Since this vertical illuminance must be calculated for a grid of multiple points on the lighting boundary up to 33 feet above the height of the luminaire, it is usually done with a commercially available lighting software program.

The threshold values in Table 4 of the credit requirements must be compared with the cumulative vertical illuminance contributed by all luminaires on the site.

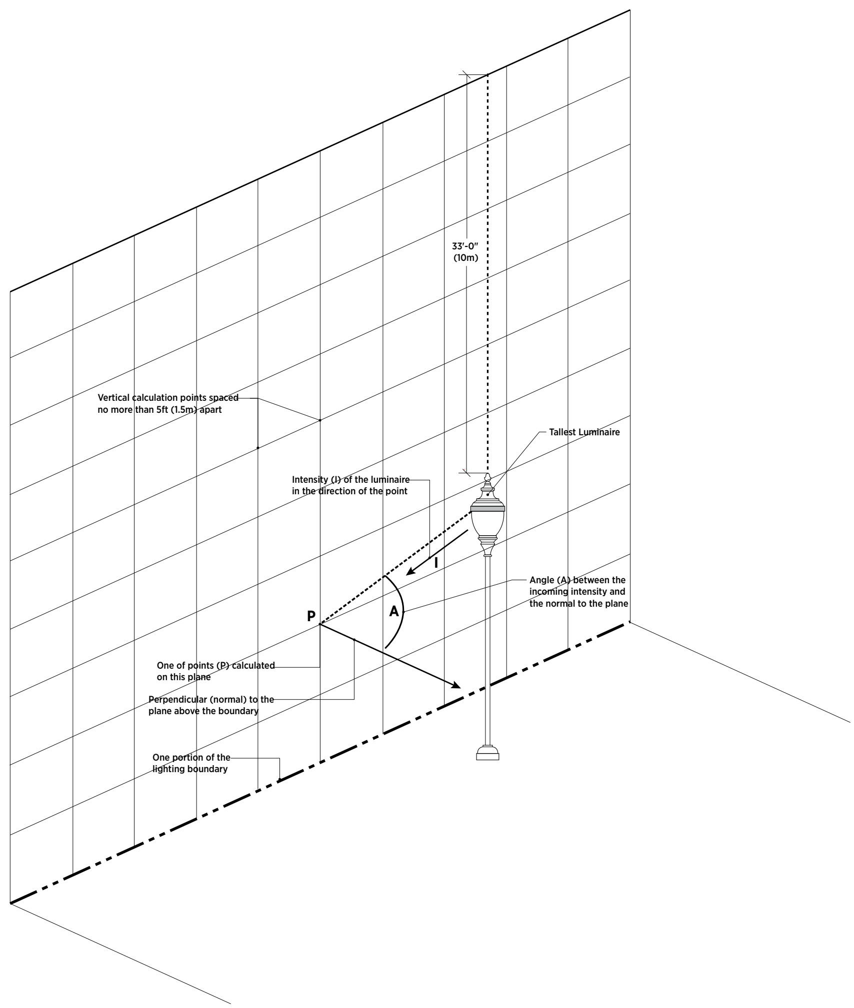


Figure 4. Measuring vertical illuminance

MOUNTING HEIGHTS

The height of the photometric center of a luminaire is considered the mounting height. Measured in distance above grade, it informs the appropriate spacing between poles and distance from the lighting boundary (Figure 5).

For example, if the photometric center of a luminaire is 20 feet (6 meters) above grade, the unit of mounting height is 20 feet (6 meters). If a pole must be two mounting heights from the lighting boundary based on the classified zone and BUG rating, then the pole must be 40 feet (12 meters) from the nearest lighting boundary. The mounting height and pole location need to be calculated for each luminaire.

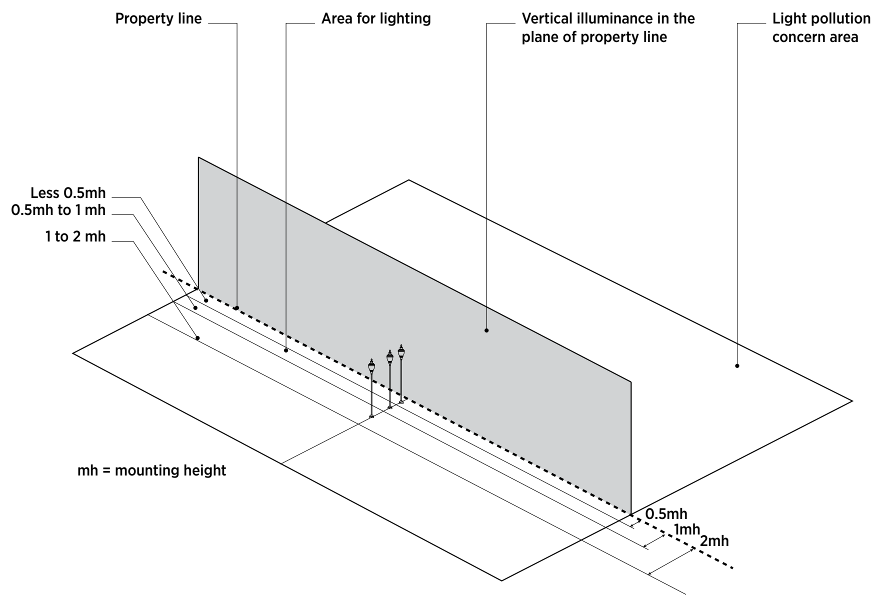


Figure 5. Mounting heights

EXAMPLES

Example 1. BUG rating

The project site is in lighting zone 2 and the preliminary design includes two exterior luminaire types—a building-mounted wallpack luminaire and a pole-mounted site-lighting luminaire.

Based on their location on the building relative to the lighting boundary, the wallpacks fall under the category of "building-mounted >2 mounting heights from any lighting boundary." The pole-mounted luminaires throughout the site fall under two referenced categories, ">2 mounting heights from lighting boundary" and "1 to 2 mounting heights from lighting boundary and properly oriented."

Based on the lighting zone and locations within the lighting boundary and following Tables 1 and 3 in the credit requirements, the following maximum luminaire BUG ratings apply:

TABLE 6. Maximum uplight ratings for luminaires, by MLO lighting zone

MLO lighting zone	Luminaire uplight rating
LZ2	U2

TABLE 7. Maximum backlight and glare ratings, by MLO lighting zone

	MLO lighting zone				
Luminaire mounting	LZ0	LZ1	LZ2	LZ3	LZ4
	Allowed backlight ratings				
> 2 mounting heights from lighting boundary	B1	B3	B4	B5	B5
1 to 2 mounting heights from lighting boundary and properly oriented	B1	B2	B3	B4	B4
	Allowed glare ratings				
Building-mounted > 2 mounting heights from any lighting boundary	G0	G1	G2	G3	G4
All other luminaires	G0	G1	G2	G3	G4

The BUG ratings for the two specified products are as follows:

- Wallpack, B2 U2 G2
- Pole-mounted luminaires, B1 U0 G1

Based on the allowable maximum luminaire BUG ratings in the tables above, the specified luminaires do not exceed the maximum allowances and thus comply with the credit requirements.

Example 2. Calculating uplight

A project team has determined that their site falls within MLO Lighting Zone 2 and is pursuing Option 2 Calculation Method for uplight. The maximum allowable percentage of total luminaire lumens emitted above horizontal is 1.5%. The project must demonstrate that 1.5% or less of total luminaire lumens are emitted above horizontal.

Based on the manufacturer's data and IES files for the various luminaires chosen for the project, the project has prepared the following table:

TABLE 8. Luminaire tracking

Luminaire	Quantity	Lumens per luminaire	Lumens above horizontal	Total luminaire lumens	Total luminaire lumens above horizontal
Type 1	10	3,000	0	30,000	0
Type 2	2	1,000	100	2,000	200
				32,000	200

The team calculates compliance as follows:

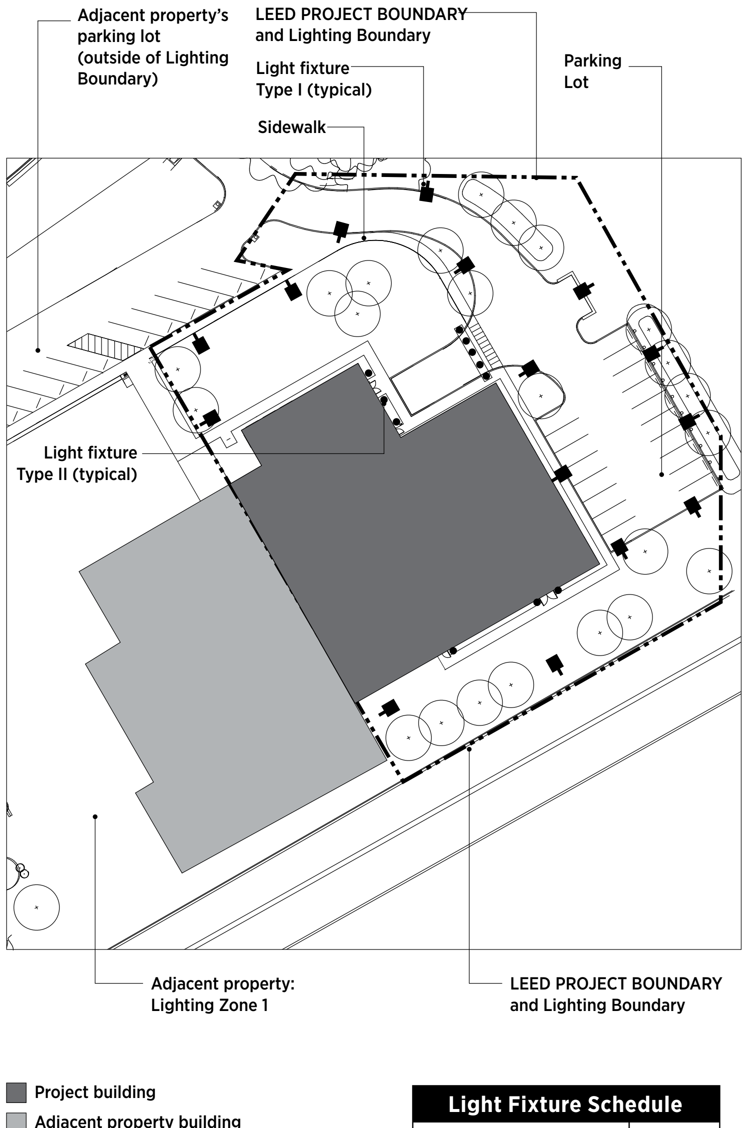
Total luminaire lumens = 32,000

Total lumens above 90° from horizontal = 200

200 / 32,000 = 0.6%

Because 0.6% is below the maximum allowable 1.5% of total lumens above horizontal, the project achieves compliance.

Example 3. Example site lighting plan



Light Fixture Schedule	
Type I Pole-Mounted Street Light Quantity: 15	
Type II Illuminated Bollard Quantity: 11	•

Project Light Zone Designation: 2

Figure 6. Example lighting plan

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	All Projects	Option 1, Uplight	Option 1, Light Trespass	Option 2, Uplight	Option 2, Light Trespass
Site lighting plan with boundaries, elements, location of fixtures, and applicable measurements	X				
Projects with internally illuminated exterior signage only: provide maximum luminance data	X				
Luminaire schedule showing uplight ratings		X			
Luminaire schedule showing backlight and glare ratings and mounting heights			X		
Calculations for lumens per luminaire and lumens emitted above horizontal				X	
Greatest vertical illuminance value for each vertical calculation plane at lighting boundary; calculation grid for one vertical plane with greatest vertical illuminance (worst-case scenario), highlighting point of greatest illuminance					X

RELATED CREDIT TIPS

SS Credit Site Assessment. The site and the project conditions may provide opportunities to reduce lighting needs. There may also be special circumstances, such as a project site located near a sensitive habitat that requires lower lighting zone designations or adjusting the lighting design to fit these conditions.

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. In some cases, earning this credit will require the team to install more luminaires at lower lamp heights to meet the boundary restrictions and BUG requirements, which could impair energy performance. A proper lighting design both minimizes light pollution and maximizes energy efficiency.

CHANGES FROM LEED 2009

- A new compliance option, based on BUG ratings, has been added.
- The lighting power density requirements have been relocated to EA Prerequisite Minimum Energy Performance.
- The interior lighting requirements have been relocated to EA Prerequistie Minimum Energy Performance.
- The photometric information now needs to include only vertical illuminance calculations. Also, point-by-point calculation output documentation needs to be provided only for the worst-case vertical plane, not all site lighting.
- Sports field lighting (including Schools projects) is not exempt from the credit requirements.

REFERENCED STANDARDS

Illuminating Engineering Society and International Dark Sky Association (IES/IDA) Model Lighting Ordinance User Guide and IES TM-15-11, Addendum A: ies.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

BUG rating a luminaire classification system that classifies luminaires in terms of backlight (B), uplight (U), and glare (G) (taken from IES/IDA Model Lighting Ordinance). BUG ratings supersede the former cutoff ratings.

emergency lighting a luminaire that operates only during emergency conditions and is always off during normal building operation

light pollution waste light from building sites that produces glare, is directed upward to the sky, or is directed off the site. Waste light does not increase nighttime safety, utility, or security and needlessly consumes energy.

light trespass obtrusive illumination that is unwanted because of quantitative, directional, or spectral attributes. Light trespass can cause annoyance, discomfort, distraction, or loss of visibility.

mounting height the distance between ground level (or the workplane) and the center of the luminaire (light fixture); the height at which a luminaire is installed.

ornamental luminaire a luminaire intended for illuminating portions of the circulation network that also serves an ornamental function, in addition to providing optics that effectively deliver street lighting, and has a decorative or historical period appearance

vertical illuminance illuminance levels calculated at a point on a vertical surface, or that occur on a vertical plane

SUSTAINABLE SITES CREDIT

Site Master Plan

This credit applies to: **Schools (1 point)**

INTENT

To ensure that the sustainable site benefits achieved by the project continue, regardless of future changes in programs or demographics.

REQUIREMENTS

The project must achieve at least four of the following six credits, using the associated calculation methods. The achieved credits must then be recalculated using the data from the master plan.

- LT Credit: High Priority Site
- SS Credit: Site Development—Protect or Restore Habitat
- SS Credit: Open Space
- SS Credit: Rainwater Management
- SS Credit: Heat Island Reduction
- SS Credit: Light Pollution Reduction

A site master plan for the school must be developed in collaboration with school authorities. Previous sustainable site design measures should be considered in all master-planning efforts so that existing infrastructure is retained whenever possible. The master plan must therefore include current construction activity plus future construction (within the building's lifespan) that affects the site. The master plan development footprint must also include parking, paving, and utilities.

Projects where no future development is planned are not eligible for this credit.

BEHIND THE INTENT

Schools must continually adapt to changes in demographics, curriculum, and program needs. To accommodate such adaptations, school buildings or campuses often must be expanded or modified. Lack of a long-range vision and constrained timeframes for project planning can result in missed opportunities for integrating new construction into existing site features and facilities.

This credit promotes the use of a master plan to support cohesive, long-term, sustainable development strategies. Furthermore, it ensures that the site infrastructure components of a current LEED project are maintained during and after future developments.

STEP-BY-STEP GUIDANCE

STEP 1. CONFIRM FUTURE DEVELOPMENT

Engage with school authorities early in the design process for the project to determine whether future development projects are being considered.

- Only sites where future development is planned are eligible for this credit.
- Future development includes expansions due to changes in program or demographics.
- A specific commitment of the future development, such as a contract, guaranteed funding, or scheduled construction, is not required.

STEP 2. CONFIRM THAT PROJECT IS PURSUING AT LEAST FOUR ELIGIBLE CREDITS

Review the credit requirements and Step-by-Step instructions for the following six credits to determine which will be earned by the current project. The project must earn at least four of the six credits using the current project boundary to achieve this credit.

- LT Credit High Priority Site
- SS Credit Site Development—Protect or Restore Habitat
- SS Credit Open Space
- SS Credit Rainwater Management
- SS Credit Heat Island Reduction
- SS Credit Light Pollution Reduction

STEP 3. DETERMINE STATUS OF ANY MASTER PLAN

Once eligible credits have been selected and confirmed, determine whether the school authority has developed or is currently developing a master plan.

- If a master plan exists or is under development and includes both the current project and the future construction project, the plan could contribute to the achievement of this credit.
- If no master plan has been written or if the current or future project is not yet included in an existing master plan, engage with school authorities to create or update the master plan.

STEP 4. CREATE OR UPDATE SITE MASTER PLAN

Include the current project, the future construction project, parking, paving and utilities in the master plan (see *Further Explanation, Example*).

- Consider how sustainable site design measures and infrastructure included in the scope of the current project can be maintained or enhanced.
- If the future needs of students and the community are uncertain, incorporate flexibility into the master plan to accommodate a range of scenarios and fluctuations in demographics.
- Potential future development is typically determined by the school authorities and design team; it may include changes in program or demographics leading to expansions, projections for supplementary spaces, or other additional structures.

STEP 5. CONFIRM COMPLIANCE FOR SELECTED ELIGIBLE CREDITS

Complete calculations for the selected eligible credits based on the current project site. Recalculate these values for the site master plan, incorporating future development conditions and data. Refer to the appropriate credit sections for explanation of credit-specific calculations.

FURTHER EXPLANATION

EXAMPLE

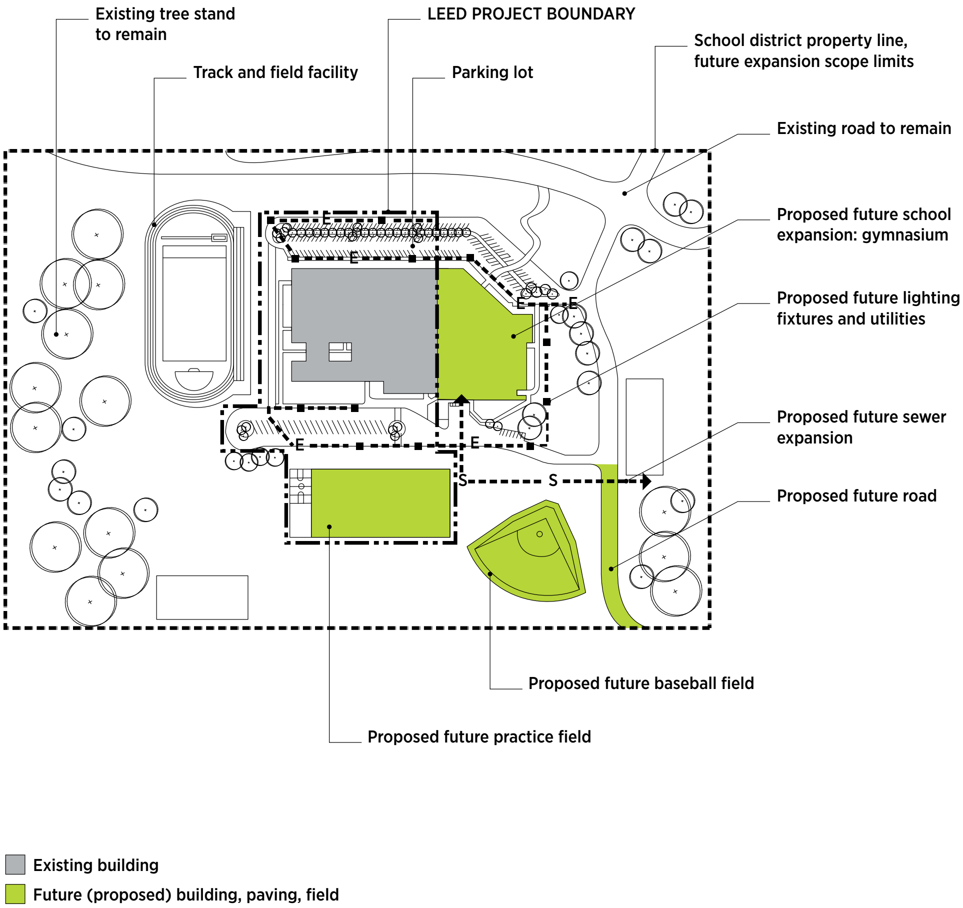


Figure 1. Example site master plan

CAMPUS

Group Approach

Submit separate documentation for each building.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Duplicate the documentation used to achieve the contributing credits, changing the input information so that it is based on the site master plan instead of the project boundary. Refer to the appropriate credit sections for information on credit-specific documentation.

Documentation	All projects
Site plan with elements and measurements, including current and future phases of development	X
Credit forms and documentation for selected eligible credits, rewritten using data for site master plan	X
Description of documentation updates made for future development	X

RELATED CREDIT TIPS

Integrative Process Credit. To earn the related credit, projects facilitate a charrette that identifies and uses opportunities to achieve synergies across disciplines and building systems to inform the site master plan.

SS Credit Joint Use of Facilities. Opportunities to share building space or formalize other community partnerships may reduce the need for future expansion, which could affect the site master plan. Stakeholder charrettes held as part of the site master plan development may inspire community partnerships, which could help the project achieve the related credit.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

master plan boundary the limits of a site master plan. The master plan boundary includes the project area and may include all associated buildings and sites outside of the LEED project boundary. The master plan boundary considers future sustainable use, expansion, and contraction.

school authority the authority responsible for decision making about school operations, districts, personnel, financing, and future development. Examples include school boards, local governments, and religious institutions.

site master plan an overall design or development concept for the project and associated (or potentially associated) buildings and sites. The plan considers future sustainable use, expansion, and contraction. The site master plan is typically illustrated, with building plans (if applicable), site drawings of planned phased development, and narrative descriptions.

SUSTAINABLE SITES CREDIT

Tenant Design and Construction Guidelines

This credit applies to: **Core and Shell (1 point)**

INTENT

To educate tenants in implementing sustainable design and construction features in their tenant improvement build-outs.

REQUIREMENTS

Publish for tenants an illustrated document with the following content, as applicable:

- a description of the sustainable design and construction features incorporated in the core and shell project and the project's sustainability goals and objectives, including those for tenant spaces;
- recommendations, including examples, for sustainable strategies, products, materials, and services; and
- information that enables a tenant to coordinate space design and construction with the building systems when pursuing the following LEED v4 for Interior Design and Construction prerequisites and credits:
  - WE Prerequisite: Indoor Water Use Reduction
  - WE Credit: Indoor Water Use Reduction
  - EA Prerequisite: Minimum Energy Performance
  - EA Prerequisite: Fundamental Refrigerant Management
  - EA Credit: Optimize Energy Performance
  - EA Credit: Advanced Energy Metering
  - EA Credit: Renewable Energy Production
  - EA Credit: Enhanced Refrigerant Management
  - MR Prerequisite: Storage and Collection of Recyclables
  - EQ Prerequisite: Minimum Indoor Air Quality Performance
  - EQ Prerequisite: Environmental Tobacco Smoke Control
  - EQ Credit: Enhanced Indoor Air Quality Strategies
  - EQ Credit: Low-Emitting Materials
  - EQ Credit: Construction Indoor Air Quality Management Plan
  - EQ Credit: Indoor Air Quality Assessment
  - EQ Credit: Thermal Comfort

- EQ Credit: Interior Lighting
- EQ Credit: Daylight
- EQ Credit: Quality Views
- EQ Credit: Acoustic Performance

Provide the guidelines to all tenants before signing the lease.

BEHIND THE INTENT

Core and Shell project teams may have limited influence on how the final tenant space is fitted out. This credit requires the team to prepare guidelines for extending the sustainable design intent of the base building into tenants' individual spaces.

Design and construction guidelines help tenant design teams understand and use a LEED building's systems and design features to achieve significant reductions in energy and resource consumption (particularly important where water and energy are submetered and tenants pay for their own usage). Suggestions for sustainable products and strategies encourage tenants to make sustainable choices.

The document also helps Core and Shell teams fully consider tenants' needs. Furthermore, a carefully thought-out set of sustainable guidelines gives a project a marketing advantage with tenants who wish to occupy a healthful building or pursue LEED for Interior Design and Construction. The time invested in developing guidelines may be well spent if the document helps attract lessees.

STEP-BY-STEP GUIDANCE

STEP 1. CONSIDER TENANTS' CHARACTERISTICS AND NEEDS

Before drafting the guidelines, consider the type and number of tenants. Think about how the needs of different tenants might vary and be sure that all uses in the building are covered by the guidelines.

- If tenant uses vary significantly, as in a mixed-use building with both hospitality and retail spaces, consider developing separate tenant guidelines.
- Consider how the guidelines can be used to support marketing of the building and leasing of specific spaces.

STEP 2. DEVELOP GUIDELINES CONTENT

During the design phase of the Core and Shell project, begin compiling a list of items and strategies to include in the guidelines. Starting early may help the base building design team optimize systems to support high-performing tenant spaces. When complete, compile guidelines into a comprehensive document(s).

STEP 3. DISTRIBUTE GUIDELINES

Provide the guidelines to all potential tenants during lease negotiations and before any tenant design and construction work begins. The guidelines do not constitute requirements for the tenants and are not binding on lessees.

FURTHER EXPLANATION

ECONOMIC CONSIDERATIONS

Some strategies and recommendations may require upfront investments on the part of the tenant. For example, tenants choosing to certify their build-out projects under the LEED for Interior Design and Construction rating system may incur additional costs for commissioning and certification. It may be helpful to indicate in the guidelines which features are likely to entail upfront costs but deliver long-term savings through, for example, lower operating costs.

SUBJECT-SPECIFIC GUIDANCE

Depending on the Core and Shell design and scope, consider including the following information in the tenant guidelines. (Related LEED for Interior Design and Construction credits are noted in parentheses.)

Water Use
Specify the building water-use reduction goals. Provide information and/or recommendations for plumbing fixtures, flow rates and systems, and product cutsheets. (Related credits: WE Prerequisite Indoor Water Use Reduction, WE Credit Indoor Water Use Reduction.)

Energy Performance
Highlight the energy-saving features of the base building and provide recommendations for tenants to further reduce energy use. The HVAC system that the Core and Shell design team chooses will affect the tenant buildout. Describe the HVAC system, including energy efficiency features and suggestions for how they can be best used. Provide recommendations or performance requirements for supplemental HVAC equipment and independent tenant systems. (Related credits: EA Prerequisite Minimum Energy Performance, EA Credit Optimize Energy Performance.)

Refrigerant Management
Include recommendations for refrigerants in cooling equipment. (Related credits: EA Prerequisite Fundamental Refrigerant Management, EA Credit Enhanced Refrigerant Management.)

Energy Use and Metering
Provide information on the building's expected energy use. Describe how the building and tenant energy uses are submetered, if applicable, and how further submetering of tenant uses can encourage energy conservation. (Related credit: EA Credit Advanced Energy Metering.)

Renewable Energy
Provide information on any on-site renewable energy systems, like photovoltaic systems, wind energy systems, solar thermal systems, and geothermal systems. (Related credit: EA Credit Renewable Energy Production.)

Commissioning
Provide details on the Core and Shell commissioning process, including the commissioning plan or report and the building's design intent, so that the tenant can evaluate whether the space is functioning as designed. Core and Shell commissioning documents can also serve as a model for tenants' own commissioning efforts. (Related credits: EA Prerequisite Fundamental Commissioning and Verification, EA Credit Enhanced Commissioning.)

Ventilation and Outdoor Air Delivery
Provide design and operational information for the ventilation system, such as how air is provided to the space (e.g., underfloor, overhead, displacement, or natural ventilation) and the amount of outside air that each system is capable of providing, so that tenants can determine how much outside air is available to them. Describe the ventilation control systems and identify opportunities for the tenant to add monitoring devices, such as CO_2 sensors, and other enhancements. (Related credit: EQ Prerequisite Minimum Indoor Air Quality Performance.)

Construction Indoor Air Quality Management
Highlight areas of the Core and Shell construction indoor air quality management plan that are applicable to the tenant buildout, particularly where tenant work may be sequenced at the same time. (Related credit: EQ Credit Construction Indoor Air Quality Management Plan.)

Indoor Chemical and Pollutant Source Control
Because multiple tenants may share air return and supply systems, describe how to isolate hazardous gases or chemicals, such as by providing separate exhaust for janitor's closets. (Related credits: EQ Credit Indoor Air Quality Assessment, EQ Credit Enhanced Indoor Air Quality Strategies.)

Interior Lighting
Lighting often represents the greatest opportunity for tenants to reduce energy consumption. Core and Shell projects that offer good natural light will enable tenants to reduce lighting power without compromising light quality. Controls and fixture selection are also critical. Guidelines might include recommendations for keeping windows clear for daylight penetration, locating workspaces or gathering spaces near windows to minimize the need for lights, using energy-efficient fixtures and lamps, and installing daylight-responsive lighting controls and occupancy sensors. (Related credits: EQ Credit Interior Lighting, EQ Credit Daylight.)

Thermal Comfort
Explain how the building's HVAC system will help maintain thermal comfort in the building. Provide the design criteria of the system (including indoor and outdoor conditions) and document any other assumptions made for the thermal comfort calculations (including space internal loads, clothing, and metabolic rate of the people in the space). Describe the building's HVAC control systems. If the building incorporates natural ventilation, describe how it can be used and how it works with the building's other systems. For a completely mechanical system, provide details on how the tenants can regulate the thermal comfort in their spaces. (Related credit: EQ Credit Thermal Comfort.)

Views
Consider views in addition to the daylighting strategies mentioned under Interior Lighting. Prepare sample layouts and illustrations so that tenant design teams can understand how to take full advantage of this amenity. (Related credit: EQ Credit Quality Views.)

Environmental Tobacco Smoke
Include the building's smoking policy as part of the tenant guidelines. If smoking is permitted in the building, the required strategies for separation, exhaust, and pressurization must be clearly communicated so that they can be included in the tenant's scope of construction. (Related credit: EQ Prerequisite Environmental Tobacco Smoke Control.)

Low-Emitting Materials
Provide a detailed list of all specified interior paints, coatings, adhesives, sealants, flooring, composite wood, ceilings, walls, and thermal and acoustic insulation that meet the requirements. If possible, include manufacturer's documentation confirming the compliance for each product. (Related credit: EQ Credit Low-Emitting Materials.)

Acoustic Performance
Provide information on the background noise level of base building's HVAC system. (Related credit: EQ Credit Acoustic Performance.)

Storage and Collection of Recyclables
Include information regarding the building's recycling policy and procedures. Note any centralized collection and storage areas. Encourage activities to reduce and reuse materials before recycling, to decrease the volume of recyclables handled. (Related credit: MR Prerequisite Storage and Collection of Recyclables.)

Sustainable Products, Materials, and Services
Describe recommended materials, products, strategies, and services to use in the tenant buildout. Sustainable material suppliers, manufactures, local salvaged material retailers, and construction waste recycling facilities may also be listed. (Materials and Resources credits.)

SUPPORTING DOCUMENTATION OPTIONS

The following supporting documentation may assist tenants in implementing sustainable strategies in their buildouts:

LEED for Interior Design and Construction Scorecard
Include a scorecard for one of the ID+C rating systems to demonstrate how base building contributions and relatively easy-to-achieve tenant space credits can support ID+C certification.

Specifications or Cutsheets
Provide performance guidance or cutsheets for plumbing fixtures, paints, finishes, and other products used in the core and shell to help tenants specify green materials in their own buildouts. Sample specification language could also be included.

Policies and Descriptions
Provide tenants with the building recycling and smoking policies, and describe any energy monitoring or metering in place for the base building.

Documentation from the LEED for Core and Shell Submittal
Tenants interested in pursuing LEED for Interior Design and Construction certification will benefit from having copies of the Core and Shell submittals to reduce duplication of documentation.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All Projects
Tenant design and construction guidelines document	X

RELATED CREDIT TIPS

All Core and Shell credits with performance thresholds. Projects may choose to adopt some or all of the guidelines as tenant requirements to support achievement of other

LEED for Core and Shell credits. For example, core and shell projects that require tenants to demonstrate a 5% reduction in lighting power density below ASHRAE 90.1 2010 (or a USGBC-approved equivalent for projects outside the U.S.) can include the assumed tenant reduction in the core and shell energy model. Such requirements must be incorporated into the tenant lease; however, it is not necessary to require tenants' compliance with all guidelines to earn this credit.

CHANGES FROM LEED 2009

Tenant guidelines are no longer required to include information on LEED for Commercial Interiors or explain how the core and shell building contributes to achieving these credits.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

SUSTAINABLE SITES CREDIT

Places of Respite

This credit applies to: **Healthcare (1 point)**

INTENT

To provide patients, staff, and visitors with the health benefits of the natural environment by creating outdoor places of respite on the healthcare campus.

REQUIREMENTS

Provide places of respite that are accessible to patients and visitors, equal to 5% of the net usable program area of the building.

Provide additional dedicated places of respite for staff, equal to 2% of the net usable program area of the building.

Places of respite must be outdoors, or be located in interior atria, greenhouses, solaria, or conditioned spaces; such interior spaces may be used to meet up to 30% of the required area if 90% of each qualifying space's gross floor area achieves a direct line of sight to unobstructed views of nature.

All areas must meet the following requirements.

- The area is accessible from within the building or located within 200 feet (60 meters) of a building entrance or access point.
- The area is located where no medical intervention or direct medical care is delivered.
- Options for shade or indirect sun are provided, with at least one seating space per 200 square feet (18.5 square meters) of each respite area, with one wheelchair space per five seating spaces.
- Horticulture therapy and other specific clinical or special-use gardens unavailable to all building occupants may account for no more than 50% of the required area.
- Universal-access natural trails that are available to visitors, staff, or patients may account for no more than 30% of the required area, provided the trailhead is within 200 feet (60 meters) of a building entrance.

Additionally, outdoor areas must meet the following requirements.

- A minimum of 25% of the total outdoor area must be vegetated at the ground plane (not including turf grass) or have overhead vegetated canopy.
- The area is open to fresh air, the sky, and the natural elements.
- Signage must meet the 2010 FGI Guidelines for Design and Construction of Health Care Facilities (Section 1.2-6.3 and Appendix A1.2-6.3:Wayfinding).
- Places of respite may not be within 25 feet (7.6 meters) of a smoking area (see EQ Prerequisite Environmental Tobacco Smoke Control).

Existing places of respite on the hospital campus may qualify if they otherwise meet the credit requirements.

BEHIND THE INTENT

Access to fresh air, daylight, and outdoor vegetation can deliver important health benefits. Natural vegetated elements allow patients, visitors, and staff to connect with nature and experience "relaxed wakefulness," a state that has been attributed to a decrease in negative emotions such as anger and anxiety.[1]

Studies have shown that patients with a view of nature recover faster, need fewer painkillers, and have fewer complications after leaving the hospital.[2] For staff, having access to nature relieves stress and enhances well-being, and workers who are able to connect with nature also report fewer illnesses and higher levels of job satisfaction.[3] Caregivers who work long hours in a fast-paced, stressful, and physically demanding environment especially value staff-only outdoor places of respite. Moreover, reducing patients' length of stay and improving staff recruitment and retention confer economic benefits.

This credit rewards quality spaces that include vegetation, have exposure to the elements, and allow opportunities for exercise and movement. Such spaces must protect patients from bad weather and poor air quality while accommodating those with limited mobility. When outdoor space provision is impossible, interior spaces with unobstructed views of nature can grant similar benefits.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE REQUIRED AREA FOR PLACES OF RESPITE

Calculate the net usable program area of the project by summing all the interior areas available to house the project's program. Exclude areas for building equipment, vertical circulation, or structural components (see *Further Explanation, Qualifying Spaces,* and ANSI/BOMA Z65.1–2010, Office Buildings: Standard Methods of Measurement, boma.org, for more information about calculating net usable program area).

Determine the required area for places of respite for patients and visitors and for staff. The area for patients and visitors must be 5% of the net usable program area, and the area for staff must be 2% of the net usable program area. For example, if the net usable program area is 10,000 square feet (930 square meters), the total required area for patients and visitors is 500 square feet (46 square meters), and the total required area for staff is 200 square feet (18 square meters).

STEP 2. DETERMINE TYPES AND SIZES OF PLACES OF RESPITE

Work with the owner, stakeholders, and designers to determine the types and areas of spaces that could be designed as places of respite.

- During the concept and schematic design phases, ensure that the project massing and the basic interior layout allow for integrated exterior spaces.
- Ensure that each type of designed space does not exceed the maximum allowed percentage of the total places of respite area (Table 1).

TABLE 1. Places of respite criteria

Type of space	Maximum % of total places of respite area	Special conditions
Interior atria, greenhouses, solaria, or conditioned spaces	30%	90% of each qualifying space's gross floor area must achieve direct line of sight to unobstructed views of nature
Horticulture therapy and other specific clinical or special-use gardens unavailable to all building occupants	50%	None
Universal-access natural trails	30%	Trailhead access must be within 200 feet (60 meters) of building entrance

1. *Rohde, C.L.E., and A.D. Kendle, Report to English Nature—Human Well-Being, Natural Landscapes and Wildlife in Urban Areas: A Review (Department of Horticulture and Landscape and the Research Institute for the Care of the Elderly, University of Reading, Bath, 1994).*
2. *Ulrich, R.S., View through a Window May Influence Recovery from Surgery, Science 224 (1984): 420–421.*
3. *Kaplan, R., and S. Kaplan, The Experience of Nature: A Psychological Perspective (New York and Cambridge: Cambridge University Press, 1989).*

STEP 3. DETERMINE LOCATIONS AND QUALITIES OF PLACES OF RESPITE

Ensure that each area of respite is appropriately located and complies with any requirements for seating, vegetation, and signage (see *Further Explanation, Qualifying Spaces*).

STEP 4. INCORPORATE QUALIFYING SPACES INTO THE DESIGN

If there are insufficient qualifying spaces in the existing facility or planned design, or the spaces do not embody the qualities listed in the credit requirements, redesign the site to include more spaces with these qualities.

- Separation of spaces for staff from spaces for visitors and patients is not required but may be appropriate in some cases.
- Some places of respite might have restricted access if they are intended for use by patients with specific conditions or needs, or as a break area for staff.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

QUALIFYING SPACES

All areas must meet these requirements:

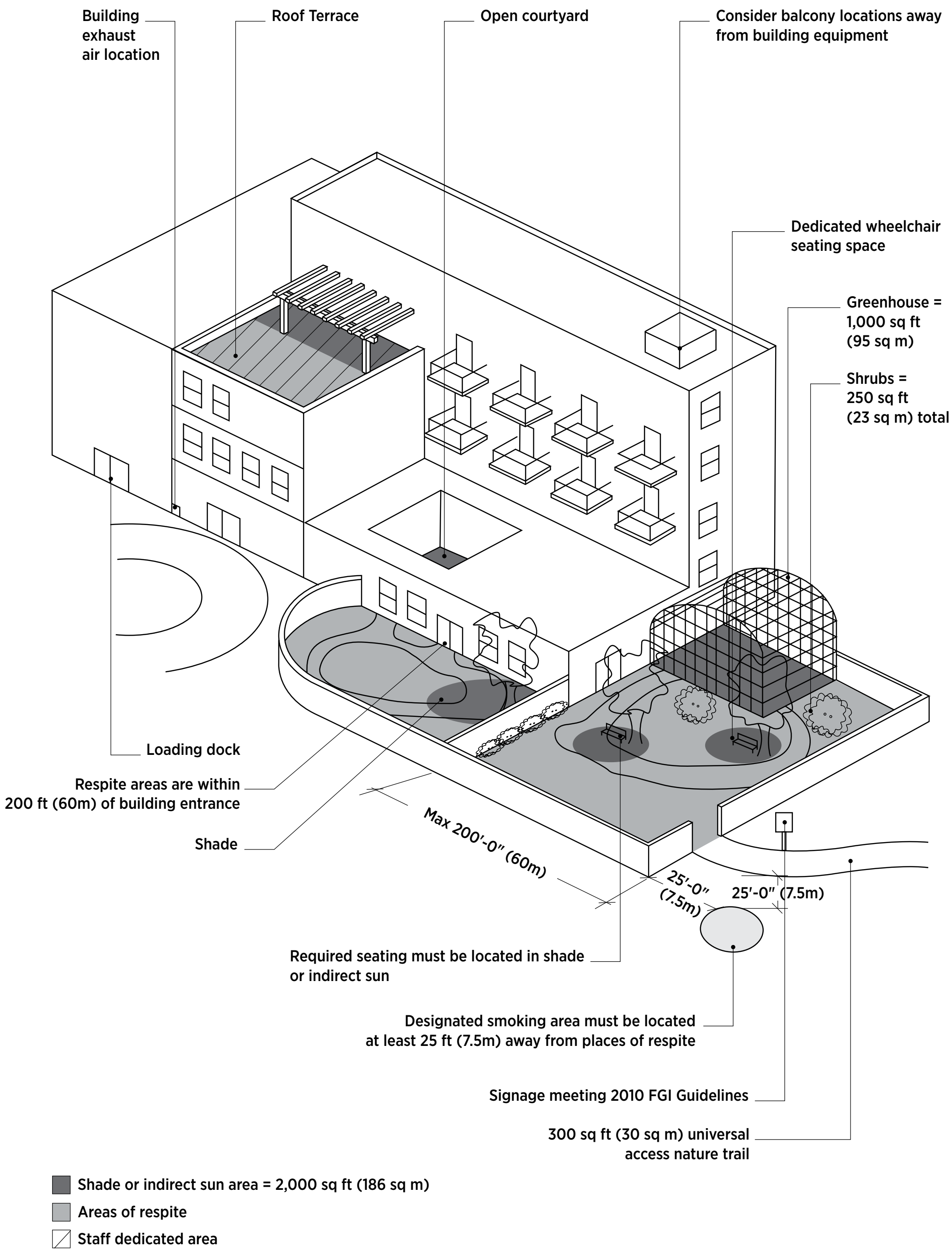
- The area is accessible from within the building or located within 200 feet (60 meters) of a building entrance or access point. Areas outside the project boundary can qualify as places of respite, provided they are within 200 feet (60 meters).
- No medical intervention or direct medical care is delivered in the respite area.
- For each 200 square feet (18 square meters) of respite area, at least one seating space and one wheelchair space for every five seating spaces are placed in shade or indirect sunlight. Examples of qualifying features include trellises and tree-shaded, wheelchair-accessible seating areas.

Outdoor spaces must meet these additional requirements:

- At least 25% of the total outdoor area must be vegetated at the ground plane (not including turf grass) or have vegetated canopy (trees and shrubs).
- The area is open to fresh air, the sky, and the natural elements.
- Signage must meet the 2010 FGI Guidelines for Design and Construction of Health Care Facilities (Section 1.2-6.3 and Appendix A1.2-6.3, Wayfinding).
- Places of respite may not be within 25 feet (7.5 meters) of a smoking area (see EQ Prerequisite Environmental Tobacco Smoke Control).

EXAMPLE

Figure 1. Example site plan



CAMPUS

Group Approach

Submit separate documentation for each building.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All Projects
Area, patient, visitor, staff, shading, and vegetation calculations	X
Site plan highlighting qualifying outdoor and/or indoor places of respite, identified by user (patient and visitor versus staff), and indicating their access points and distances, proximity to smoking areas, planes of vegetation and vegetated canopy, and shaded seating spaces (showing shade pattern throughout day)	X
Drawings or photographs of wayfinding signage	X

RELATED CREDIT TIPS

SS Credit Direct Exterior Access. Outdoor places of respite qualify as exterior access spaces for patients if they meet the location requirements of the related credit.

SS Credit Rainwater Management. Rain gardens and other rainwater management features may also serve as outdoor places of respite.

SS Credit Site Development—Protect or Restore Habitat. Outdoor places of respite may also provide places to restore or conserve habitat.

SS Credit Open Space. Meeting the vegetation requirements of this credit will help meet the requirements of the related credit. Similar qualities of open space are required for both credits.

EQ Prerequisite Environmental Tobacco Smoke Control. To confirm compliance with the nonsmoking requirement, ensure that the project has completed documentation for the related prerequisite.

CHANGES FROM LEED 2009

A requirement that 25% of all qualifying outdoor space be vegetated at the ground plane or with overhead vegetated canopy (trees and shrubs only) was added to ensure that vegetation is present to provide additional benefits.

REFERENCED STANDARDS

2010 FGI Guidelines for Design and Construction of Health Care Facilities: fgiguidelines.org

EXEMPLARY PERFORMANCE

Projects may earn exemplary performance by demonstrating *both* of the following:

- Provide 10% of net usable program area as places of respite for patients and visitors
- Provide 4% of the net usable program area as places of respite for staff

DEFINITIONS

net usable program area the sum of all interior areas in the project available to house the project's program. It does not include areas for building equipment, vertical circulation, or structural components.

place of respite an area that connects healthcare patients, visitors, and staff to health benefits of the natural environment. (Adapted from Green Guide for Health Care Places of Respite Technical Brief)

SUSTAINABLE SITES CREDIT

Direct Exterior Access

This credit applies to: **Healthcare (1 point)**

INTENT

To provide patients and staff with the health benefits associated with direct access to the natural environment.

REQUIREMENTS

Provide direct access to an exterior courtyard, terrace, garden, or balcony. The space must be at least 5 square feet (0.5 square meters) per patient for 75% of all inpatients and 75% of qualifying outpatients whose clinical length of stay (LOS) exceeds four hours.

Patients whose length of stay exceeds four hours, and whose treatment makes them unable to move, such as emergency, stage 1 surgical recovery, and critical care patients, may be excluded.

Places of respite outside the building envelope that meet the requirements of SS Credit Places of Respite that are immediately adjacent to clinical areas or with direct access from inpatient units may be included.

Qualifying spaces must be designated as nonsmoking The spaces must also meet the requirements for outdoor air contaminant concentrations enumerated in EQ Credit Enhanced Indoor Air Quality Strategies, Option 2 and be located more than 100 feet (30 meters) from building exhaust air locations, loading docks, and roadways with idling vehicles.

BEHIND THE INTENT

Time spent outdoors and views of nature provide important health benefits to all people, but especially hospital patients. Being outside allows people to connect with nature and experience "relaxed wakefulness," a state attributed to a decrease in negative emotions such as anger and anxiety.[1]

Studies have shown that patients with a natural view or access to nature recover faster, need fewer painkillers, and have fewer complications after leaving the hospital.[2] Quiet areas where people can reconnect to the natural cycles of day and night, seasonal changes, and weather patterns provide relief from stressful environments.

This credit rewards designs that include easy access to nature. Direct access can be critical for patients with limited mobility or short times between treatments. Furthermore, access that allows for privacy encourages patients to go outside at times when they do not wish to cross through public areas.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE NUMBER OF PATIENTS

Use the peak number of inpatients and peak number of qualifying outpatients to determine the minimum required outdoor area. The peak number of inpatients used for credit calculations should correspond to the total peak inpatients used across all credits (see *Definitions* and *Getting Started, Occupancy*).

To determine the peak number of qualifying outpatients, begin with the total peak outpatients in the project and make the following adjustments:

- Outpatients whose length of stay is less than four hours are considered nonqualifying. Do not include these outpatients in credit calculations.
- Outpatients whose length of stay exceeds four hours and whose treatment makes them immobile may be excluded from calculations. These patients include those in emergency, stage 1 surgical recovery, stage 2 recovery, and similar spaces. For the purposes of credit documentation, these patients are "excluded outpatients."
- Qualifying outpatients are all nonexcluded patients whose length of stay is four hours or more. Examples of qualifying outpatients may include patients undergoing renal dialysis, infusion therapies, ambulatory surgery intake, and stage 2 recovery.

In the preliminary design phases of a project, the peak number of inpatients can be estimated by approximating the total number of inpatient beds. To estimate the peak number of qualifying outpatients, consider the types of outpatients that the facility serves. Use the number of qualifying outpatient beds, treatment room capacity, or similar information to estimate the number of qualifying outpatients.

STEP 2. DETERMINE REQUIRED OUTDOOR AREA

Use Equation 1 to calculate the required outdoor area. At least 5 square feet (0.5 square meters) of space must be provided per patient for 75% of peak inpatients and 75% of peak qualifying outpatients.

EQUATION 1. Required outdoor area

$$\text{Required outdoor area} = 5\ \text{ft}^2 \times (.75)\ \text{peak inpatients} + 5\ \text{ft}^2 \times (.75)\ \text{qualifying outpatients}$$

OR

$$\text{Required outdoor area} = 0.5\ \text{m}^2 \times (.75)\ \text{peak inpatients} + 0.5\ \text{m}^2 \times (.75)\ \text{qualifying outpatients}$$

STEP 3. DETERMINE OUTDOOR SPACE NEEDS AND QUALITIES

Work with the owner, stakeholders, and designers to determine the types and areas of outdoor spaces that will meet project goals and the credit intent.

- Unlike SS Credit Places of Respite, interior spaces do not count toward this credit.

1. *Rohde, C.L.E., and A.D. Kendle, Report to English Nature—Human Well-Being, Natural Landscapes and Wildlife in Urban Areas: A Review (Department of Horticulture and Landscape and the Research Institute for the Care of the Elderly, University of Reading, Bath, 1994).*
2. *Ulrich, R.S., View through a Window May Influence Recovery from Surgery, Science 224 (1984): 420–421.*

- Private balconies must meet the minimum size requirement. For example, a balcony for one patient must be at least 5 square feet (0.5 square meter).
- The exterior areas can be shared patient spaces, provided the total area meets the required size based on the number of patients using the space.
- Consult the outdoor air contaminant concentration requirements in EQ Credit Enhanced Indoor Air Quality Strategies, Option 2, and ensure that contaminants do not exceed the National Ambient Air Quality Standards thresholds (or a local equivalent for projects outside the U.S.).
- Identify the locations of building air exhausts, loading docks, and potential vehicle idling areas (e.g., designated delivery areas, waste disposal locations) and locate the outdoor spaces at least 100 feet (30 meters) away.

STEP 4. INCORPORATE DIRECT ACCESS TO QUALIFYING SPACES INTO PROJECT DESIGN

If there are insufficient qualifying spaces in the existing facility or planned design, or the spaces do not embody the qualities listed in the credit, redesign the site to include more spaces that provide direct access to an exterior courtyard, terrace, garden, or balcony.

- During the concept and schematic design phases, ensure that the project massing and the basic interior layout allow for integrated exterior spaces. For patients with limited mobility, ensure that respite areas are accessible and close to patients' rooms. Areas outside the project boundary can qualify, provided they meet the requirements of the credit.
- Patients must have access to these spaces directly from their rooms or treatment areas. Shared exterior connections are allowed, but interior connections (e.g., through a patient's room) are not.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

EXAMPLE

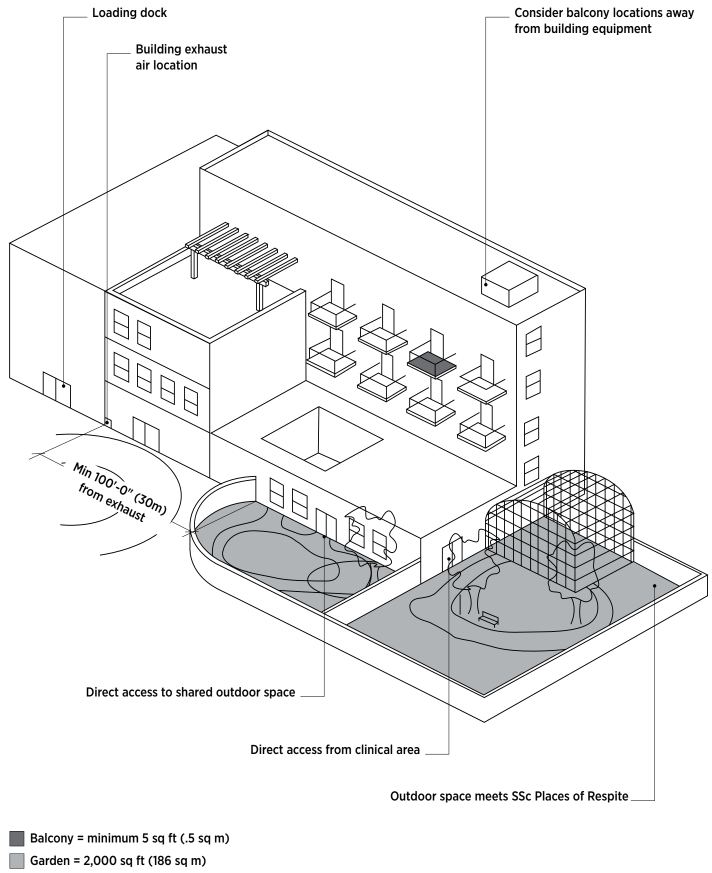


Figure 1. Direct access to places of respite

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All Projects
Area and patient calculations	X
Site plan indicating locations of accessible outdoor areas, area takeoffs, building air exhausts, exterior exhaust vents, and access points and distances to outdoor areas	X

RELATED CREDIT TIPS

SS Credit Places of Respite. Outdoor places of respite can qualify as exterior access spaces for patients if there is direct access.

SS Credit Rainwater Management. Rain gardens and other rainwater management features may also serve as outdoor spaces that meet the requirements of this credit.

EQ Credit Enhanced Indoor Air Quality Strategies, Option 2. Achieving the outdoor air contaminant concentrations in this related credit satisfies the outdoor air quality component of SS Credit Direct Exterior Access for Patients.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

direct access a means of entering a space without having to leave the floor or pass through another patient's room, dedicated staff space, service or utility space, or major public space. Patients' and public circulation corridors, common sitting areas, and waiting and day space may be part of a direct access route.

inpatient an individual admitted to a medical, surgical, maternity, specialty, or intensive-care unit for a length of stay exceeding 23 hours

length of stay the amount of time a person remains in a health care facility as an admitted patient

outpatient a patient who is not hospitalized for 24 hours or more but who visits a hospital, clinic, or associated healthcare facility for diagnosis or treatment

place of respite an area that connects healthcare patients, visitors, and staff to health benefits of the natural environment. (Adapted from Green Guide for Health Care Places of Respite Technical Brief)

SUSTAINABLE SITES CREDIT

Joint Use of Facilities

This credit applies to: **Schools (1 point)**

INTENT

To integrate the school with the community by sharing the building and its playing fields for nonschool events and functions.

REQUIREMENTS

OPTION 1. MAKE BUILDING SPACE OPEN TO THE GENERAL PUBLIC (1 POINT)

In collaboration with the school authorities, ensure that at least three of the following types of spaces in the school are accessible to and available for shared use by the general public:

- auditorium;
- gymnasium;
- cafeteria;
- one or more classrooms;
- playing fields and stadiums; and
- joint parking.

Provide access to toilets in joint-use areas after normal school hours.

OR

OPTION 2. CONTRACT WITH SPECIFIC ORGANIZATIONS TO SHARE BUILDING SPACE (1 POINT)

In collaboration with the school authorities, contract with community or other organizations to provide at least two types of dedicated-use spaces in the building, such as the following:

- commercial office;
- health clinic;
- community service centers (provided by state or local offices);
- police office;
- library or media center;
- parking lot; and
- one or more commercial businesses.

Provide access to toilets in joint-use areas after normal school hours.

OR

OPTION 3. USE SHARED SPACE OWNED BY OTHER ORGANIZATIONS (1 POINT)

In collaboration with the school authorities, ensure that at least two of the following six types of spaces that are owned by other organizations or agencies are accessible to students:

- auditorium;
- gymnasium;
- cafeteria;
- one or more classrooms;
- swimming pool; and
- playing fields and stadiums.

Provide direct pedestrian access to these spaces from the school. In addition, provide signed joint-use agreements with the other organizations or agencies that stipulate how these spaces will be shared.

BEHIND THE INTENT

A joint-use agreement encourages community organizations and businesses to share existing amenity spaces. Doing so brings social benefits to the local community; it also may reduce the need for new development, thereby preserving previously undeveloped land and avoiding the financial costs and environmental consequences of new construction.

Local communities benefit most when multiple organizations share the costs of constructing, operating, and maintaining a facility. Joint-use agreements allow buildings and sites that would typically go unused after normal business or operating hours to offer to host community programs, thereby maximizing the useful life of the building. In addition, communities may enjoy new or more convenient services.

STEP-BY-STEP GUIDANCE

STEP 1. ENGAGE SCHOOL AUTHORITIES

Initiate preliminary discussions with the school authorities, ideally before or during the design phase of the project, to identify the best opportunities for shared use in the school.

School expansion limits, parking capacity limits, resource availability, and the pros and cons of shared spaces are among the points to discuss when meeting with the school authorities.

STEP 2. SELECT ONE OPTION

- Option 1 is for projects with multiple assembly spaces that could be made accessible to the general public.
- Option 2 is for projects that could be designed to include spaces for external groups or companies.
- Option 3 is for projects that will provide student access to spaces owned by other organizations and located off site.

Option 1. Make Building Space Open to the General Public

STEP 1. ALLOCATE SHARED SPACES

Work with the school authorities to identify and allocate at least three types of eligible shared spaces within the project that are to be made available to the general community.

- Discuss community needs with the school authorities to determine which types of spaces will be made available.
- Obtain written confirmation from the school authorities that these spaces will be made available to the public.

STEP 2. DESIGNATE FACILITIES FOR SHARED SPACES

Designate restroom facilities that are accessible to shared-space users after normal school hours.

STEP 3. ESTABLISH TERMS AND CONDITIONS OF USAGE

Meet with the school authorities to establish terms and conditions surrounding the usage of the shared spaces (see *Further Explanation, Examples*). Draft a shared-use policy stipulating that at least three types of dedicated-use spaces will be available for public use. Alternatively, demonstrate that an existing policy is in place that meets the criteria. Also describe the specific facilities for use by the general public, and their terms and conditions. Indicate how the availability of the spaces will be communicated to the community. There is no minimum length of contract required. Fees for access to the shared spaces may be determined at the discretion of involved parties.

Option 2. Contract with Specific Organizations to Share Building Space

STEP 1. ALLOCATE DEDICATED-USE SHARED SPACES

Work with school authorities to identify and allocate at least two types of eligible dedicated-use spaces within the project that will be made available to specific outside organizations.

- Together with school authorities, identify community organizations, companies, or government organizations that need assembly space.
- Collaborate with the school authorities and the chosen outside organization(s) to determine which spaces in the project will be shared.

STEP 2. DESIGNATE FACILITIES FOR DEDICATED-USE SHARED SPACES

Designate restroom facilities that are accessible to shared-space users after normal school hours.

STEP 3. ESTABLISH TERMS AND CONDITIONS OF USAGE

Meet with the school authorities and the organization(s) that will use the dedicated spaces to establish terms and conditions of usage. Alternatively, demonstrate that an existing policy is in place that meets the criteria. Ensure that a signed contract (joint agreement) is in place between the school authorities and the organization(s); this joint agreement must stipulate that at least two types of dedicated-use spaces will be shared with the organization(s). There is no minimum length of contract required. Fees for access to the shared spaces may be determined at the discretion of involved parties.

Option 3. Use Shared Space Owned by Other Organizations

STEP 1. DETERMINE WHICH SPACES WILL BE ACCESSIBLE TO STUDENTS

Collaborate with school authorities, neighboring agencies, and outside companies to identify eligible facilities owned by organizations in the community that could be made accessible to students.

- Discuss students' needs and planned school facilities with the school authorities to determine which types of additional spaces would be desirable or necessary. Jointly identify local community groups, companies, or government organizations that may have the desired facilities.
- Collaborate with the school authorities and the identified community organizations to confirm accessibility of at least two types of eligible spaces to students.
- The facilities must be accessible on foot. An example is a park across the street from the school to which students can walk on a continuous sidewalk. Ineligible examples are a park across a busy road without crosswalks, and a pool three miles—an infeasible distance for pedestrians—from the school.

STEP 2. ESTABLISH TERMS AND CONDITIONS OF USAGE

Meet with the school authorities and community organization(s) providing the shared spaces to establish terms and conditions of usage (see *Further Explanation, Examples*). Alternatively, demonstrate that an existing policy is in place that meets the criteria. Ensure that a signed contract is in place between the school authorities and the outside organization(s). This joint agreement must stipulate that at least two types of dedicated-use spaces will be shared with the students. Describe the accessibility of the shared spaces. There is no minimum length of contract required. Fees for access to the shared spaces may be determined at the discretion of involved parties.

FURTHER EXPLANATION

EXAMPLE

Figure 1. Sample floor plan for shared-use spaces

Sample documentation narrative for Option 1

School X has established an agreement with the local land-use planning agency to use specified spaces within the school for meetings and activities. The use of the school by external organizations may not interfere with school programs and must occur after school hours and on weekends. Spaces available for use by community organizations are the Auditorium, Classroom B, Restrooms, and Parking Lot 1. These spaces are identified on the accompanying drawings.

Sample documentation narrative for Option 3

School X has established an agreement with the local government to use the gymnasium and swimming pool in the public recreation center. The public recreation center is located approximately 1,000 feet (305 meters) from the school and is accessible by a sidewalk; students will cross one two-lane road at a traffic light that has a walk signal. Use of the recreation spaces will take place before and during normal school operating hours. These spaces are identified on the accompanying site plan as G1(gymnasium) and S1 (swimming pool).

CAMPUS

Group Approach
Submit separate documentation for each building

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3
Floor plan highlighting joint-use spaces, restroom facilities, and room names	X	X	
Shared-use policy with terms, conditions, and description of communication to public	X		
Signed agreement between school authorities and occupying organization(s)		X	
Signed agreement stipulating how spaces will be shared with students			X
Site plan showing pedestrian access route and distance from school to joint-use spaces			X

RELATED CREDIT TIPS

LT Credit Surrounding Density and Diverse Uses. A project that is located in a dense area with multiple uses is more likely to be able to achieve compliance with Option 3 of this credit.

SS Credit Site Master Plan. Documented opportunities to share building space or formalize other community partnerships may reduce the need for future expansion, which could affect the site master plan. Stakeholder charrettes held to comply with the related credit may inspire community partnerships, which could help the project achieve this credit.

LT Credit Reduced Parking Footprint. Shared school parking lots or parking lots on neighboring sites used for school functions may reduce the number of new parking spaces for the related credit.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

Water Efficiency (WE)

OVERVIEW

The Water Efficiency (WE) section addresses water holistically, looking at indoor use, outdoor use, specialized uses, and metering. The section is based on an "efficiency first" approach to water conservation. As a result, each prerequisite looks at water efficiency and reductions in potable water use alone. Then, the WE credits additionally recognize the use of nonpotable and alternative sources of water.

The conservation and creative reuse of water are important because only 3% of Earth's water is fresh water, and of that, slightly over two-thirds is trapped in glaciers.[1] Typically, most of a building's water cycles through the building and then flows off-site as wastewater. In developed nations, potable water often comes from a public water supply system far from the building site, and wastewater leaving the site must be piped to a processing plant, after which it is discharged into a distant water body. This pass-through system reduces streamflow in rivers and depletes freshwater aquifers, causing water tables to drop and wells to go dry. In 60% of European cities with more than 100,000 people, groundwater is being used faster than it can be replenished.[2]

In addition, the energy required to treat water for drinking, transport it to and from a building, and treat it for disposal represents a significant amount of energy use not captured by a building's utility meter. Research in California shows that roughly 19% of all energy used in this U.S. state is consumed by water treatment and pumping.[3]

In the U.S., buildings account for 13.6% of potable water use,[4] the third-largest category, behind thermoelectric power and irrigation. Designers and builders can construct green buildings that use significantly less water than conventional construction by incorporating native landscapes that eliminate the need for irrigation, installing water-efficient fixtures, and reusing wastewater for nonpotable water needs. The Green Building Market Impact Report 2009 found that LEED projects were responsible for saving an aggregate 1.2 trillion gallons (4.54 trillion liters) of water.[5] LEED's WE credits encourage project teams to take advantage of every opportunity to significantly reduce total water use.

1. *U.S. Environmental Protection Agency, Water Trivia Facts, water.epa.gov/learn/kids/drinkingwater/water_trivia_facts.cfm (accessed September 12, 2012).*
2. *Statistics: Graphs & Maps, UN Water, http://www.unwater.org/statistics/en/ (accessed July 9, 2014).*
3. *energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF*
4. *USGBC, Green Building Facts, http://www.usgbc.org/articles/green-building-facts.*
5. *Green Outlook 2011, Green Trends Driving Growth (McGraw-Hill Construction, 2010), aiacc.org/wp-content/uploads/2011/06/greenoutlook2011.pdf (accessed on September 12, 2012).*

CROSS-CUTTING ISSUES

The WE category comprises three major components: indoor water (used by fixtures, appliances, and processes, such as cooling), irrigation water, and water metering. Several kinds of documentation span these components, depending on the project's specific water-saving strategies.

Site plans: Plans are used to document the location and size of vegetated areas and the locations of meters and submeters. Within the building, floorplans show the location of fixtures, appliances, and process water equipment (e.g., cooling towers, evaporative condensers), as well as indoor submeters. The same documentation can be used in credits in the Sustainable Sites category.

Fixture cutsheets: Projects must document their fixtures (and appliances as applicable) using fixture cutsheets or manufacturers' literature. This documentation is used in the Indoor Water Use Reduction prerequisite and credit.

Alternative water sources: A project that includes graywater reuse, rainwater harvesting, municipally supplied wastewater (purple pipe water), or other reused sources is eligible to earn credit in WE Credit Outdoor Water Use Reduction, WE Credit Indoor Water Use Reduction, WE Credit Cooling Tower Water Use, and WE Credit Water Metering. But the team cannot apply the same water to multiple credits unless the water source has sufficient volume to cover the demand of all the uses (e.g., irrigation plus toilet-flushing demand).

Occupancy calculations: The Indoor Water Use Reduction prerequisite and credit require projections based on occupants' usage. The Location and Transportation and Sustainable Sites categories also use project occupancy calculations. Review the occupancy section in *Getting Started* to understand how occupants are classified and counted. Also see WE Prerequisite Indoor Water Use Reduction for additional guidance specific to the WE section.

WATER EFFICIENCY PREREQUISITE

Outdoor Water Use Reduction

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To reduce outdoor water consumption.

REQUIREMENTS

Reduce outdoor water use through one of the following options. Nonvegetated surfaces, such as permeable or impermeable pavement, should be excluded from the landscape area calculations. Athletic fields and playgrounds (if vegetated) and food gardens may be included or excluded at the project team's discretion.

OPTION 1. NO IRRIGATION REQUIRED

Show that the landscape does not require a permanent irrigation system beyond a maximum two-year establishment period.

OR

OPTION 2. REDUCED IRRIGATION

Reduce the project's landscape water requirement by at least 30% from the calculated baseline for the site's peak watering month. Reductions must be achieved through plant species selection and irrigation system efficiency, as calculated by the Environmental Protection Agency (EPA) WaterSense Water Budget Tool.

BEHIND THE INTENT

Landscape irrigation practices consume large quantities of potable water, sometimes accounting for 30% to 70% of the water consumed in nonagricultural use. Potable water is a precious resource globally. For example, in many European cities, groundwater is being used at a faster rate than it can be replenished, according to the World Business Council for Sustainable Development.[1] Good landscape design and use of native, adapted, and drought-tolerant plants can dramatically reduce and even eliminate the need for irrigation while better integrating the building site into its surroundings and attracting native wildlife. Native plants also tend to require less fertilizer and fewer chemical pesticides, which degrade water quality when carried away in stormwater runoff.

The landscape water requirement (LWR) can be estimated by developing a water budget that allows landscape professionals to consider the effects of the many design variables, such as plant types, planting density, and irrigation system elements. Using a water budget optimizes water use in landscape designs.

STEP-BY-STEP GUIDANCE

Projects with no landscape area are exempt from this prerequisite.

For U.S. projects, the WaterSense Water Budget Tool automatically derives rainfall and evapotranspiration from the project's zip code. Skip Step 1 and go to Step 2.

STEP 1. PROJECTS OUTSIDE U.S. ONLY: OBTAIN PRECIPITATION AND EVAPOTRANSPIRATION DATA TO DETERMINE IRRIGATION REQUIREMENTS

Gather average monthly precipitation data and evapotranspiration rates (ET_o) for the project area to determine the site's potential irrigation needs. Precipitation data and ET_o can be found for most locations around the world (see *Further Explanation, International Tips*).

- Projects outside the U.S: use the non-U.S. water budget calculator, which can be found on usgbc.org. Projects must provide rainfall and evapotranspiration data for their location. This calculator uses SI units.

STEP 2. DETERMINE VEGETATED AREAS

On a map, indicate all areas on the project site that will have vegetation.

- The following landscape types may be included or excluded from landscape calculations: vegetated playgrounds, athletic fields, food gardens, and urban agricultural areas.
- When planning the site layout, consider factors such as proximity to water source for optimized irrigation, distance from water meter, and so on.

STEP 3. SELECT PLANT TYPES AND COVERAGE

Identify plant types and coverage that will balance water use efficiency with the area's intended function.

- Reserve grass for play fields or other activities that require turf; using turf for groundcover will make it very difficult to meet prerequisite and credit thresholds.
- Once established, native and drought-tolerant plants generally require little to no irrigation.
- Consider the U.S. Department of Agriculture's plant database and the Lady Bird Johnson Wildflower Center's native plant database as resources. Both databases provide standardized information about native plants—for example, moisture requirements and preferred growing conditions—along with distribution data, plant images, and references.

STEP 4. SELECT ONE OPTION

Select the appropriate option for the project's irrigation needs, as described in the credit requirements.

- Option 1 is for projects that do not require irrigation, based on the location and landscape design. Projects that have no landscape area automatically achieve this prerequisite.
- Option 2 is for projects that require irrigation.

1. *unwater.org/statistics_use.html.*

Option 1. No Irrigation Required

STEP 1. DEVELOP THE PLANT SPECIES AND WATER REQUIREMENT NARRATIVE

- Describe the plantings and explain why they will not require irrigation beyond their specified establishment periods. Indicate why average rainfall will be sufficient.
- A landscaping plan showing native plants may be provided to confirm that irrigation will not be required, based on local rainfall and plants' water demands.

Option 2. Reduced Irrigation

STEP 1. REDUCE IRRIGATION NEEDS BY ALTERING DESIGN

Project teams can dramatically alter irrigation demand by selecting plants that are appropriate for their intended uses.

- Reserve grass for play fields or other activities that require turf; using turf for groundcover will dramatically affect the ability to meet prerequisite and credit thresholds.
- Restore or plant native species to replace areas requiring intensive irrigation.

STEP 2. CALCULATE LANDSCAPE WATER BUDGET

Calculate water use as a percentage of total irrigation and peak-month irrigation demand using the WaterSense Water Budget Tool (see *Further Explanation, About WaterSense, Examples,* and *International Tips*).

- Use the tool for vegetated areas only. Do not include hardscapes (whether pervious or impervious) or unvegetated softscapes, such as mulched paths and playgrounds.
- Resolve uncertainties about plants' water requirements by referring to local resources such as plant guides, the state agricultural extension service, or nurseries to classify each plant type as a low, medium, or high water user.
- Projects may not enter zero landscape water consumption for any landscaped area.
- If only part of the lot is irrigated, complete the calculation twice—once for the irrigated section, and again for the unirrigated area—and sum the results.
- Additional savings gained by using alternative water sources and smart sensor technologies are addressed in WE Credit Outdoor Water Use Reduction. No credit is given for alternative water sources in this prerequisite.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

ABOUT WATERSENSE

The U.S. Environmental Protection Agency's WaterSense website includes this reference for native vegetation in various parts of the U.S.: epa.gov/watersense/outdoor/what_to_plant.html.

Use the WaterSense Water Budget Data Finder to estimate the evapotranspiration rate (ET_o) in inches per month for the critical month of the year, based on a project's zip code. ET_o, a measurement of water lost from a well-maintained expanse of average-height green grass and the surrounding soil, varies with a location's sunshine, wind, humidity, and temperature. Hot, dry, and windy locations have higher ET_o values than cool, humid locations. Data for these variables are based on 30-year historical averages. Data for projects outside the U.S. are not included in this tool.

The WaterSense Water Budget Tool (epa.gov/watersense/water_budget/) calculates a baseline landscape water requirement of a typical landscape, as described above. Different plant species and their arrangement in the landscape can be entered, and the tool estimates the effect of these design variables on LWR. Project teams outside the U.S. may use this tool with local data.

Design decisions about the different components of irrigation water delivery systems also factor into the estimates the tool provides.

WaterSense irrigation controller specifications (epa.gov/WaterSense/products/controltech.html) outline the requirements for weather-based irrigation controller systems. These systems earn projects a standard 15% reduction in landscape water requirement for WE Credit Outdoor Water Use Reduction.

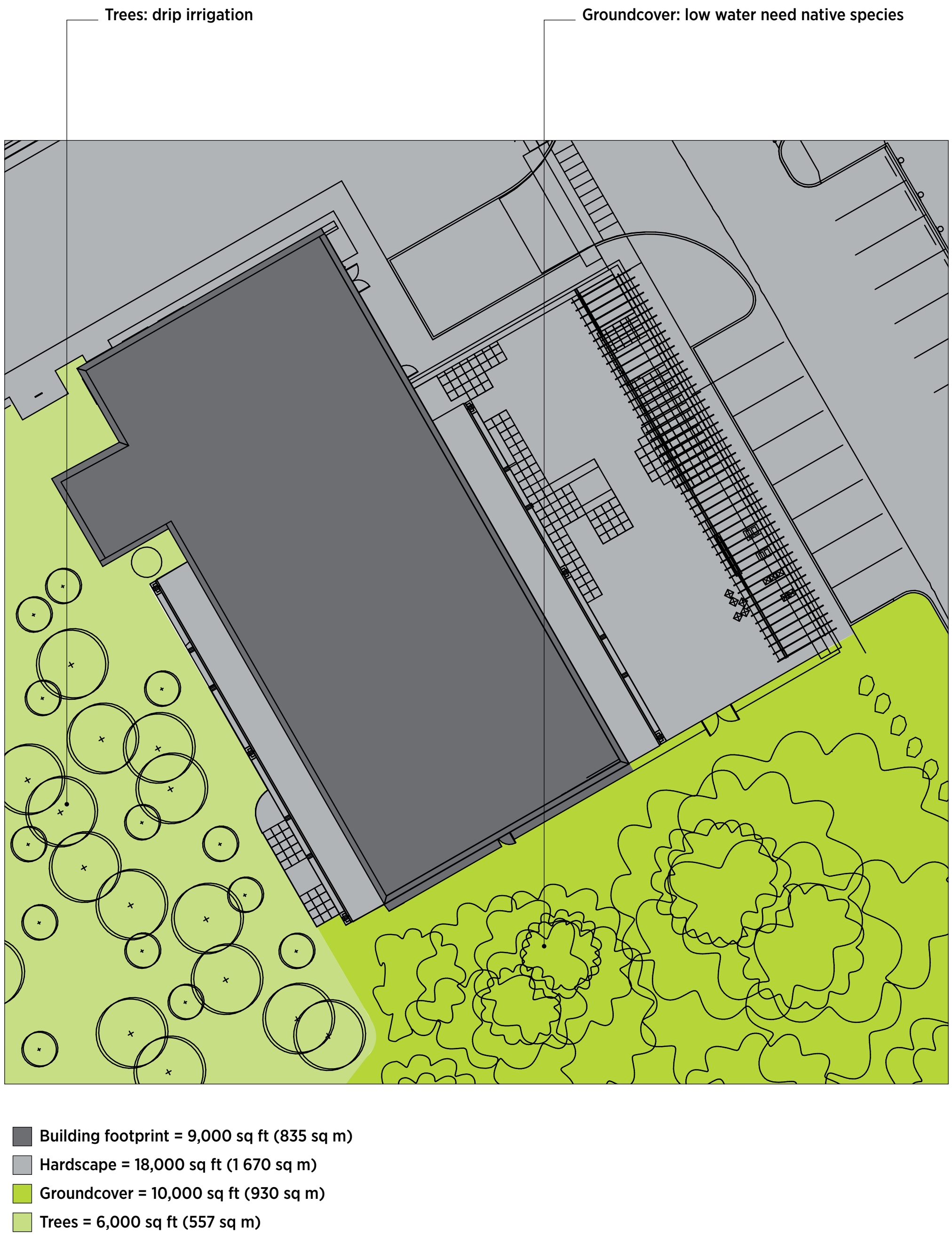


Figure 1. Example Site Plan

Examples

Each location's rainfall and evapotranspiration levels determine how much water a project needs. Consider two projects using Option 2, each with a fairly water-efficient landscape around an office building, one in Livingston, New Jersey, and one in Palo Alto, California (Figure 1).

Example 1. Livingston, New Jersey

The location is a typical suburban community in northern New Jersey. Its zip code is 07039. The team uses the EPA WaterSense Water Budget Data Finder:

- Enter Zip Code: 07039
- Peak Month: Jun
- ET_o Value: 6.30 inches/month
- Rainfall: 3.40 inches/month

When landscape area is entered, the tool offers these results (Figure 2):

- Total: 16,000 sq ft
- 10,000 sq ft of groundcover—low water need, native species, drip irrigation
- 6,000 sq ft of trees—medium water need, drip irrigation

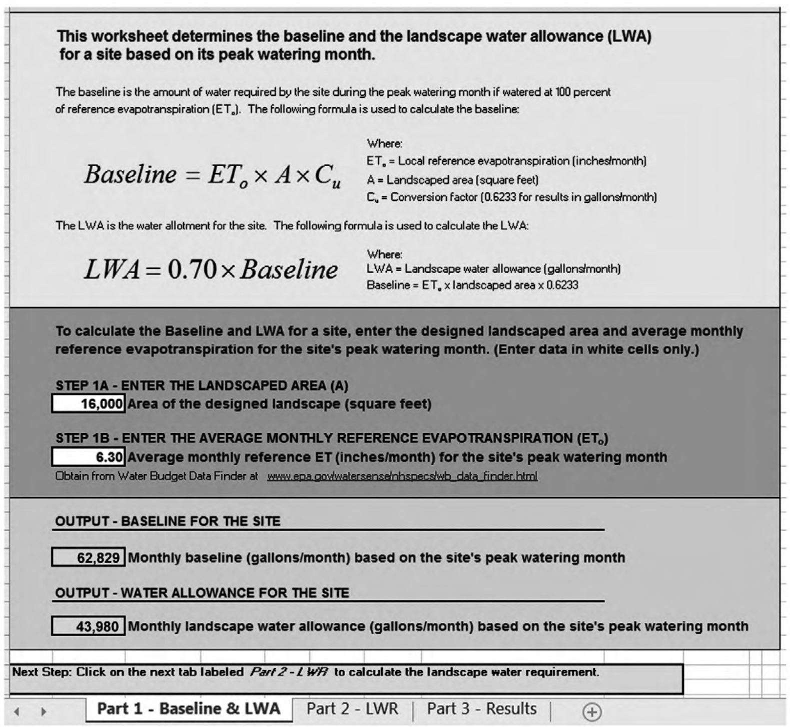


Figure 2. Part 1 - Baseline & LWA of the Water Budget Tool for Livingston, NJ Location. Screenshot taken from https://www3.epa.gov/watersense/excel/water_budget_tool.xlsx

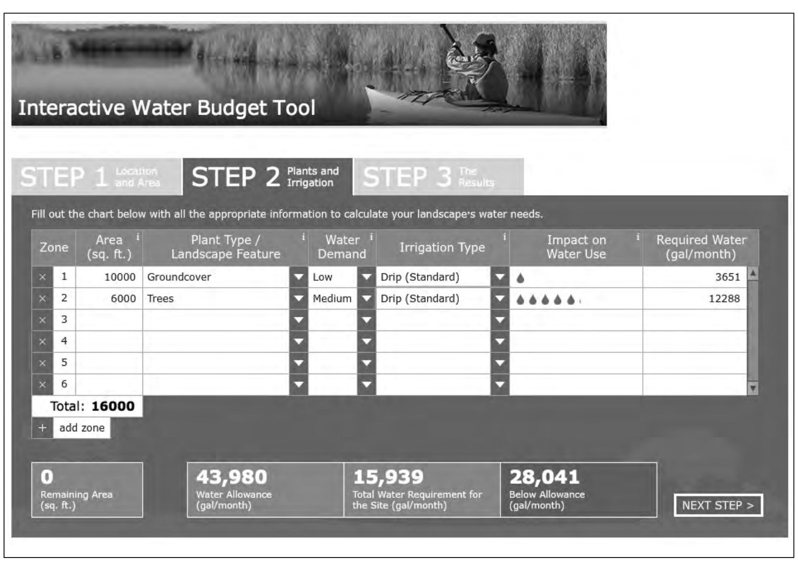


Figure 3. Water Budget Calculation for Livingston, NJ Location. Screenshot taken from http://www.epa.gov/watersense

The landscape water allowance equals 43,980 gallons/month. The landscape water baseline equals 62,829 gallons/month. The LWR for this design in this location is 15,939 gallons/month. The total savings from the baseline amounts to 75%. Since only 30% is required to meet the prerequisite, the project easily achieves compliance.

Example 2. Palo Alto, California

Palo Alto is in a fairly dry region of the country. The team uses the EPA WaterSense Water Budget Data Finder:

- Enter Zip Code: 94301
- Peak Month: Jul
- ET_o Value: 6.00 inches/month
- Rainfall: 0.00 inches/month

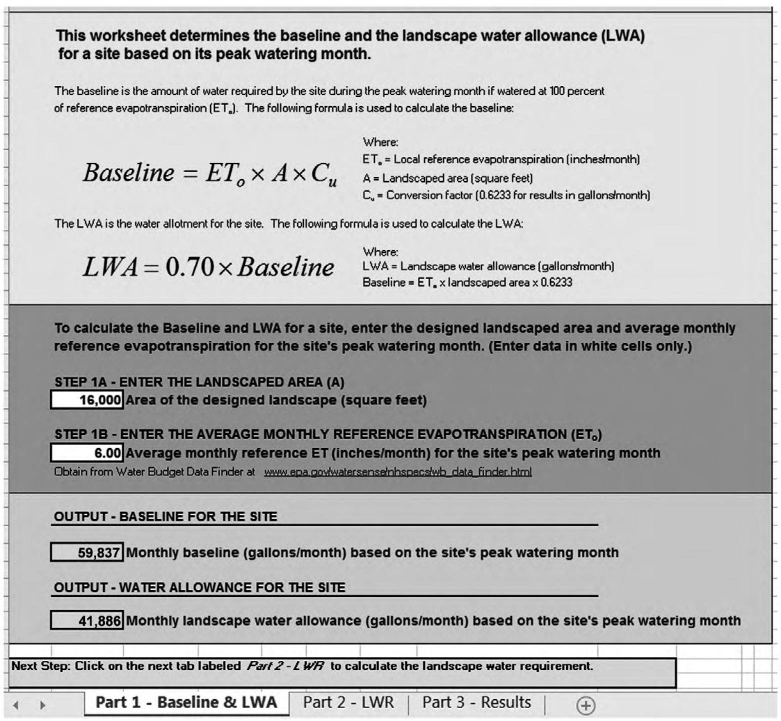


Figure 4. Part 1 - Baseline & LWA of the Water Budget Tool for Palo Alto, CA Location. Screenshot taken from https://www3.epa.gov/watersense/excel/water_budget_tool.xlsx

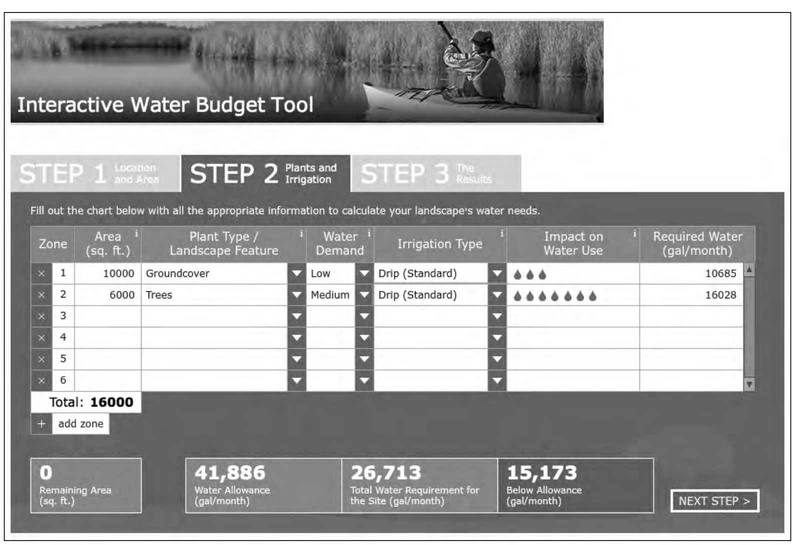


Figure 5. Water Budget Calculation for Palo Alto, CA Location. Screenshot taken from http://www.epa.gov/watersense

With a total landscape area of 16,000 square feet—10,000 square feet of groundcover (low water need, native species, drip irrigation) and 6,000 square feet of trees (medium water need, drip irrigation)—the tool now calculates a landscape water allowance of 41,886 gallons/month, and a landscape water baseline of 59,837 gallons/month. Compared with the New Jersey example above, the landscape water requirement for this design has increased to 26,713 gallons/month. The total savings from baseline is now 55%, but since only 30% is required, the project still achieves the prerequisite.

INTERNATIONAL TIPS

The World Meteorological Organization website (worldweather.wmo.int) and other sources provide annual precipitation data for many sites. If precipitation data for the project location are unavailable, they must be estimated.

Evapotranspiration data are available through various government and academic sources. The Food and Agriculture Organization of the United Nations (fao.org/nr/water/eto.html) calculates reference evapotranspiration using a variety of algorithms based on monthly average weather data. The month with the largest deficit between reference evapotranspiration and rainfall is the peak watering month.

The international version of the WaterSense Water Budget Tool can be found on the USGBC website under this credit's resources section.

CAMPUS

Group Approach

All buildings in the group may be documented as one. Use the total landscaped area of the entire campus. The results of the Water Budget Tool apply to all buildings within the group.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Site plan showing vegetated areas	X	
Narrative for plant species and water requirements	X	
Site plan showing location and size of landscape zones		X
Water Budget Tool report		X

RELATED CREDIT TIPS

WE Prerequisite Building-Level Water Metering. Projects that meter landscape irrigation separately will find it easier to meet this prerequisite and subsequent credits for outdoor water use and water metering.

CHANGES FROM LEED 2009

- Modified calculator used for this credit
- Moved alternative water source credit and smart sensor irrigation to the credit

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

adapted plant vegetation that is not native to a particular region but that has characteristics that allow it to live in the area. Adapted plants do not pose the same problems as invasive species.

combination oven discharge water released from an oven that includes a steam cycle or option

conventional irrigation a region's most common system for providing water to plants by nonnatural means. A conventional irrigation system commonly uses pressure to deliver water and distributes it through sprinkler heads above the ground.

cooling tower blowdown the water discharged from a cooling tower typically because increased salinity or alkalinity has caused scaling. Cooling tower blowdown may be too saline for use in landscape irrigation.

evapotranspiration the combination of evaporation and plant transpiration into the atmosphere. Evaporation occurs when liquid water from soil, plant surfaces, or water bodies becomes vapor. Transpiration is the movement of water through a plant and the subsequent loss of water vapor.

foundation drain the water discharged from a subsurface drainage system. If a building foundation is below the water table, a sump pump may be required. Discharge from the sump may be stored and used for irrigation.

graywater "untreated household waste water which has not come into contact with toilet waste. Graywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washers and laundry tubs. It must not include waste water from kitchen sinks or dishwashers" (Uniform Plumbing Code, Appendix G, Gray Water Systems for Single-Family Dwellings); "waste water discharged from lavatories, bathtubs, showers, clothes washers and laundry sinks" (International Plumbing Code, Appendix C, Gray Water Recycling Systems). Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences can likely be found in state and local codes. Project teams should comply with the graywater definition established by the authority having jurisdiction in the project area.

hardscape the inanimate elements of the building landscaping. It includes pavement, roadways, stonewalls, wood and synthetic decking, concrete paths and sidewalks, and concrete, brick, and tile patios.

hydrozone a group of plantings with similar water needs

industrial process water any water discharged from a factory setting. Before this water can be used for irrigation, its quality needs to be checked. Saline or corrosive water should not be used for irrigation.

landscape water requirement (**LWR**) the amount of water that the site landscape area(s) requires for the site's peak watering month

native vegetation an indigenous species that occurs in a particular region, ecosystem, and habitat without direct or indirect human actions. Native species have evolved to the geography, hydrology, and climate of that region. They also occur in communities; that is, they have evolved together with other species. As a result, these communities provide habitat for a variety of other native wildlife species. Species native to North America are generally recognized as those occurring on the continent prior to European settlement. Also known as native plants.

peak watering month the month with the greatest deficit between evapotranspiration and rainfall. This is the month when the plants in the site's region potentially require the most supplemental water typically a mid-summer month. (Sustainable Sites Initiative)

potable water water that meets or exceeds U.S. Environmental Protection Agency drinking water quality standards (or a local equivalent outside the U.S.) and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells or municipal water systems

rainwater harvesting the capture, diversion, and storage of rain for future beneficial use. Typically, a rain barrel or cistern stores the water; other components include the catchment surface and conveyance system. The harvested rainwater can be used for irrigation.

reclaimed water wastewater that has been treated and purified for reuse

reference evapotranspiration rate the amount of water lost from a specific vegetated surface with no moisture limitation. Turf grass with height of 120 mm is the reference vegetation.

softscape the elements of a landscape that consist of live, horticultural elements

xeriscaping landscaping that does not require routine irrigation

WATER EFFICIENCY PREREQUISITE

Indoor Water Use Reduction

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To reduce indoor water consumption.

REQUIREMENTS

Building Water Use

For the fixtures and fittings listed in Table 1, as applicable to the project scope, reduce aggregate water consumption by 20% from the baseline. Base calculations on the volumes and flow rates shown in Table 1.

All newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled (or a local equivalent for projects outside the U.S.).

TABLE 1. Baseline water consumption of fixtures and fittings

Fixture or fitting	Baseline (IP units)	Baseline (SI units)
Toilet (water closet)*	1.6 gpf	6 lpf
Urinal*	1.0 gpf	3.8 lpf
Public lavatory (restroom) faucet	0.5 gpm at 60 psi all others except private applications	1.9 lpm at 415 kPa, all others except private applications
Private lavatory faucets*	2.2 gpm at 60 psi	8.3 lpm at 415 kPa
Kitchen faucet (excluding faucets used exclusively for filling operations)	2.2 gpm at 60 psi	8.3 lpm at 415 kPa
Showerhead*	2.5 gpm at 80 psi per shower stall	9.5 lpm at 550 kPa per shower stall

*WaterSense label available for this product type
gpf = gallons per flush gpm = gallons per minute psi = pounds per square inch
lpf = liters per flush lpm = liters per minute kPa = kilopascals

Appliance and Process Water Use

Install appliances, equipment, and processes within the project scope that meet the requirements listed in the tables below.

TABLE 2. Standards for appliances

Appliance	Requirement
Residential clothes washers	ENERGY STAR or performance equivalent
Commercial clothes washers	CEE Tier 3A
Residential dishwashers (standard and compact)	ENERGY STAR or performance equivalent
Prerinse spray valves	≤ 1.3 gpm (4.9 lpm)
Ice machine	ENERGY STAR or performance equivalent and use either air-cooled or closed-loop cooling, such as chilled or condenser water system

gpm = gallons per minute   lpm = liters per minute

TABLE 3. Standards for processes

Process	Requirement
Heat rejection and cooling	No once-through cooling with potable water for any equipment or appliances that reject heat
Cooling towers and evaporative condensers	Equip with • makeup water meters • conductivity controllers and overflow alarms • efficient drift eliminators that reduce drift to maximum of 0.002% of recirculated water volume for counterflow towers and 0.005% of recirculated water flow for cross-flow towers

gpm = gallons per minute   lpm = liters per minute

HEALTHCARE, RETAIL, SCHOOLS, AND HOSPITALITY ONLY

In addition, water-consuming appliances, equipment, and processes must meet the requirements listed in Tables 4 and 5.

TABLE 4. Standards for appliances

Kitchen equipment		Requirement (IP units)	Requirement (SI units)
Dishwasher	Undercounter	≤ 1.6 gal/rack	≤ 6.0 liters/rack
	Stationary, single tank, door	≤ 1.4 gal/rack	≤ 5.3 liters/rack
	Single tank, conveyor	≤ 1.0 gal/rack	≤ 3.8 liters/rack
	Multiple tank, conveyor	≤ 0.9 gal/rack	≤ 3.4 liters/rack
	Flight machine	≤ 180 gal/hour	≤ 680 liters/hour
Food steamer	Batch	≤ 6 gal/hour/pan	≤ 23 liters/hour/pan
	Cook-to-order	≤ 10 gal/hour/pan	≤ 38 liters/hour/pan
Combination oven	Countertop or stand	≤ 3.5 gal/hour/pan	≤ 13 liters/hour/pan
	Roll-in	≤ 3.5 gal/hour/pan	≤ 13 liters/hour/pan

TABLE 5. Process requirements

Process	Requirement
Discharge water temperature tempering	Where local requirements limit discharge temperature of fluids into drainage system, use tempering device that runs water only when equipment discharges hot water OR Provide thermal recovery heat exchanger that cools drained discharge water below code-required maximum discharge temperatures while simultaneously preheating inlet makeup water OR If fluid is steam condensate, return it to boiler
Venturi-type flow-through vacuum generators or aspirators	Use no device that generates vacuum by means of water flow through device into drain

BEHIND THE INTENT

Potable water usage in buildings constitutes a large portion of freshwater consumption. Strategies to reduce potable water use in buildings entail the selection of efficient plumbing fittings, fixtures, and equipment. Fixtures that use 20% to 50% less water than code-required levels are now widely available. The WaterSense label was developed by the U.S. Environmental Protection Agency to identify these efficient fixtures and ensure that higher efficiency does not come at the cost of performance. The WaterSense label has been incorporated as a requirement for this credit to ensure that fixtures in a LEED building are both water efficient and high performing.

In some buildings, intensive appliance and process water use can exceed water use from fixtures and landscape combined. This is especially true for buildings with cooling towers or evaporative condensers. Appliance and process water use is therefore addressed specifically with a separate set of requirements.

Because the WE section is designed around an "efficiency first" model, the prerequisite deals only with the efficiency of fixtures and fittings; alternative or nonpotable water sources that offset potable water demand are also addressed in the corresponding credit.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT COMPLIANCE PATH

Determine the appropriate compliance path(s) for the project.

- Compliance Path 1 Prescriptive Achievement is for projects whose installed fixtures do not exceed WaterSense maximum levels. Compliance is documented through product cutsheets or fixture schedules.
- Compliance Path 2 Usage-Based Calculation is for projects that cannot demonstrate the 20% reduction for each fixture, based on manufacturers' documentation. Using the indoor water use calculator provided by USGBC, the project team must perform calculations to show that, in aggregate, the fixtures comply with prerequisite requirements. Projects pursuing points under WE Credit Indoor Water Use Reduction must use this compliance path.

STEP 2. SELECT WATERSENSE-LABELED PRODUCTS

Select WaterSense-labeled products for all newly installed fixtures that are eligible for labeling by verifying that the manufacturer and model are listed on the WaterSense website. The WaterSense label can be found for fixtures in the following product categories:

- Tank-type toilet (water closet)
- Water-using urinals
- Private lavatory faucets
- Showerheads

The following fixture types are not labeled by WaterSense and must comply with the percentage reduction criteria:

- Tankless toilets
- Composting toilets and waterless toilets
- Waterless urinals
- Public lavatory faucets

Using aerators is an acceptable water savings strategy.

- Newly installed aerators or flow restrictors added to private lavatories or showers must be WaterSense labeled.
- For private lavatories, WaterSense requires a maximum flow rate of 1.5 gallons per minute at 60 pounds per square inch and a minimum flow rate of 0.8 gallons per minute at 20 pounds per square inch. The installed fixtures in the design case must use the rated flow rate from the manufacturer, and the underlying assumptions must remain consistent between the baseline and design cases.

For projects in countries where WaterSense-labeled products are not readily available, see *Further Explanation, International Tips*.

STEP 3. SELECT HIGH-EFFICIENCY FIXTURES

For all product categories, including those covered by WaterSense, specify low-flow fixtures. Where possible, select fixtures that meet or exceed the 20% reduction indicated in the prerequisite requirements.

- Some equipment does not need to meet the 20% reduction threshold (see *Further Explanation, Excluded Water-Using Equipment*).
- The distinctions between public and private determine which thresholds each fixture and fitting must meet (see *Further Explanation, Public versus Private Lavatories*).
- For guidance on unusual fixtures, see *Further Explanation, Unique or Nonstandard Water Closets*.
- Sinks can be defined as public, private, kitchen, or process, depending on use and location. Kitchen sinks include all sinks in public or private buildings that are used with patterns and purposes similar to residential kitchen sinks. Hotel or motel kitchenette sinks, office kitchenette sinks, staff lounge sinks, pantry or nutrition station sinks, school classroom sinks (if used similarly to residential kitchen sinks), and commercial (food service) kitchen hand sinks that do not pass through a grease interceptor are considered kitchen sinks.

STEP 4. SELECT HIGH-EFFICIENCY APPLIANCES

Select appliances that meet the labeling or performance requirements outlined in the prerequisite requirements. Existing appliances intended for reuse in the project are not required to meet the requirements in Table 2. Standards for appliances.

- ENERGY STAR may not be readily available in all areas (see *Further Explanation, International Tips*).
- Commercial projects with noncommercial, standard-sized dishwashers must comply with the residential dishwasher requirements.
- Residential criteria include all noncommercial-grade clothes washers in office spaces, daycare centers, and so on.
- Ice machines that are ineligible for the ENERGY STAR label—for example, ice machines within refrigerators—do not need to comply with the prerequisite requirement.

STEP 5. DESIGN PROCESS WATER SYSTEMS

Where applicable, select and design appliances and equipment that meet the standards for process water in the prerequisite requirements. Existing equipment intended for reuse in the project is not required to meet the requirements in Table 3. Standards for processes.

- For heat rejection, the requirements apply to systems such as sterilizers, autoclaves, ice machines, x-ray machines, MRI machines, CT scanners, and other medical equipment the cooling for which involves large amounts of water and energy.
- Design equipment-cooling systems to limit or eliminate potable water use and to capture and reuse excess generated heat. Install air-cooled or closed-loop cooling instead of open-loop (i.e., once-through) systems for medical equipment. Redundancy for cooling in critical applications may be required; as emergency backups, consider recirculating systems, draining technology, and holding tanks, as well as nonpotable water sources for air-cooled vacuum pumps and once-through cooling systems.
- For medical equipment, consider designing and installing a dedicated nonpotable water loop to serve multiple pieces.
- If discharge waste temperature is regulated, consider recovering and reusing the system's waste heat for low-temperature heating (e.g., domestic water preheating).

STEP 6. DEVELOP COOLING TOWER NARRATIVE, IF APPLICABLE

Describe the cooling tower or evaporative condenser system, and address the meters, controllers, alarms, and features indicated in the credit requirements.

COMPLIANCE PATH 1. PRESCRIPTIVE ACHIEVEMENT (PREREQUISITE ONLY)

STEP 1. CONFIRM PRESCRIPTIVE COMPLIANCE

Ensure that all selected fixtures meet the following prescriptive flush or flow rate thresholds.

TABLE 6. Maximum installed flush or flow rates for prescriptive path

Fixture or fitting	Maximum installed flush or flow rate (IP)	Maximum installed flush or flow rate (SI)	Threshold below code baseline
Toilet (water closet)*	1.28 gpf**	4.8 lpf**	20%
Urinal*	0.50 gpf	1.9 lpf	50%
Public lavatory (restroom) faucet	0.40 gpm	1.5 lpm	20%
Private lavatory faucets*	1.50 gpm	5.7 lpm	32%
Kitchen faucet	1.75 gpm	6.7 lpm	20%
Showerhead*	2.00 gpm	7.6 lpm	20%

* The WaterSense label is available for this fixture type.
**The average flush rate for dual-flush toilets must be calculated as the average flush volume of one full flush and two reduced flushes, using a 1:2 (high flush:low flush) ratio.
gpf = gallons per flush gpm = gallons per minute lpf = liters per flush lpm = liters per minute

STEP 2. COLLECT MANUFACTURERS' INFORMATION

Compile fixture cutsheets or manufacturers' information for all fixtures and appliances. The fixture data must highlight the flush or flow rates. A plumbing fixture schedule is acceptable, provided it contains the fixture manufacturer, model, flush or flow rate information, and the WaterSense designation where applicable.

COMPLIANCE PATH 2. USAGE-BASED CALCULATION

STEP 1. COMPILE CUTSHEETS OR PREPARE PLUMBING FIXTURE SCHEDULE

For each fixture, compile manufacturer's data that indicate its flush or flow rate.

- To simplify the collection of calculation data, consider creating a table or plumbing fixture schedule that indicates the flush or flow rate information for each fixture.
- For ease of documentation, collect fixture model, flush or flow rate, percentage of occupants with access to the fixture, and so on.

STEP 2. GATHER INFORMATION FOR CALCULATOR

The indoor water use calculator requires the following information:

- **Project occupancy.** Count occupants consistently across all LEED credits (see *Further Explanation, Occupant Types*).
  - If the project has different sets of fixtures for different parts of the building, create a separate table for each subset. If fixtures are uniform across the project and restroom access is unrestricted, multiple calculations are not necessary; one calculation can cover all building fixtures and occupants.
  - A separate calculation to accommodate visitors is not necessary because the calculator automatically assigns them a lower daily usage rate. For example, it assumes that visitors do not use kitchen faucets.
- **Gender ratio.** The default gender mix is half male and half female. Assumptions that differ from the default must be supported by a narrative and supporting data (see *Further Explanation, Gender Ratio*).
- **Days of operation.** The default number of days of operation per year is 365.
  - If the project is in use for only a portion of the year or closes on specific days, the days of operation can be reduced.
  - The same number of days of operation must be applied to both the baseline and the design cases.
  - Ensure that the number of days of use is consistent with the building's operating schedule and prepare supporting documentation.
- **Fixture types used in the project.**

STEP 3. COMPLETE CALCULATIONS

Complete the calculations for the design case (installed) flush and flow fixtures. The following information is required:

- Fixture type
- Flush or flow rate
- Fixture manufacturer and model (which should match cutsheets)
- Percentage of occupants using each fixture model. The total for all fixtures of each type must total 100% of occupants for standard fixture types.

The calculator determines usage based on Equation 1 (see *Further Explanation, Calculations* and *Default Durations and Uses*).

EQUATION 1. Basic indoor water use reduction calculation

$$\text{Daily water use for each fixture type} = \text{Fixture flush or flow rate} \times \text{Duration of use} \times \text{Users} \times \text{Uses per person per day}$$

- The duration of use, number of users, and uses per person per day must be the same in both the baseline and the design cases.
- Dual-flush toilet flush rates must be calculated as the average using a 1:2 (high flush:low flush) ratio.
- Metering faucets measured in gallons (liters) per cycle (gpc, lpc) and cycle duration in manufacturer's documentation must be converted to a flow rate in gallons (liters) per minute (gpm, lpm). Use Equation 2 to perform the conversion.

EQUATION 2. Faucet flow rate conversion

$$\text{Flow rate (gpm)} = \left\{ \frac{\text{Gallons per cycle (gpc)} \times 60 \text{ sec}}{\text{Cycle duration (seconds)}} \right\}$$

$$\text{Flow rate (lpm)} = \left\{ \frac{\text{Liters per cycle (lpc)} \times 60 \text{ sec}}{\text{Cycle duration (seconds)}} \right\}$$

For example, convert a 0.2 gpc metering faucet with a 12-second cycle duration as follows:

$$\left\{ \frac{0.2 \text{ gpc} \times 60 \text{ sec}}{12 \text{ sec}} \right\} = 1 \text{ gpm}$$

Likewise, convert a 0.76 lpc metering faucet with a 12-second cycle duration as follows:

$$\left\{ \frac{0.76 \text{ lpc} \times 60 \text{ sec}}{12 \text{ sec}} \right\} = 3.8 \text{ lpm}$$

Provide manufacturer's documentation to confirm the flow rate conversion.

FURTHER EXPLANATION

CALCULATIONS

See equations in *Step-by-Step Guidance*. Calculations are built into the indoor water use calculator; the following is provided for reference.

The usage-based calculation for the project is the difference between the calculated design case and a baseline case. The percentage is determined by dividing the design case reduction by the baseline reduction. In traditional plumbing design, calculations are based on fixture counts; the methodology under this prerequisite calculates water use according to fixture consumption rates and estimated use. Occupants' estimated use is determined by counting full-time-equivalent and transient occupants and applying appropriate fixture use rates to each. The calculator estimates the percentage reduction of potable water use, compared with the baseline, using the following equation (see *Further Explanation, Default Durations and Uses* for more about this equation's variables).

EQUATION 1. Basic indoor water use reduction calculation

$$\text{Daily water use for each fixture type} = \text{Fixture flush or flow rate} \times \text{Duration of use} \times \text{Users} \times \text{Uses per person per day}$$

The calculator produces the following:

- Annual baseline water consumption (gallons or liters per year)
- Annual design case water consumption (gallons or liters per year)
- Percentage savings between baseline and design cases

EQUATION 3. Indoor water-use reduction

$$\text{\% improvement from baseline} = \left\{ \frac{\text{Baseline volume} - \text{Performance volume}}{\text{Baseline Volume}} \right\} \times 100$$

This prerequisite deals only with the water efficiency of fittings and fixtures, appliances, and processes that use potable water. Water derived from alternative sources, such as captured rainwater, is not considered under this prerequisite but can be used to document additional savings in WE Credit Indoor Water Use Reduction.

EXCLUDED WATER-USING EQUIPMENT

Appliances and equipment that use water on materials intended for human consumption may be excluded. For example, bread and produce misters, soda machines, coffee-making machines, and fixtures used to fill sinks for washing produce are excluded.

Fixtures whose flow rates are regulated by health codes may be excluded from the calculation. For example, regulated medical equipment is considered a process water user and is excluded from fixture calculations. Process water sinks are excluded from the fixture water-use reduction calculations.

The following list provides examples of process water sink fixtures that are excluded.

Specialized

- Janitor sinks
- Laboratory sinks regulated for medical or industrial purposes

Commercial kitchens (food service)

- Commercial kitchen (food service) sinks and prep sinks, including pot filling sinks, wash-down, and cleaning sinks

Health care

- Surgical scrub sinks
- Exam or procedure room sinks for clinical use
- Medication room sinks

General

- Janitor closet sinks
- Soiled utility room flushing rim sinks
- Soiled utility room hand-washing sinks
- Clean utility room hand-washing sinks

PUBLIC VERSUS PRIVATE LAVATORIES

Lavatory faucets must be classified as public or private. The Uniform Plumbing Code, International Plumbing Code, and the National Standard Plumbing Code each define private as those fixtures in residences, hotel or motel guest rooms, and private rooms in hospitals. All other applications are deemed to be public.

Fixtures used by residential occupants and fixtures used by residential-type occupants who use the building for sleeping accommodations fall into the private classification. Resident bathrooms in dormitories, patient bathrooms in hospital and nursing homes, and prisoner bathrooms are considered private use.

If it is unclear whether the classification should be public or private, default to public use flow rates in performing the calculations.

Lavatory faucets are intended for hand washing (Table 7). Private lavatory faucets are subject to the federal standard of 2.2 gallons per minute at 60 pounds per square inch (8.3 liters per minute at 415 kilopascals). Public lavatory faucets are subject to the federal standard of 0.5 gallons per minute at 60 pounds per square inch (1.9 liters per minute at 415 kilopascals).

TABLE 7. Typical public and private lavatory faucet applications

Lavatory faucet	Classification
Restroom sink School classroom sinks (if used primarily for hand washing)	Public (baseline: 0.5 gpm, 1.9 lpm)
Residential bathroom sink Hotel or motel bathroom sink Dormitory bathroom sink Patient room sink Patient bathroom sink in hospital or nursing home	Private (baseline: 2.2 gpm, 8.3 lpm)

gpm = gallons per minute   lpm = liters per minute

Unique or Nonstandard Water Closets

For unique or nonstandard toilets and fixtures, the following may apply:

- **Toilets with flush valve control and separate bowls.** The flush rates should be based on installed flush valve. Confirm that bowl and flush valve rates are compatible to ensure performance.
- **Prison fixtures.** Flow rates and flushing mechanisms must conform to the same design standards as commercial toilets.

- **Children's toilets.** Flow rates and flushing mechanisms must conform to the same design standards as commercial toilets. Confirm that the flush rates of the flush valves are compatible with the bowl sizes to ensure performance.
- **Squat (floor-mounted) toilets.** Flow rates and flushing mechanisms must conform to the same design standards as commercial toilets.

OCCUPANT TYPES

Identify the daily average number of building users by type (see *Getting Started, Occupancy*). The indoor water use calculator requires total occupant counts in the following categories:

- Employees and staff, expressed as full-time-equivalent (FTE) employees
- Residents

  Determine the number of residents—residential occupants in dormitories, hospital in-patients, prisoners, hotel guests, and any other people who use the building for sleeping accommodations. For apartments or multifamily residences where resident occupancy is unknown, estimate the default resident number as the total number of bedrooms + 1 for each residential unit. For example, assume two residents per one-bedroom unit, three residents per two-bedroom unit, and so forth, unless a different assumption is warranted.
  - Include inpatients at health care facilities with residents.
  - Include hotel guests with residents. Calculate the number of overnight hotel guests based on the number and size of units in the project. Assume 1.5 occupants per guest room and multiply the resulting total by 60% (average hotel occupancy, per American Hotel and Lodging Association).
- K–12 students. See *Further Explanation*, *Rating System Variations*.
- Retail customers
- Visitors (excluding retail customers)
  - Include outpatients and higher education students.
  - Report visitors as a daily average total.

If occupancy is known, use the actual occupant counts for calculating occupancy. Use occupancy numbers that are a representative daily average over the course of the year. If the occupancy is not known, see *Getting Started, Occupancy*).

Tables 8 and 9 (see *Further Explanation, Default Duration and Uses*) provide default fixture use values for different occupancy types. These values should be used in the calculations unless special circumstances warrant modifications (see *Further Explanation, Rating System Variations*).

GENDER RATIO

The default gender ratio for full-time-equivalent occupants is 50:50. In special circumstances, where an alternative ratio may be justified, provide a narrative and supporting documentation. Modifications to the 50:50 ratio must be shown to apply for the life of the building.

Acceptable special circumstances include projects specifically designed for an alternative gender ratio—for example, a single-gender educational facility. Such projects must show that flush and flow fixtures have been distributed to account for the modified ratio. Project teams must provide documentation of the code-required plumbing fixture counts per gender so that the review team can verify that the flush-fixture ratio installed in the project supports the alternative gender ratio.

Gender ratio affects water usage only when urinals are installed. If the project does not include urinals, a 50:50 or 0:100 male:female ratio should yield the same usage results.

DEFAULT DURATIONS AND USES

Duration of use and uses per day are calculated using defaults (Tables 8 and 9).

TABLE 8. Nonresidential default fixture uses

Fixture type	Duration (sec)	Uses per day			
		Employees (FTE)	Visitors	Retail customers	Students
Water closet (female)	n/a	3	0.5	0.2	3
Water closet (male)	n/a	1	0.1	0.1	1
Urinal (female)	n/a	0	0	0	0
Urinal (male)	n/a	2	0.4	0.1	2
Public lavatory faucet	30	3	0.5	0.2	3
Shower	300	0.1	0	0	0
Kitchen sink	15	1	0	0	0

TABLE 9. Residential default fixture uses

Equipment	Duration (sec)	Uses per day
Water closet (female)	n/a	5
Water closet (male)	n/a	5
Private lavatory Faucet	60	5
Shower	480	1
Kitchen sink	60	4

For residents, hospital inpatients, hotel guests, prisoners, or any other residential occupants who use the building for sleeping accommodations, use the default residential fixture usage assumptions.

RATING SYSTEM VARIATIONS

Core and Shell

Include in the prerequisite documentation only plumbing fixtures, appliances, and process water installed as a part of the Core and Shell project's scope of work (i.e., what the developer is installing in the project). Do not include as-yet-uninstalled (future) plumbing fixtures, appliances, and process water. If no eligible plumbing fixtures, appliances, and process water are installed as part of the Core and Shell project scope of work, the project automatically achieves this prerequisite.

If plumbing fixtures are installed by the developer in otherwise-incomplete tenant spaces, include those plumbing fixtures installed as part of the Core and Shell project scope and use the default occupancy counts to account for their usage in the calculations if pursing Compliance Path 2. If the occupancy is not known, see *Getting Started, Occupancy*. Use code occupancy to determine the project occupancy.

Schools

Appliance and process water-use equipment installed in the project must meet the requirements of Tables 4 and 5 of the prerequisite.

For K–12 schools that close on weekends, holidays, and for eight weeks of school vacation, assume 195 days of operation.

For occupancy calculations (Table 10), in deciding whether to count individuals as employees, students, or visitors, consider their fixture-use patterns. For example, a volunteer who serves four hours each day in an elementary school will likely have the same plumbing usage patterns as full-time staff. Such a volunteer could therefore be considered to have an FTE value of 0.5. On the other hand, an individual who attends a high school basketball game may be expected to use the water closets and lavatory faucets in the school building infrequently and therefore should be counted as a visitor. Report visitors as average daily totals.

TABLE 10. Default fixture uses in schools, by occupancy type

Fixture Type	FTE	Student	Visitors
Water Closet			
Female	3	3	0.5
Male	1	1	0.1
Urinal			
Female	0	0	0
Male	2	2	0.4
Lavatory faucet	3	3	0.5
Shower	0.1	0	0
Kitchen Sink	1	0	0

When calculating annual occupancy for schools with multiple sessions, consider a session a discrete period of school building operation. A session can be defined by a season or by other variations in building occupancy and usage, such as weekend programming by a community organization. If the school building is used for more than one session annually, calculate the percentage for each session, based on the number of days in the session divided by the total number of days during which the school building operates annually, using Equation 4.

EQUATION 4. School session as percentage of annual operation

$$\text{Session \%} = \text{Days in session} \,/\, \text{Annual days of operation}$$

Then calculate the annual occupants of each gender by multiplying the number of occupants in each session by the session percentage (from Equation 1) and adding the results of all sessions together, using Equation 5:

EQUATION 5. Annual occupancy for Schools projects

$$\text{Annual occupants, by gender} = \left\{ \text{Session A FTEs, by gender} \times \text{Session \%} \right\} + \left\{ \text{Session B FTEs, by gender} \times \text{Session \%} \right\}$$

FTE = full-time equivalent

PROJECT TYPE VARIATIONS

Mixed-Use Projects
If a mixed-use project uses the same fixtures throughout the building, complete one calculation for building water use. If the spaces use different fixtures or have dramatically different patterns of occupancy or varying annual days of operation, complete the indoor water use calculator with a separate fixture group for each space type.

Additions
All fixtures within the project boundary must be included in the prerequisite calculations. If the project boundary includes only the addition, the fixtures or fittings outside the addition do not need to be included in the calculations for prerequisite compliance, even if used by project occupants.

INTERNATIONAL TIPS

For fixtures that require the WaterSense label in countries where the label is unavailable, look up acceptable WaterSense substitutes at usgbc.org. Project outside the U.S. must meet WaterSense flush and flow rates.

For appliances that require the ENERGY STAR label, a project outside the U.S. may install products that are not labeled under the ENERGY STAR program if they meet the ENERGY STAR product specifications, available on the ENERGY STAR website. All products must meet the standards of the current version of ENERGY STAR as of the date of their purchase.

For appliances that require the Consortium for Energy Efficiency (CEE) label, a project outside the U.S. may purchase products that have not been qualified or labeled by CEE if they meet the CEE product criteria for efficiency.

Projects served by water supply pressures different than specified in LEED v4 may install pressure compensating aerators in flow fixtures to achieve the desired flow rate without compromising user satisfaction.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects		Projects with appliance or process water
	Prescriptive	Usage-based calculation	
Product cutsheets, manufacturers' information	X	X	X
Indoor water use calculator		X	

RELATED CREDIT TIPS

WE Prerequisite Building-Level Water Metering. Metering of potable water usage will allow facilities management staff to monitor changes in water usage as efficiency measures are implemented.

WE Credit Water Metering. Additional submetering of water-using systems will give facilities management staff actual performance data on specific water efficiency measures so that they can make adjustments to reduce water consumption. The credit builds on the prerequisite by requiring a higher level of water efficiency. In this prerequisite, projects may demonstrate compliance through product cutsheets showing that all fixtures meet or exceed the minimum reduction threshold; in the credit, a usage-based calculation is mandatory.

CHANGES FROM LEED 2009

- This prerequisite now includes requirements for water-using appliances and processes, as well as cooling towers and evaporative condensers.
- The WaterSense label requirements were recommended in LEED 2009. They are now mandatory in the U.S., with local equivalents allowed outside the U.S.
- The prescriptive compliance path, based on demonstrating that all fixtures are 20% below baseline, is new.
- Duration-based savings from autocontrol faucets with automatic fixture sensors or metering controls are no longer allowed in the design case. Studies have shown that autocontrol faucets do not save water because users frequently reactivate the faucet after initial use or stop washing before the cycle ends.
- Applying nonpotable water is no longer allowed as an alternative compliance path in the prerequisite. Alternative water sources can, however, earn points in the corresponding credit.

REFERENCED STANDARDS

Energy Policy Act (EPAct) of 1992 and as amended: eere.energy.gov/femp/regulations/epact1992.html

EPAct 2005: eere.energy.gov/femp/regulations/epact2005.html

International Association of Plumbing and Mechanical Officials Publication IAPMO/ANSI UPC 1-2006, Uniform Plumbing Code 2006, Section 402.0, Water-Conserving Fixtures and Fittings: iapmo.org

International Code Council, International Plumbing Code 2006, Section 604, Design of Building Water Distribution System: iccsafe.org

ENERGY STAR: energystar.gov

Consortium for Energy Efficiency: cee1.org

WaterSense: epa.gov/watersense

IgCC/ASHRAE 189.1 cooling tower and evaporative condenser requirements: ashrae.org/resources--publications/bookstore/standard-189-1

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

closed-loop cooling a system that acts as a heat sink for heat-rejecting building and medical equipment by recirculating water. Because the water is sealed within the system, some closed-loop cooling systems use nonpotable water (such as recycled process water harvested from an air handler's cooling coil condensate).

conductivity the measurement of the level of dissolved solids in water, using the ability of an electric current to pass through water. Because it is affected by temperature, conductivity is measured at 25°C for standardization.

drift water droplets carried from a cooling tower or evaporative condenser by a stream of air passing through the system. Drift eliminators capture these droplets and return them to the reservoir at the bottom of the cooling tower or evaporative condenser for recirculation.

makeup water water that is fed into a cooling tower system or evaporative condenser to replace water lost through evaporation, drift, bleed-off, or other causes

metering control a regulator that limits the flow time of water, generally a manual-on and automatic-off device, most commonly installed on lavatory faucets and showers

nonpotable water water that does not meet drinking water standards

potable water water that meets or exceeds U.S. Environmental Protection Agency drinking water quality standards (or a local equivalent outside the U.S.) and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells or municipal water systems

process water water that is used for industrial processes and building systems, such as cooling towers, boilers, and chillers. It can also refer to water used in operational processes, such as dishwashing, clothes washing, and ice making.

WATER EFFICIENCY PREREQUISITE

Building-Level Water Metering

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To support water management and identify opportunities for additional water savings by tracking water consumption.

REQUIREMENTS

Building Water Use

Install permanent water meters that measure the total potable water use for the building and associated grounds. Meter data must be compiled into monthly and annual summaries; meter readings can be manual or automated.

Commit to sharing with USGBC the resulting whole-project water usage data for a five-year period beginning on the date the project accepts LEED certification or typical occupancy, whichever comes first.
This commitment must carry forward for five years or until the building changes ownership or lessee.

BEHIND THE INTENT

Disparities often exist between how buildings are designed to operate and how they actually perform. Numerous factors may be responsible: flaws in energy modeling, inadequate commissioning, inaccurate assumptions about occupants' behavior, lack of coordination during the transition from construction to operations, or the everyday operation of the building systems. By collecting and analyzing performance data, USGBC aims to compare building performance across the LEED portfolio to identify common traits among high and low performers, and share these findings to help project teams improve building performance.

One system often subject to gaps between projected and actual performance is water use. As a first step in improving efficiency, the project team must install water metering to track water consumption by both the project building and any associated grounds.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY ALL POTABLE WATER END USES

Determine all end uses of potable water in the project building and on the grounds. These could include water consumption for plumbing fixtures, cooling towers and evaporative condensers, laundering, dishwashing, indoor and outdoor water features, irrigation, exterior cleaning, and manufacturing processes.

Examples of potable water sources that must be metered include the following:

- Public water supply
- On-site well
- On-site potable water treatment system

STEP 2. DETERMINE SCOPE OF PUBLIC WATER SUPPLY METERING, IF APPLICABLE

If all water comes from a public water supply and the utility's water meter provides monthly consumption data, that system's meter meets the prerequisite requirements. However, the project team may have little influence on the location and function of the meter, so the building owner should confirm the following with the public water supplier:

- Location: where the meter will be located (e.g., inside the building, under or above ground outside)
- Accessibility: how the building manager will reach the meter
- Reporting: how the meter will be read (e.g., manually or via remote transmission)

If the public water supplier restricts access to the meter or uses proprietary remote reporting technology, the project team may meet the prerequisite requirement by tracking water usage through monthly billing. To collect more frequent or accurate data, the team may elect to install a private meter downstream of the public water supply meter.

STEP 3. DETERMINE NUMBER, LOCATION, AND TYPE OF ALL METERS

If the project is not served by a public water supply, or if the project uses multiple sources of potable water, two or more meters may be required. A single meter installed downstream of multiple potable water supply systems may be used if it is upstream of all project water uses.

- In some cases, projects may elect to use multiple meters to gain additional information on water use.
- Select locations with easy access for reading and maintenance.
- There are no requirements for the type of meters except that they be permanent.
- Additional meters may be needed to satisfy the requirements for WE Prerequisite Indoor Water Use Reduction and WE Credit Water Metering (see *Related Credit Tips*).

Prepare a narrative describing the location of the building level water meter(s) serving the project and site, as applicable. If nonpotable water is included in the metered water volume, note this in the narrative and describe how volumes can be managed and tracked separately.

STEP 4. TRACK WATER CONSUMPTION

Begin tracking water use when the project achieves LEED certification or at occupancy, whichever occurs first. To place water use data in the context of building operations, consider tracking building occupancy changes and maintenance activities concurrently. The additional information may help explain fluctuations in usage patterns.

STEP 5. SHARE WATER CONSUMPTION DATA WITH USGBC

Commit to sharing with USGBC the whole-project water usage data acquired from permanent meters installed in accordance with the prerequisite requirements. The project owner must commit to sharing water use data with USGBC for five years in one of two ways:

- USGBC-approved data template
- Third-party data source

To see the most recent list of data-sharing pathways, visit USGBC's credit library, at usgbc.org/credits.

FURTHER EXPLANATION

RATING SYSTEM VARIATIONS

Core and Shell

Metering and data collection are the same for Core and Shell projects. Data may be collected from the spaces that the LEED project team did not fit out as part of the project scope. Water data sharing must continue following fit-out and occupancy of the project unless there is a change of ownership or lessee.

PROJECT TYPE VARIATIONS

Multifamily Residential

Either use a whole-building meter or, provided all potable water uses are accounted for, aggregate data from submeters for each unit and common spaces.

INTERNATIONAL TIPS

Project teams outside the U.S. may use ENERGY STAR Portfolio Manager or the manual tracking template to track and report their energy and water consumption to USGBC.

CAMPUS

Group Approach

Submit separate documentation for each building. Potable water used for landscape irrigation must be tracked in any of three ways: by including it with a single building, by installing a dedicated meter, or by installing multiple meters.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
Meter declaration	X
Sharing commitment	X

RELATED CREDIT TIPS

WE Prerequisite Indoor Water Use Reduction. The related prerequisite requires separate water submeters for cooling tower makeup and blowdown and for evaporative condensers.

WE Credit Water Metering. The related credit encourages project teams to install submeters on certain systems serving the building.

EA Prerequisite Building-Level Energy Metering. Water meters may be tracked by a building automation system (BAS) that also records energy consumption. Data sharing for both this and the related prerequisite can be achieved through ENERGY STAR's Portfolio Manager.

CHANGES FROM LEED 2009

This is a new prerequisite. The ongoing tracking and reporting components were previously required under Minimum Program Requirement 6 for all LEED 2009 projects.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

potable water water that meets or exceeds U.S. Environmental Protection Agency drinking water quality standards (or a local equivalent outside the U.S.) and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells or municipal water systems

private meter a device that measures water flow and is installed downstream from the public water supply meter or as part of an on-site water system maintained by the building management team

public water supply (**PWS**) a system for the provision to the public of water for human consumption through pipes or other constructed conveyances. To be considered public, such system must have at least 15 service connections or regularly serve at least 25 individuals. (Adapted from U.S. Environmental Protection Agency)

WATER EFFICIENCY CREDIT

Outdoor Water Use Reduction

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1 point)

INTENT

To reduce outdoor water consumption.

REQUIREMENTS

Reduce outdoor water use through one of the following options. Nonvegetated surfaces, such as permeable or impermeable pavement, should be excluded from landscape area calculations. Athletic fields and playgrounds (if vegetated) and food gardens may be included or excluded at the project team's discretion.

OPTION 1. NO IRRIGATION REQUIRED (2 POINTS EXCEPT HEALTHCARE, 1 POINT HEALTHCARE)

Show that the landscape does not require a permanent irrigation system beyond a maximum two-year establishment period.

OR

OPTION 2. REDUCED IRRIGATION (2 POINTS EXCEPT HEALTHCARE, 1 POINT HEALTHCARE)

Reduce the project's landscape water requirement (LWR) by at least 50% from the calculated baseline for the site's peak watering month. Reductions must first be achieved through plant species selection and irrigation system efficiency as calculated in the Environmental Protection Agency (EPA) WaterSense Water Budget Tool.

Additional reductions beyond 30% may be achieved using any combination of efficiency, alternative water sources, and smart scheduling technologies.

TABLE 1. Points for reducing irrigation water

Percentage reduction from baseline	Points (except Healthcare)	Points (Healthcare)
50%	1	1
100%	2	—

BEHIND THE INTENT

See WE Prerequisite Outdoor Water Use Reduction, *Behind the Intent*. Potable water consumption may be further reduced by reusing potable water and using nonpotable water sources.

STEP-BY-STEP GUIDANCE

STEP 1. FOLLOW METHODOLOGY IN WE PREREQUISITE OUTDOOR WATER USE REDUCTION

STEP 2. SELECT ONE OPTION

Select the appropriate option for the project's irrigation needs, as described in the credit requirements.

- Option 1 is for projects that do not require irrigation, based on the project location and landscape design. This credit can also be achieved by projects that have no landscape area.
- Option 2 is for projects that require irrigation.

Option 1. No Irrigation Required

Develop the plant species and water requirement narrative.

- Include a description of the plantings and explain why they will not require irrigation beyond their specified establishment periods. Indicate why average rainfall will be sufficient.
- A landscaping plan showing native plants may be provided to confirm that irrigation will not be required, based on local rainfall and plants' water demands.

Option 2. Reduced Irrigation

STEP 1. REDUCE IRRIGATION NEEDS BY ALTERING DESIGN

Project teams can dramatically alter irrigation demand by selecting plants that are appropriate for their intended uses.

- Reserve grass for play fields or other activities that require turf; using turf for groundcover will make it very difficult to meet the credit thresholds.
- Restore or plant native species to replace areas requiring intensive irrigation.

STEP 2. CONSIDER ALTERNATIVE WATER SOURCES

Site-derived alternative water sources or treated wastewater provided by a municipal agency can offset potable water used for irrigation (see *Further Explanation, Alternative Water Sources*).

STEP 3. CONSIDER ALTERNATIVE IRRIGATION CONTROLS

Smart-sensor technology irrigation controls can deliver additional water savings.

STEP 4. CALCULATE LANDSCAPE WATER BUDGET

Determine water savings as a percentage of total irrigation and peak-month irrigation demand by using the WaterSense Water Budget Tool (see *Further Explanation, About WaterSense, Examples,* and *International Tips*).

- Use the tool for vegetated areas only. Do not include hardscapes (whether pervious or impervious) or unvegetated softscapes, such as mulched paths and playground areas.
- The following landscape types may be included or excluded from landscape calculations: vegetated playgrounds, athletic fields, food gardens, and urban agricultural areas.

- When planning the site layout, consider factors such as proximity to water source for optimized irrigation, distance from water meter, and so on. Resolve uncertainties about plants' water requirements by referring to local resources, such as plant guides, state agricultural extension services, or nurseries to classify each plant type as a low, medium, or high water user.
- Projects may not enter zero landscape water consumption for any landscaped area. If only part of the lot is irrigated, complete the calculation twice—once for the irrigated section and again for the unirrigated area—and sum the results.

STEP 5. CALCULATE ADJUSTED LANDSCAPE WATER REQUIREMENT

Calculate monthly supply from alternative sources.

- Determine water quantity from alternative sources (e.g., using historical rainfall data) or from projected demand when water is reused. Rainwater harvesting volume can be calculated using Equations 1 and 2.
- Ensure that the rainwater needed in the peak month can be stored on-site.
- Alternative calculations for rainwater cistern sizing may be used.

EQUATION 1. Rainwater harvesting from roof

$$\text{Gallons per 1 inch of rain} = \text{Roof area in ft}^2 \times 0.6$$

EQUATION 2. Monthly harvested rainwater volume

$$\text{Amount available} = \text{Gallons per 1 inch of rain} \times \text{Average inches rain per month}$$

Determine the adjusted landscape water requirement using Equation 3.

EQUATION 3. Adjusted monthly landscape water requirement (LWR)

$$\text{Adjusted LWR (volume/month)} = \text{LWR (volume/month)} - \text{Alternative water quantity (volume/month)}$$

STEP 6. CALCULATE ADDITIONAL REDUCTION FROM BASELINE FOR SMART IRRIGATION CONTROLS

Count only irrigation controls whose smart-sensor technology meets the WaterSense criteria. These controls result in an additional 15% reduction that project teams can take from the landscape water requirement.

EQUATION 4. Adjusted monthly landscape water requirement (LWR)

$$\text{Final LWR} = \text{(Prerequisite LWR or adjusted LWR)} - (.15 \times \text{Prerequisite LWR})$$

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

ALTERNATIVE WATER SOURCES

Alternative water sources include reclaimed wastewater, graywater, swimming pool backwash filter, refrigeration system condensate, captured rainwater, stormwater and foundation drain water, steam system condensate, fluid cooler discharge, food steamer discharge, combination oven discharge, industrial process water, fire pump test water, municipally supplied treated wastewater, and ice machine condensate.

Testing site-derived alternative water to confirm its suitability for irrigation uses is recommended. Salinity is one concern. Irrigation with saline water in an arid environment causes salt buildup in the soil, eventually degrading it. Condensate and cooling tower blowdown in particular may have salinity levels precluding use for irrigation. A second concern is that alternative water supplies must be stored until needed for irrigation; the timing and reliability of the supply must be assessed.

When calculating alternative water source annual projections, follow these guidelines:

- Depending on supply timing and availability, monthly water budget calculations may be necessary to show how much potable water may be replaced. Calculate irrigation water demand during each month of the irrigation season.
- Assume that alternative water will be used for irrigation as it is available. The contribution of alternative water to the peak month irrigation demand must be based on having excess alternative water available and stored before the peak month.

ABOUT WATERSENSE

EPA's WaterSense website includes this reference for native vegetation in various parts of the US: epa.gov/watersense/outdoor/what_to_plant.html.

Use the WaterSense Water Budget Data Finder (epa.gov/watersense/new_homes/wb_data_finder.html) to estimate the evapotranspiration rate (ET_o) in inches per month for the critical month of the year based on a project's zip code. ET_o, a measurement of the amount of water lost from a well-maintained expanse of average-height green grass and the surrounding soil, varies with a location's sunshine, wind, humidity, and temperature. Hot, dry, and windy locations have higher ET_o values than cool, humid locations. Data for these variables are based on 30-year historical averages. Data for projects outside the U.S. are not included in this tool.

The WaterSense Water Budget Tool (epa.gov/watersense/water_budget/) calculates a baseline landscape water requirement of a typical landscape, as described above. Different plant species and their arrangement in the landscape can be entered, and the Water Budget Tool estimates the effect of these design variables on LWR. Projects outside the U.S. may use this tool with local data.

Varying elements of irrigation water delivery systems can help in estimating how design decisions affect water requirements.

WaterSense irrigation controller specifications (epa.gov/WaterSense/products/controltech.html) outline the requirements for weather-based irrigation controller systems. These systems earn projects a standard 15% reduction in landscape water requirements for this credit.

EXAMPLES

A location's rainfall and evapotranspiration levels determine how much water a project needs. Consider two projects using Option 2, each with a fairly water-efficient landscape around an office building, one in Livingston, New Jersey, and one in Palo Alto, California (Figure 1).

Example 1. Livingston, New Jersey

The location is a typical suburban community in northern New Jersey. The team uses the EPA WaterSense Water Budget Data finder:

- Enter Zip Code: 07039
- Peak Month: Jun
- ETo Value: 6.30 inches/month
- Rainfall: 3.40 inches/month

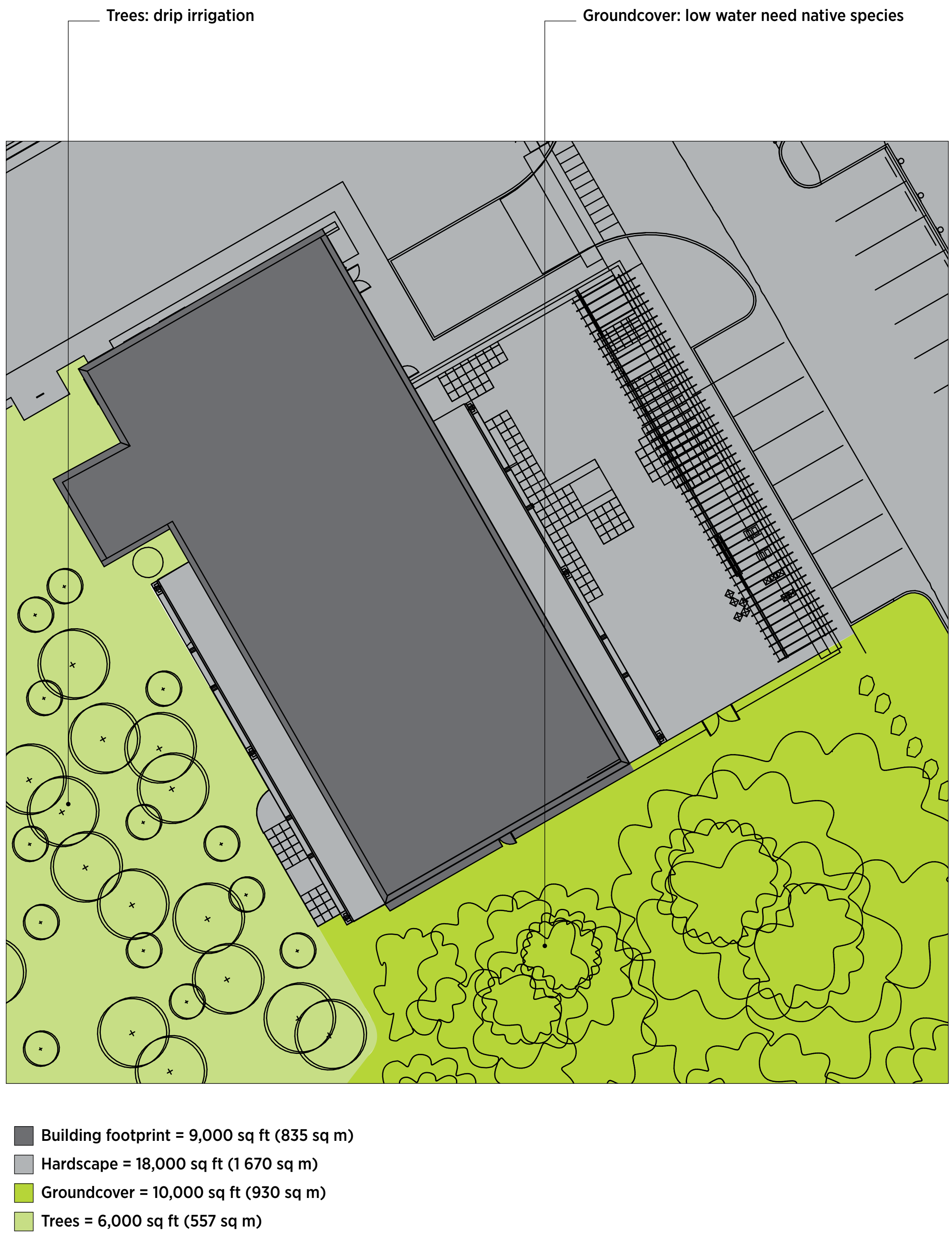


Figure 1. Example Site Plan

When landscape area is entered, the tool offers these results (Figure 2):

- Total: 16,000 sq ft
- 10,000 sq ft of groundcover—low water need, native species, drip irrigation
- 6,000 sq ft of trees—medium water need, drip irrigation

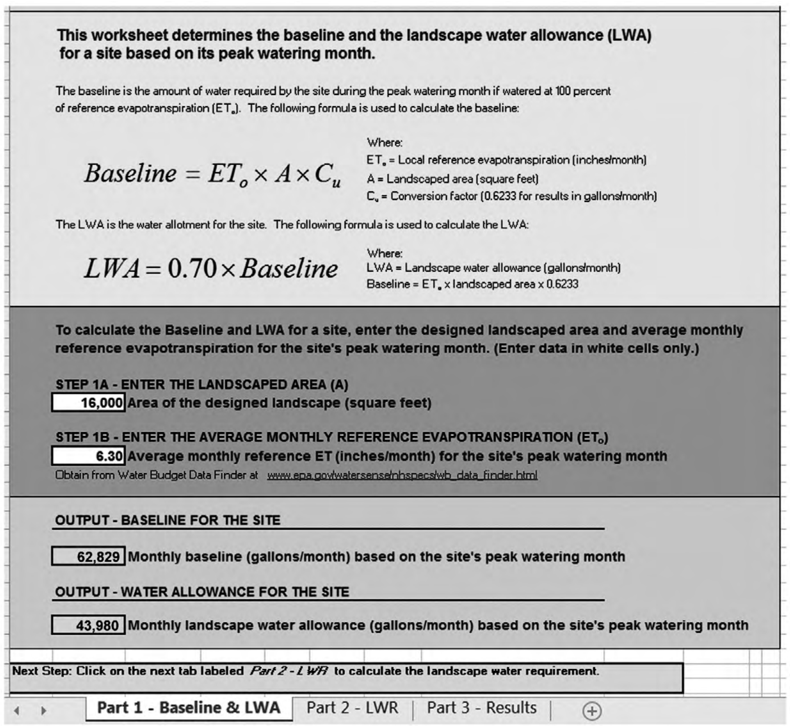


Figure 2. Part 1 - Baseline & LWA of the Water Budget Tool for Livingston, NJ Location. Screenshot taken from https://www3.epa.gov/watersense/excel/water_budget_tool.xlsx

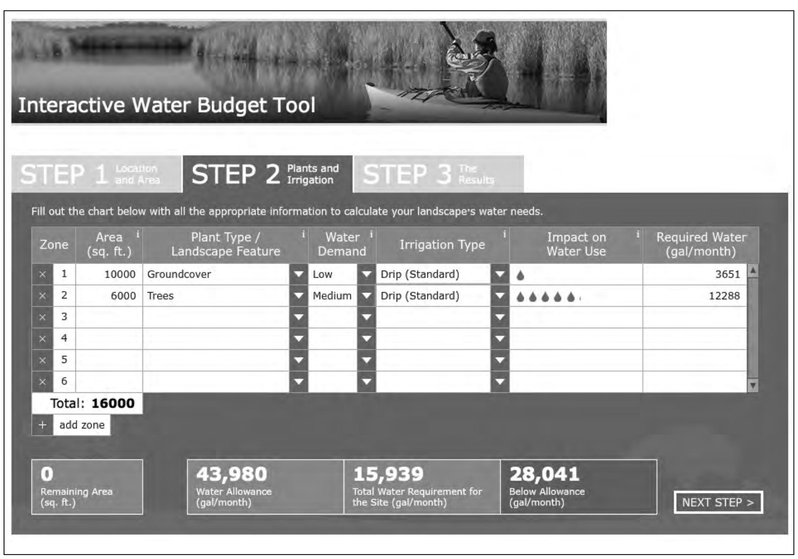


Figure 3. Water Budget Calculation for Livingston, NJ Location. Screenshot taken from http://www.epa.gov/watersense

The landscape water allowance equals 43,980 gallons/month. The landscape water baseline equals 62,829 gallons/month. The LWR for this design in this location is 15,939 gallons/month. The total savings from the baseline without alternative water sources amounts to 75%. The project achieves the credit and earns 1 point.

The team has determined that rainwater harvested from the building's roof will supply all the project's outdoor water needs. Given the average monthly rainfall in this location and the roof's area, the average monthly rainwater available for harvesting is 18,360 gallons per month: Equation 1 in Step-by-step is used to calculate the amount of rainwater harvested from the roof:

- Gallons per 1 inch of rain = 9,000 ft^2 × 0.6
- Gallons per 1 inch of rain = 5,400 gal

Equation 2 in Step-by-step is then used to determine the monthly harvested rainwater volume:

- Amount available = 5,400 gal/in × 3.4 in/mo
- Amount available = 18,360 gal/mo

The team ensures that the rainwater needed in the peak watering month can be stored onsite and installs a rainwater cistern capable of holding 20,000 gallons of rainwater for irrigation.

Equation 3 in Step-by-step is used to determine the adjusted landscape water requirement:

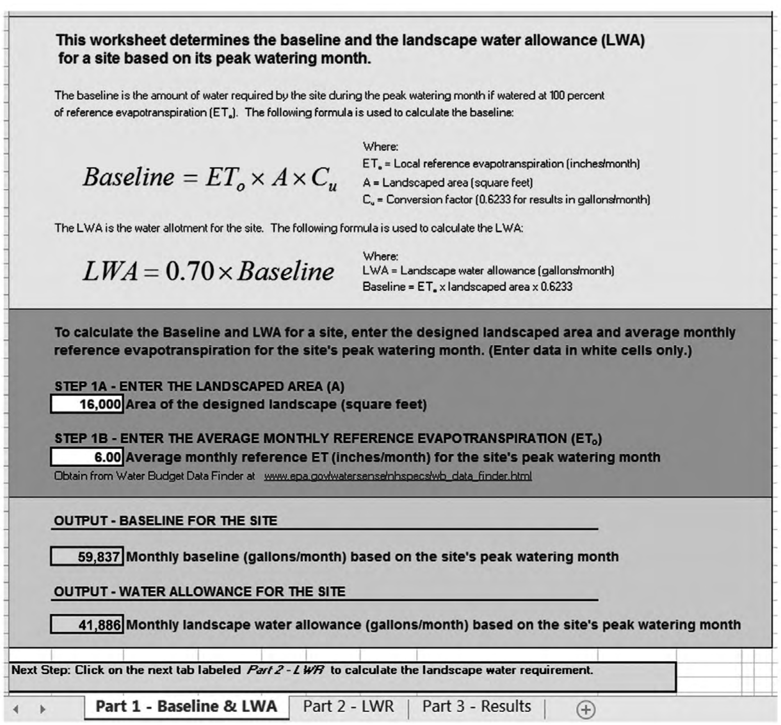
- Adjusted LWR = 15,939 gal/mo – 18,360 gal/mo
- Adjusted LWR = –2,421 gal/mo

The total water requirement is 15,939 gallons a month. Minus the 18,360 gallons a month available for harvesting, the project uses –2,421 gallons a month (i.e., it has a rainwater surplus). The total savings is 100%, for 2 points.

Example 2. Palo Alto, California

Palo Alto is in a fairly dry region of the country. The team uses the EPA WaterSense Water Budget Data Finder:

- Enter Zip Code: 94301
- Peak Month: Jul
- ET_o Value: 6.00 inches/month
- Rainfall: 0.00 inches/month



This worksheet determines the baseline and the landscape water allowance (LWA) for a site based on its peak watering month.

The baseline is the amount of water required by the site during the peak watering month if watered at 100 percent of reference evapotranspiration (ET_o). The following formula is used to calculate the baseline:

$$Baseline = ET_o \times A \times C_u$$

Where:
ET_o = Local reference evapotranspiration (inches/month)
A = Landscaped area (square feet)
C_u = Conversion factor (0.6233 for results in gallons/month)

The LWA is the water allotment for the site. The following formula is used to calculate the LWA:

$$LWA = 0.70 \times Baseline$$

Where:
LWA = Landscape water allowance (gallons/month)
Baseline = ET_o x landscaped area x 0.6233

To calculate the Baseline and LWA for a site, enter the designed landscaped area and average monthly reference evapotranspiration for the site's peak watering month. (Enter data in white cells only.)

STEP 1A - ENTER THE LANDSCAPED AREA (A)
16,000 Area of the designed landscape (square feet)

STEP 1B - ENTER THE AVERAGE MONTHLY REFERENCE EVAPOTRANSPIRATION (ET_o)
6.00 Average monthly reference ET (inches/month) for the site's peak watering month
Obtain from Water Budget Data Finder at www.epa.gov/watersense/nhspecs/wb_data_finder.html

OUTPUT - BASELINE FOR THE SITE
59,837 Monthly baseline (gallons/month) based on the site's peak watering month

OUTPUT - WATER ALLOWANCE FOR THE SITE
41,886 Monthly landscape water allowance (gallons/month) based on the site's peak watering month

Next Step: Click on the next tab labeled *Part 2 - LWR* to calculate the landscape water requirement.

Part 1 - Baseline & LWA | Part 2 - LWR | Part 3 - Results

Figure 4. Part 1 - Baseline & LWA of the Water Budget Tool for Palo Alto, CA Location. Screenshot taken from https://www3.epa.gov/watersense/excel/water_budget_tool.xlsx

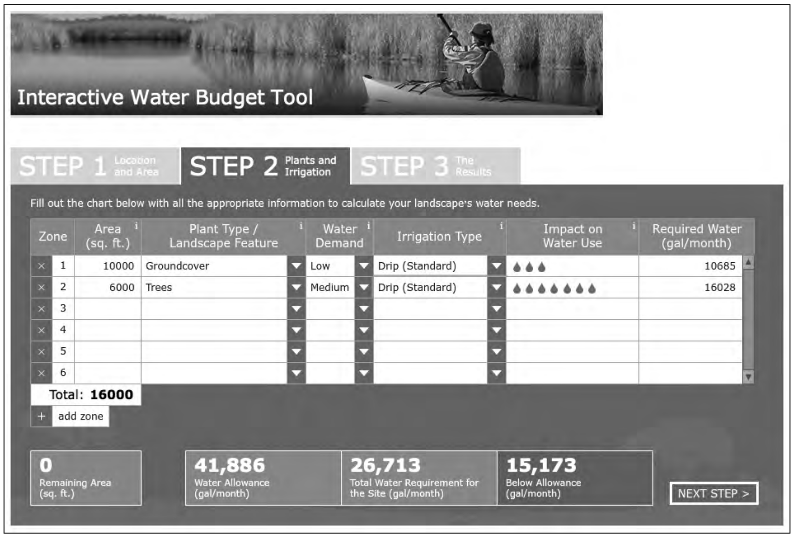


Figure 5. Water Budget Calculation for Palo Alto, CA Location. Screenshot taken from http://www.epa.gov/watersense

With a total landscape area of 16,000 square feet—10,000 square feet of groundcover (low water need, native species, drip irrigation) and 6,000 square feet of trees (medium water need, drip irrigation)—the tool now calculates a landscape water allowance of 41,886 gallons/month, and a landscape water baseline of 59,837 gallons/month. Compared with the New Jersey example above, the landscape water requirement for this design has increased to 26,713 gallons/month. The total savings is now 55%, for 1 point.

INTERNATIONAL TIPS

The World Meteorological Organization website (worldweather.wmo.int) and other sources provide annual precipitation data for many sites. If precipitation data for the project location are unavailable, they must be estimated.

Evapotranspiration data are available through various government and academic sources. The Food and Agriculture Organization of the United Nations (fao.org/nr/water/eto.html) calculates reference evapotranspiration using a variety of algorithms based on monthly average weather data. The month with the largest deficit between reference evapotranspiration and rainfall is the peak watering month.

The international version of the WaterSense Water Budget Tool can be found on the USGBC website under this credit's resources section (See International Tips, Canada).

CAMPUS

Group Approach

All buildings in the group may be documented as one. Use the total landscaped area of the entire campus. The results of the Water Budget Tool apply to all buildings in the group.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Alternative water source and controls calculations		X

RELATED CREDIT TIPS

SS Credit Rainwater Management. Rainwater management can aid in the recovery of rainwater as an alternative irrigation source.

WE Prerequisite Indoor Water Use Reduction. Graywater is a potential source for reducing outdoor potable water use.

WE Credit Cooling Tower Water Use. Cooling tower blowdown water and other cooling tower process water are potential alternative water sources for meeting outdoor water demand.

WE Prerequisite Building-Level Water Metering. Landscape water meters can aid in achieving this credit and prepare the project for certification under LEED for Building Operations and Maintenance. The landscape may be metered separately or with the whole building.

WE Credit Water Metering. Metering the landscape separately contributes to achieving the related credit.

CHANGES FROM LEED 2009

- This is a new credit.
- The WaterSense Water Budget Tool is now listed as the referenced calculation tool.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

conventional irrigation a region's most common system for providing water to plants by nonnatural means. A conventional irrigation system commonly uses pressure to deliver water and distributes it through sprinkler heads above the ground.

evapotranspiration the combination of evaporation and plant transpiration into the atmosphere. Evaporation occurs when liquid water from soil, plant surfaces, or water bodies becomes vapor. Transpiration is the movement of water through a plant and the subsequent loss of water vapor.

graywater "untreated household waste water which has not come into contact with toilet waste. Graywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washers and laundry tubs. It must not include waste water from kitchen sinks or dishwashers" (Uniform Plumbing Code, Appendix G, Gray Water Systems for Single-Family Dwellings); "waste water discharged from lavatories, bathtubs, showers, clothes washers and laundry sinks" (International Plumbing Code, Appendix C, Gray Water Recycling Systems). Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences can likely be found in state and local codes. Project teams should comply with the graywater definition established by the authority having jurisdiction in the project area.

hardscape the inanimate elements of the building landscaping. It includes pavement, roadways, stonewalls, wood and synthetic decking, concrete paths and sidewalks, and concrete, brick, and tile patios.

industrial process water any water discharged from a factory setting. Before this water can be used for irrigation, its quality needs to be checked. Saline or corrosive water should not be used for irrigation.

hydrozone a group of plantings with similar water needs

native vegetation an indigenous species that occurs in a particular region, ecosystem, and habitat without direct or indirect human actions. Native species have evolved to the geography, hydrology, and climate of that region. They also occur in communities; that is, they have evolved together with other species. As a result, these communities provide habitat for a variety of other native wildlife species. Species native to North America are generally recognized as those occurring on the continent prior to European settlement. Also known as native plants.

peak watering month the month with the greatest deficit between evapotranspiration and rainfall. This is the month when the plants in the site's region potentially require the most supplemental water typically a mid-summer month. (Sustainable Sites Initiative)

potable water water that meets or exceeds U.S. Environmental Protection Agency drinking water quality standards (or a local equivalent outside the U.S.) and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells or municipal water systems

rainwater harvesting the capture, diversion, and storage of rain for future beneficial use. Typically, a rain barrel or cistern stores the water; other components include the catchment surface and conveyance system. The harvested rainwater can be used for irrigation.

reclaimed water wastewater that has been treated and purified for reuse

reference evapotranspiration rate the amount of water lost from a specific vegetated surface with no moisture limitation. Turf grass with height of 120 mm is the reference vegetation.

softscape the elements of a landscape that consist of live, horticultural elements

xeriscaping landscaping that does not require routine irrigation

WATER EFFICIENCY CREDIT

Indoor Water Use Reduction

This credit applies to:

New Construction (1–6 points)
Core and Shell (1–6 points)
Schools (1–7 points)
Retail (1–7 points)
Data Centers (1–6 points)
Warehouses and Distribution Centers (1–6 points)
Hospitality (1–6 points)
Healthcare (1–7 points)

INTENT

To reduce indoor water consumption.

REQUIREMENTS

Further reduce fixture and fitting water use from the calculated baseline in WE Prerequisite Indoor Water Use Reduction. Additional potable water savings can be earned above the prerequisite level using alternative water sources. Include fixtures and fittings necessary to meet the needs of the occupants. Some of these fittings and fixtures may be outside the project boundary. Points are awarded according to Table 1.

TABLE 1. Points for reducing water use

Percentage reduction	Points (BD+C)	Points (Schools, Retail, Hospitality, Healthcare)
25%	1	1
30%	2	2
35%	3	3
40%	4	4
45%	5	5
50%	6	—

SCHOOLS, RETAIL, HOSPITALITY, AND HEALTHCARE ONLY

Meet the percentage reduction requirements above.

AND

APPLIANCE AND PROCESS WATER

Install equipment within the project scope that meets the minimum requirements in Table 2, 3, 4, or 5 . One point is awarded for meeting all applicable requirements in any one table. All applicable equipment listed in each table must meet the standard.

Schools, Retail, and Healthcare projects can earn a second point for meeting the requirements of two tables.

To use Table 2, the project must process at least 120,000 lbs (57 606 kg) of laundry per year.

TABLE 2. Compliant commercial washing machines

Washing machine	Requirement (IP units)	Points (Schools, Retail, Hospitality, Healthcare)
On-premise, minimum capacity 2,400 lbs (1 088 kg) per 8-hour shift	Maximum 1.8 gals per pound *	Maximum 7 liters per 0.45 kilograms *

* Based on equal quantities of heavy, medium, and light soil laundry.

To use Table 3, the project must serve at least 100 meals per day of operation. All process and appliance equipment listed in the category of kitchen equipment and present on the project must comply with the standards.

TABLE 3. Standards for commercial kitchen equipment

Kitchen equipment		Requirement (IP units)	Requirement (SI units)
Dishwasher	Undercounter	ENERGY STAR	ENERGY STAR or performance equivalent
	Stationary, single tank, door	ENERGY STAR	ENERGY STAR or performance equivalent
	Single tank, conveyor	ENERGY STAR	ENERGY STAR or performance equivalent
	Multiple tank, conveyor	ENERGY STAR	ENERGY STAR or performance equivalent
	Flight machine	ENERGY STAR	ENERGY STAR or performance equivalent
Food steamer	Batch (no drain connection)	≤ 2 gal/hour/pan including condensate cooling water	≤ 7.5 liters/hour/pan including condensate cooling water
	Cook-to-order (with drain connection)	≤ 5 gal/hour/pan including condensate cooling water	≤ 19 liters/hour/pan including condensate cooling water
Combination oven	Countertop or stand	≤ 1.5 gal/hour/panincluding condensate cooling water	≤ 5.7 liters/hour/pan including condensate cooling water
	Roll-in	≤ 1.5 gal/hour/pan including condensate cooling water	≤ 5.7 liters/hour/pan including condensate cooling water
Food waste disposer	Disposer	3-8 gpm, full load condition, 10 minute automatic shutoff; or 1 gpm, no-load condition	11–30 lpm, full load condition, 10-min automatic shutoff; or 3.8 lpm, no-load condition
	Scrap collector	Maximum 2 gpm makeup water	Maximum 7.6 lpm makeup water
	Pulper	Maximum 2 gpm makeup water	Maximum 7.6 lpm makeup water
	Strainer basket	No additional water usage	No additional water usage

gpm = gallons per minute gph = gallons per hour lpm = liters per minute lph = liters per hour

To use Table 4, the project must be a medical or laboratory facility.

TABLE 4. Compliant laboratory and medical equipment

Lab equipment	Requirement (IP units)	Points (Schools, Retail, Hospitality, Healthcare)
Reverse-osmosis water purifier	75% recovery	75% recovery
Steam sterilizer	For 60-inch sterilizer, 6.3 gal/U.S. tray For 48-inch sterilizer, 7.5 gal/U.S. tray	For 1520-mm sterilizer, 28.5 liters/DIN tray For 1220-mm sterilizer, 28.35 liters/DIN tray
Sterile process washer	0.35 gal/U.S. tray	1.3 liters/DIN tray
X-ray processor, 150 mm or more in any dimension	Film processor water recycling unit	
Digital imager, all sizes	No water use	

To use Table 5, the project must be connected to a municipal or district steam system that does not allow the return of steam condensate.

TABLE 5. Compliant municipal steam systems

Steam system	Standard
Steam condensate disposal	Cool municipally supplied steam condensate (no return) to drainage system with heat recovery system or reclaimed water
OR	
Reclaim and use steam condensate	100% recovery and reuse

BEHIND THE INTENT

See *Behind the Intent* in WE Prerequisite Indoor Water Use Reduction.

STEP-BY-STEP GUIDANCE

STEP 1. COMPLETE CALCULATIONS IN PREREQUISITE

Follow the instructions in WE Prerequisite Indoor Water Use Reduction to determine water savings resulting from efficiency of fixtures and fittings.

STEP 2. CONSIDER ALTERNATIVE WATER SOURCES

Alternatives to potable water include municipally supplied reclaimed water (“purple pipe” water), graywater, rainwater, stormwater, treated seawater, condensate, foundation dewatering water, used process water, and reverse osmosis reject water.

- Untreated water sources ineligible for this credit include raw water from naturally occurring surface bodies of water, streams, rivers, groundwater, well water, and water discharged from an open-loop geothermal system.
- When choosing alternative sources of water, target the uses that require the least treatment first. In most cases, water can be reused outside the building (for irrigation) or inside (for toilet flushing) with minimal treatment, but other uses will require more energy-intensive treatment.

STEP 3. CALCULATE ADDITIONAL SAVINGS FROM USING NONPOTABLE WATER

If the project is using an alternative, nonpotable water source, calculate the total annual projected water savings, using Equation 1.

EQUATION 1. Indoor water-use reduction with nonpotable supply

$$\text{Total water savings} = \left\{ \frac{\text{Annual baseline water consumption} - \left(\text{Annual design case water consumption} - \text{Annual nonpotable water supply}\right)}{\text{Annual baseline water consumption}} \right\} \times 100$$

- Prepare documentation, including a narrative describing the nonpotable water source, plumbing system design drawings that highlight the nonpotable water system, and supply and demand calculations that confirm the available quantity of nonpotable water.
- Address any change to the calculated usage demand of seasonal availability or storage capacity. If the nonpotable water is used for multiple applications—for example, flush fixtures and landscape irrigation—a sufficient quantity must be available to meet the demands of all uses. The amount of nonpotable water meant for indoor and outdoor uses cannot exceed the total annual nonpotable water supply.

STEP 4. SELECT HIGH-EFFICIENCY SPECIALIZED APPLIANCE AND PROCESS WATER SYSTEMS, WHERE APPLICABLE (RETAIL, HEALTHCARE, HOSPITALITY & SCHOOLS PROJECTS ONLY)

Retail, Healthcare, and Schools projects may earn 1 point (up to 2 points) by meeting the requirements of one or two of the appliance and process water tables in the credit requirements (see *Further Explanation, Example*). Hospitality projects may earn 1 point for meeting the requirements of one of the appliance and process water tables in the credit requirements. In all cases, appliance and process water-use equipment installed in the project must meet the requirements of Table 2 of the prerequisite requirements.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance* and in the indoor water use calculator provided by USGBC.

EXAMPLE

Foxhill School has a cafeteria that serves about 600 meals per day and a gymnasium with a commercial washing machine for washing uniforms, towels, and other linens with a capacity of more than 120,000 pounds per year (54 431 kilograms per year) of laundry.

- The school meets the qualification requirements for Tables 2 and 3 of the credit requirements.
- The kitchen includes some but not all of the items listed in Table 3 of the credit requirements:
    - Dishwasher, under counter (1), ENERGY STAR-labeled
    - Dishwasher, single tank, conveyor (1), ENERGY STAR-labeled
    - Combination oven, roll-in (2), using 1.0 gallons per hour per pan (3.8 liters per hour per pan), including condensate cooling water
    - No food steamer
    - No food waste disposer
- The gymnasium laundry uses 1.6 gallons per pound of laundry (12.4 liters per kilogram of laundry).

The school can earn 2 points for appliance and process water savings, in addition to the savings from its fixtures.

RATING SYSTEM VARIATIONS

Core and Shell

Include in the credit documentation all plumbing fixtures necessary to meet the occupants' needs whether they will be installed as part of the project's scope of work or not. For example, include at a minimum all necessary restroom fixtures (toilets, urinals, and lavatories) to meet the project occupants' needs, and showers when seeking LT Credit Bicycle Facilities. Assume that the as-yet-uninstalled (future) fixtures have the baseline water consumption rates. Kitchen sinks must be included in the credit calculations if installed in the project's scope of work or if addressed in a tenant sales or lease agreement. However, if future kitchen sinks are not installed as part of the project's scope of work or are not addressed in a tenant sales or lease agreement, they may be excluded from the credit calculations. A core and shell project can earn credit for the plumbing fixtures installed as part of the project's scope if all fixtures necessary to meet occupants' needs are included in the calculations and if all occupants of the incomplete tenant spaces are included in the calculations.

A project team may earn credit for the efficiency of not-yet-installed future plumbing fixtures by submitting a legally binding tenant sales or lease agreement. The agreement, signed by both owner and tenant, must state the performance requirements for the future fixtures, including the maximum water flush or flow rates and the WaterSense label (or a local equivalent for projects outside the U.S.) for all newly installed fixtures eligible for labeling. The project cannot earn credit this way unless the tenant sales or lease agreement is fully executed.

PROJECT TYPE VARIATIONS

Additions

For credit compliance, include in the credit documentation all plumbing fixtures necessary to meet the occupants' needs whether they will be installed as part of the project's scope of work or not. Include at a minimum all necessary restroom fixtures (toilets, urinals, and lavatories) to meet the project occupants' needs, and showers when seeking LT Credit Bicycle Facilities. The WaterSense label requirement does not apply to fixtures that are outside of the scope of the LEED project.

Mixed-Use Projects

If a mixed-use project uses the same fixtures throughout the building, complete a single calculation of building water use. If the spaces use different fixtures or have dramatically different patterns of occupancy or varying annual days of operation, complete the indoor water use calculator with a separate fixture group for each space type.

Multifamily Residential

Use residential occupancy.

INTERNATIONAL TIPS

For fixtures that require the WaterSense label in countries where the label is unavailable, look up acceptable WaterSense substitutes at usgbc.org. Projects in unlisted countries must comply with the 20%-below-baseline requirement but have no additional performance requirements.

For appliances that require the ENERGY STAR label, a project outside the U.S. may install products that are not labeled under the ENERGY STAR program if they meet the ENERGY STAR product specifications, available on the ENERGY STAR website. All products must meet the standards of the current version of ENERGY STAR as of the date of their purchase.

CAMPUS

Group Approach

Eligible. The percentage reduction can be based on the total combined water use reduction in all LEED project buildings. The baseline adjustment for year of substantial system completion should be averaged based on all plumbing fixtures in all buildings. If nonpotable water systems will be shared by multiple projects, ensure adequate supply to meet the demands of all projects using nonpotable water. The nonpotable water may not be double-counted among projects. Submit separate documentation for each building, as required for WE Prerequisite Indoor Water Use Reduction.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Fixtures	Appliances	Process water
		(Retail, Healthcare, Hospitality, and Schools projects only)	
Alternative water source calculations (if applicable)	X		
Plumbing system design drawings (if applicable)	X		
Alternative water narrative	X		
Cutsheets, manufacturers' information	X	X	X
Indoor water use calculator	X		

RELATED CREDIT TIPS

WE Prerequisite Building-Level Water Metering. Metering of potable water usage allows facilities management staff to monitor changes as efficiency measures are implemented.

WE Credit Water Metering. Submetering of water-using systems provides water efficiency performance data so that facilities operators can optimize water consumption.

CHANGES FROM LEED 2009

- Appliance and process water savings can earn credit under the Retail, Healthcare, Hospitality, and Schools rating systems.
- The WaterSense label requirements, merely recommended in LEED 2009, are now mandatory in the U.S., with local equivalencies allowed elsewhere.

- Duration-based savings from autocontrol faucets with automatic fixture sensors or metering controls are no longer allowed in the design case. Studies have shown that autocontrol faucets do not save water because users frequently reactivate the faucet after initial use or stop washing before the cycle ends.
- To earn points, project teams must include fixtures necessary to meet the occupants' needs. When no facilities are available within project boundaries, the closest available restrooms must be included in credit calculations. These additional restrooms can be excluded from prerequisite compliance requirements.

REFERENCED STANDARDS

The Energy Policy Act (EPAct) of 1992 and as amended: eere.energy.gov/femp/regulations/epact1992.html

EPAct 2005: eere.energy.gov/femp/regulations/epact2005.html

International Association of Plumbing and Mechanical Officials Publication IAPMO / ANSI UPC 1-2006, Uniform Plumbing Code 2006, Section 402.0, Water-Conserving Fixtures and Fittings: iapmo.org

International Code Council, International Plumbing Code 2006, Section 604, Design of Building Water Distribution System: iccsafe.org

ENERGY STAR: energystar.gov

WaterSense: epa.gov/watersense

IgCC/ASHRAE 189.1 – cooling tower and evaporative condenser requirements:
ashrae.org/resources--publications/bookstore/standard-189-1

EXEMPLARY PERFORMANCE

Achieve 55% water use reduction.

DEFINITIONS

alternative water source nonpotable water from other than public utilities, on-site surface sources, and subsurface natural freshwater sources. Examples include graywater, on-site reclaimed water, collected rainwater, captured condensate, and rejected water from reverse osmosis systems (IgCC).

baseline water consumption a calculated projection of building water use assuming code-compliant fixtures and fittings with no additional savings compared with the design case or actual water meter data

potable water water that meets or exceeds U.S. Environmental Protection Agency drinking water quality standards (or a local equivalent outside the U.S.) and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells or municipal water systems

nonpotable water water that does not meet drinking water standards

process water water that is used for industrial processes and building systems, such as cooling towers, boilers, and chillers. It can also refer to water used in operational processes, such as dishwashing, clothes washing, and ice making.

WATER EFFICIENCY CREDIT

Cooling Tower Water Use

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To conserve water used for cooling tower makeup while controlling microbes, corrosion, and scale in the condenser water system.

REQUIREMENTS

For cooling towers and evaporative condensers, conduct a one-time potable water analysis, measuring at least the five control parameters listed in Table 1.

TABLE 1. Maximum concentrations for parameters in condenser water

Parameter	Maximum level
Ca (as $CaCO_3$)	1000 ppm
Total alkalinity	1000 ppm
SiO_2	100 ppm
Cl^-	250 ppm
Conductivity	2000 μS/cm

ppm = parts per million
μS/cm = micro siemens per centimeter

Calculate the number of cooling tower cycles by dividing the maximum allowed concentration level of each parameter by the actual concentration level of each parameter found in the potable makeup water. Limit cooling tower cycles to avoid exceeding maximum values for any of these parameters.

TABLE 2. Points for cooling tower cycles

Cooling tower cycles	Points
Maximum number of cycles achieved without exceeding any filtration levels or affecting operation of condenser water system (up to maximum of 10 cycles)	1
Achieve a minimum 10 cycles by increasing the level of treatment in condenser or make-up water OR Meet the minimum number of cycles to earn 1 point and use a minimum 20% recycled nonpotable water	2

BEHIND THE INTENT

Refrigeration systems remove heat, usually from air, to cool interior building spaces. This heat is expelled into either the atmosphere or another medium. A cooling tower or evaporative condenser removes heat in part by evaporating water; as the water absorbs heat, it changes from a liquid to a vapor. As the water evaporates, however, dissolved solids become more concentrated in the remaining water and eventually begin to deposit scale on cooling tower or evaporative condenser elements, making such systems less efficient. To prevent buildup of deposits, cooling tower and evaporative condenser systems remove a portion of the water through a process called blowdown. Makeup water is then added to replace evaporative losses and blowdown volume. Cooling towers can therefore account for large portions of a building's total water use.

To significantly reduce makeup water inputs, it is important to achieve target cycles of concentration (see *Further Explanation, Cycles of Concentration*). Cooling tower or evaporative condenser water efficiency is measured in the number of recirculation cycles before water must be removed by blowdown.

Increasing the number of cycles can save thousands of gallons of potable water during a building's peak cooling periods. Chemically analyzing makeup water allows for calculation of optimal cycles. Cycles can also be increased by treating water to remove or sequester dissolved solids rather than relying only on blowdown and input of fresh makeup water.

STEP-BY-STEP GUIDANCE

Only projects served by cooling towers or evaporative condensers are eligible for this credit.

STEP 1. OBTAIN WATER ANALYSIS

Whether the project uses 100% potable or 100% nonpotable water for cooling, the first step is to obtain a chemical analysis.

- Engage a water treatment professional to perform the analysis. If a potable water analysis has already been completed, it must be no more than five years old.
- At a minimum, the analysis must measure the concentration parameters identified in the credit requirements. Highlight each parameter in the documentation.
- Describe the analysis. The narrative must identify the source of the makeup water and the process for analysis.

STEP 2. CALCULATE CYCLES OF CONCENTRATION

Determine how many times the cooling tower or evaporative condenser water can circulate through the system without creating performance or operational problems by using Equation 1, based on the maximum concentrations indicated in the credit requirements.

EQUATION 1. Indoor water-use reduction

$$\text{Cycles of concentration} = \frac{\text{Acceptable maximum concentrations in condenser water}}{\text{Parameter concentrations in makeup water}}$$

STEP 3. IDENTIFY LIMITING FACTOR

Identify which concentration parameter has the fewest calculated cycles before it exceeds the maximum concentration. That parameter's number of cycles, the limiting factor, will determine the maximum number of cycles for the cooling tower or evaporative condenser.

STEP 4. SET COOLING TOWER OR EVAPORATIVE CONDENSER CYCLES

Adjust the cooling tower or evaporative condenser settings for the maximum number of cycles without exceeding concentration levels or affecting condenser operation.

STEP 5. INCREASE SYSTEM PERFORMANCE

Increase the number of cycles by treating the water or, if the project is using 100% potable water, supplementing it with water from a nonpotable source.

- Evaluate whether greater potable water efficiency could be achieved by treating makeup water to reduce or sequester some of the dissolved solids.
- Nonpotable water derived from the site can offset a portion of the potable water used for makeup (see *Further Explanation, Selecting Nonpotable Sources*).

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

CYCLES OF CONCENTRATION

Cycles of concentration are the number of times that a volume of water can circulate through a cooling tower system before dissolved minerals become so concentrated (as water is lost to evaporation) that they precipitate and cause scaling—deposits that reduce the efficiency of the cooling system. To dilute the concentration of minerals, some water must be removed (blowdown) and replaced with fresh makeup water, or the water must be chemically treated, or both. The number of times water can cycle through the system before scaling becomes a problem depends on the amount of total dissolved solids (TDS) in the original water and the temperature of the water and heat exchange surfaces. Low-temperature water with low initial TDS levels can be circulated through more cycles than very hot, mineral-laden ("hard") water.

More technically, a cycle of concentration is defined as the ratio of TDS levels in makeup water to TDS levels in water removed through blowdown, evaporative loss, and drift (windage). A higher number of cycles indicates better water efficiency because less makeup water is required.

Building maintenance staff can monitor cycles of concentration by comparing the amount of soluble chloride ions (measured in parts per million, ppm) in makeup water with that in the recirculating water. A test kit is typically available through the cooling tower or evaporative condenser manufacturer or the service contractor responsible for maintaining makeup water chemistry. The minimum number of cycles would be a once-through system that runs the makeup water through the heat exchange media once, without recirculating it. For obvious reasons, this wasteful use of water is discouraged. Yet as cycles increase, the amount of TDS also increases, resulting in potential fouling of the system. Optimizing the number of cycles avoids both of these scenarios.

SELECTING NONPOTABLE SOURCES

When selecting a nonpotable source, consider the factors that affect makeup water quality. Acceptable sources should have relatively low levels of dissolved solids. Stormwater runoff from the ground surface or graywater may contain contaminants, including dissolved chlorides that may need treatment. In contrast, air-conditioning condensate and rainwater collected from building roofs have relatively low mineral content.

Good nonpotable water sources include the following:

- Air-conditioner condensate
- Rainwater
- Steam system condensate
- Food steamer discharge water
- Fire pump test water
- Ice machine condensate

Other factors to consider are ease of transport to the cooling tower and required volume of makeup water.

EXAMPLE

Analysis of the makeup water for a cooling tower or evaporative condenser at an office building reveals the following concentrations:

TABLE 3. Analysis of makeup water

Parameter	Maximum allowable concentrations	Makeup water concentrations
Calcium (as $CaCO_3$)	1,000 ppm	100 ppm
Alkalinity	1,000 ppm	200 ppm
SiO_2	100 ppm	20 ppm
Chloride	250 ppm	50 ppm
Conductivity	2,000 μS/cm	300 μS/cm

The cycles of concentration based on each of these parameters are as follows:

TABLE 4. Cycles of concentration

Calcium (as $CaCO_3$)	1,000 / 100 = 10 cycles
Alkalinity	1,000 / 200 = 5 cycles
SiO_2	100 / 20 = 5 cycles
Chloride	250 / 50 = 5 cycles
Conductivity	2,000 / 300 = 6.7 cycles

The lowest number—five cycles—is therefore the maximum cycles of concentration for this makeup water.

CAMPUS

Group Approach

All buildings in the group project may be documented as one.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	1 point	2 points
Potable water analysis results	X	X
Potable water analysis narrative	X	X
Cycles of concentration calculations	X	X
Nonpotable water calculations		X
Water treatment calculations		X
Nonpotable water analysis (if using 100% nonpotable water)		X

RELATED CREDIT TIPS

WE Prerequisite Indoor Water Use Reduction. The related prerequisite requires makeup meters, conductivity controllers and overflow alarms, and efficient drift eliminators that reduce drift to a maximum of 0.002% of recirculated water volume for counterflow towers, 0.005% of recirculated water flow for cross-flow towers. These performance and tracking measures allow for better ongoing maintenance of efficient cooling tower or evaporative condenser systems.

WE Credit Water Metering. Subsystem meters to measure cooling tower or evaporative condenser makeup water can assist in water management and can help optimize cycles of concentration.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

blowdown the removal of makeup water from a cooling tower or evaporative condenser recirculation system to reduce concentrations of dissolved solids

makeup water water that is fed into a cooling tower system or evaporative condenser to replace water lost through evaporation, drift, bleed-off, or other causes

WATER EFFICIENCY CREDIT

Water Metering

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To support water management and identify opportunities for additional water savings by tracking water consumption.

REQUIREMENTS

Install permanent water meters for two or more of the following water subsystems, as applicable to the project:

- **Irrigation.** Meter water systems serving at least 80% of the irrigated landscaped area. Calculate the percentage of irrigated landscape area served as the total metered irrigated landscape area divided by the total irrigated landscape area. Landscape areas fully covered with xeriscaping or native vegetation that requires no routine irrigation may be excluded from the calculation.
- **Indoor plumbing fixtures and fittings.** Meter water systems serving at least 80% of the indoor fixtures and fitting described in WE Prerequisite Indoor Water Use Reduction, either directly or by deducting all other measured water use from the measured total water consumption of the building and grounds.
- **Domestic hot water.** Meter water use of at least 80% of the installed domestic hot water heating capacity (including both tanks and on-demand heaters).
- **Boiler with aggregate projected annual water use of 100,000 gallons (378 500 liters) or more, or boiler of more than 500,000 BtuH (150 kW).** A single makeup meter may record flows for multiple boilers.
- **Reclaimed water.** Meter reclaimed water, regardless of rate. A reclaimed water system with a makeup water connection must also be metered so that the true reclaimed water component can be determined.
- **Other process water.** Meter at least 80% of expected daily water consumption for process end uses, such as humidification systems, dishwashers, clothes washers, pools, and other subsystems using process water.

HEALTHCARE PROJECTS ONLY

In addition to the requirements above, install water meters in any five of the following:

- purified water systems (reverse-osmosis, de-ionized);
- filter backwash water;
- water use in dietary department;
- water use in laundry;
- water use in laboratory;
- water use in central sterile and processing department;
- water use in physiotherapy and hydrotherapy and treatment areas;
- water use in surgical suite;
- closed-looped hydronic system makeup water; and
- cold-water makeup for domestic hot water systems.

BEHIND THE INTENT

Metering water usage by subsystem helps facilities managers better gauge a building's water efficiency. Submetering the major building water systems provides a way to formulate independent system baselines, track usage against those baselines, isolate and identify potential sources of waste, and take corrective action. Moreover, submetering helps track periodic changes in water usage and provides the data necessary to calculate opportunities for water savings at a systemwide level.

This credit expands on WE Prerequisite Building-Level Water Metering, which requires a main water meter to measure the total quantity of water entering the building.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY CANDIDATE SYSTEMS FOR SUBMETERING

Identify all systems serving the project building and grounds. These subsystems may include irrigation, indoor plumbing fixtures, domestic hot water, process water, reclaimed water, and boiler water. Cooling tower submeters are addressed separately, under WE Prerequisite Indoor Water Use Reduction.

- Consider those subsystems that consume the most water, are the most expensive to operate, or most closely align with the goals of the building management.
- Consider not only the number, types, and sizes of meters but also the effort required to take meter readings.
- The cost of a wet meter (a meter installed in the pipe) increases with pipe size; many external, clamp-on meters are adaptable to a range of pipe sizes. Clamp-on meters are more costly on small-diameter pipes, but initial cost differences are reduced for larger pipes.
- The higher cost of a larger meter may be offset by reduced operations and maintenance costs if facilities staff will be making manual readings.
- Automatic data logging also adds to initial cost, but it may be cost-effective if it reduces the effort of obtaining and recording readings.
- Plumbing system layout affects where submeters can be installed. New construction projects may facilitate submetering during plumbing system design.
- Some projects may require more than one submeter to measure 80% to 100% of flow in some systems.
- If flush fixtures and flow fixtures as described in WE Prerequisite Indoor Water Use Reduction are submetered separately (i.e. not aggregated), this approach contributes as two water subsystems for credit compliance.

STEP 2. DETERMINE SCOPE OF SUBMETERING

Identify which subsystems are most appropriate to submeter based on the project objectives.

- As noted in WE Prerequisite Building-Level Water Metering, consider location and accessibility when placing submeters, particularly for taking manual readings.
- If the project team is claiming credit for irrigation, indoor plumbing fixtures, domestic hot water, or other process water submeters, at least 80% of water distribution must be submetered. If 100% of the water used by a subsystem is metered, no calculation is necessary.
- Determine how much of the total water system will be submetered by comparing the submetered portions with total landscape area, number of indoor fixtures, domestic water heating units, or process use quantities, as follows:

EQUATION 1. Landscape area

$$\frac{\text{Metered irrigated landscape area}}{\text{Total irrigated landscape area}} \geq 0.8$$

Unirrigated landscape areas should not be included in either the numerator or denominator of this

EQUATION 2. Fixtures

$$\frac{\text{Number of metered indoor fixtures and fittings}}{\text{Total number of indoor fixtures}} \geq 0.8$$

EQUATION 3. Domestic hot water

$$\frac{\text{Heating capacity of metered domestic water heating units}}{\text{Total heating capacity of all domestic water heating units}} \geq 0.8$$

EQUATION 4. Other process water

$$\frac{\text{Daily metered gallons (or liters) for process-type end uses}}{\text{Total expected daily gallons (or liters) for process-type end uses}} \geq 0.8$$

- If the team is using reclaimed water for irrigation, 100% of this water must be submetered. The meter for reclaimed water may also be the same meter that is counted for irrigation, fixtures, or process water. If reclaimed water is used in multiple applications in the project (e.g., for irrigation, flush fixtures, or process water), then all reclaimed water use must be metered; the team may report data from multiple submeters, as applicable.
- Discuss water efficiency goals with the building operations and maintenance team to ensure that the metered systems reflect needs.
- Healthcare projects have specific requirements. See *Further Explanation, Rating System Variations*.

STEP 3. SELECT METERING EQUIPMENT

Choose a submeter type if no existing meters are present or if existing meters need replacing.

- Submeters may be manually read or connected to a building information system. The meters may be equipped with data logging capability independent of a building information system.
- If meters are to be read manually, consider digital indicators, which may reduce errors in recording.
- Wet meters will likely be the most cost-effective approach. However, clamp-on meters may be simpler to install.

Prepare a narrative describing the subsystems metered, including the location and model of each installed submeter.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

RATING SYSTEM VARIATIONS

Healthcare

Healthcare projects must meter five additional subsystems, as outlined in the credit requirements. For example, submetering all laundry water use counts as one metered subsystem.

PROJECT TYPE VARIATIONS

Multifamily

Water use in common areas can be submetered to earn this credit. Metering in residential units may be included or excluded, but should be done uniformly. Multifamily projects still need to meter full subsystems (for common areas or the whole building) to earn credit.

Additions

For additions to existing buildings, the submetered systems may either follow the project boundary or include both the addition and the original building.

If the original building is included within the project boundary, then all submeters must account for old and new building water use. If the project boundary includes only the addition, the project team may choose to submeter the water use of only the addition.

If the fixtures used by the addition are all within the original building, the project boundary must include the original building for the team to earn credit for the fixture submeter.

CAMPUS

Group Approach

Submit separate documentation for each building. Each building in the group must have an individual whole-building water meter. Each individual building in the group must meet the credit requirements for submetering of indoor plumbing fixtures and fittings, domestic hot water, and other process water. All buildings in the group can be served by the same submeter for irrigation systems, boilers, and reclaimed water, provided all the water used by the group is captured.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
Water metering strategy narrative	X

RELATED CREDIT TIPS

WE Prerequisite Building-Level Water Metering. For this credit, submetered systems must be within the boundaries of the whole-building water meter required for the related prerequisite.

WE Prerequisite Indoor Water Use Reduction. If fixtures and fittings submeters are used to earn this credit, meter the water systems serving at least 80% of the indoor fixtures and fittings described in the related prerequisite—either directly or by deducting all other measured water use from the measured total water consumption of the building and grounds.

WE Prerequisite Outdoor Water Use Reduction. If irrigation submeters are used to earn this credit, meter the water systems serving at least 80% of the irrigated landscaped area identified in the related prerequisite.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

external meter a device installed on the outside of a water pipe to record the volume of water passing through it. Also known as a clamp-on meter.

reclaimed water wastewater that has been treated and purified for reuse

wet meter a device installed inside a water pipe to record the volume of passing water

Energy and Atmosphere (EA)

OVERVIEW

The Energy and Atmosphere (EA) category approaches energy from a holistic perspective, addressing energy use reduction, energy-efficient design strategies, and renewable energy sources.

The current worldwide mix of energy resources is weighted heavily toward oil, coal, and natural gas.[1] In addition to emitting greenhouse gases, these resources are nonrenewable: their quantities are limited or they cannot be replaced as fast as they are consumed.[2] Though estimates regarding the remaining quantity of these resources vary, it is clear that the current reliance on nonrenewable energy sources is not sustainable and involves increasingly destructive extraction processes, uncertain supplies, escalating market prices, and national security vulnerability. Accounting for approximately 40% of the total energy used today,[3] buildings are significant contributors to these problems.

Energy efficiency in a green building starts with a focus on design that reduces overall energy needs, such as building orientation and glazing selection, and the choice of climate-appropriate building materials. Strategies such as passive heating and cooling, natural ventilation, and high-efficiency HVAC systems partnered with smart controls further reduce a building's energy use. The generation of renewable energy on the project site or the purchase of green power allows portions of the remaining energy consumption to be met with non–fossil fuel energy, lowering the demand for traditional sources.

The commissioning process is critical to ensuring high-performing buildings. Early involvement of a commissioning authority helps prevent long-term maintenance issues and wasted energy by verifying that the design meets the owner's project requirements and functions as intended. In an operationally effective and efficient building, the staff understands what systems are installed and how they function. Staff must have training and be receptive to learning new methods for optimizing system performance so that efficient design is carried through to efficient performance.

The EA category recognizes that the reduction of fossil fuel use extends far beyond the walls of the building. Projects can contribute to increasing the electricity grid's efficiency by enrolling in a demand response program.

1. *iea.org/publications/freepublications/publication/kwes.pdf*
2. *cnx.org/content/m16730/latest/*
3. *unep.org/sbci/pdfs/SBCI-BCCSummary.pdf*

Demand response allows utilities to call on buildings to decrease their electricity use during peak times, reducing the strain on the grid and the need to operate more power plants, thus potentially avoiding the costs of constructing new plants. Similarly, on-site renewable energy not only moves the market away from dependence on fossil fuels but may also be a dependable local electricity source that avoids transmission losses and strain on the grid.

The American Physical Society has found that if current and emerging cost-effective energy efficiency measures are employed in new buildings and in existing buildings as their heating, cooling, lighting, and other equipment is replaced, the growth in energy demand from the building sector could fall from a projected 30% increase to zero between now and 2030.[4] The EA section supports the goal of reduced energy demand through credits related to reducing usage, designing for efficiency, and supplementing the energy supply with renewables.

4. *Energy Future: Think Efficiency* (*American Physical Society, September 2008*), *aps.org/energyefficiencyreport/report/energy-bldgs.pdf* (*accessed September 13, 2012*).

ENERGY AND ATMOSPHERE PREREQUISITE

Fundamental Commissioning and Verification

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.

REQUIREMENTS

Commissioning Process Scope

Complete the following commissioning (Cx) process activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies, in accordance with ASHRAE Guideline 0-2005 and ASHRAE Guideline 1.1–2007 for HVAC&R Systems, as they relate to energy, water, indoor environmental quality, and durability.

Requirements for exterior enclosures are limited to inclusion in the owner's project requirements (OPR) and basis of design (BOD), as well as the review of the OPR, BOD and project design. NIBS Guideline 3-2012 for Exterior Enclosures provides additional guidance.

- Develop the OPR.
- Develop a BOD.

The commissioning authority (CxA) must do the following:

- Review the OPR, BOD, and project design.
- Develop and implement a Cx plan.
- Confirm incorporation of Cx requirements into the construction documents.
- Develop construction checklists.
- Develop a system test procedure.

- Verify system test execution.
- Maintain an issues and benefits log throughout the Cx process.
- Prepare a final Cx process report.
- Document all findings and recommendations and report directly to the owner throughout the process.

The review of the exterior enclosure design may be performed by a qualified member of the design or construction team (or an employee of that firm) who is not directly responsible for design of the building envelope.

Commissioning Authority

By the end of the design development phase, engage a commissioning authority with the following qualifications.

- The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy;
- The CxA may be a qualified employee of the owner, an independent consultant, or an employee of the design or construction firm who is not part of the project's design or construction team, or a disinterested subcontractor of the design or construction team.
  - For projects smaller than 20,000 square feet (1 860 square meters), the CxA may be a qualified member of the design or construction team. In all cases, the CxA must report his or her findings directly to the owner.

Project teams that intend to pursue EA Credit Enhanced Commissioning should note a difference in the CxA qualifications: for the credit, the CxA may not be an employee of the design or construction firm nor a subcontractor to the construction firm.

Current Facilities Requirements and Operations and Maintenance Plan

Prepare and maintain a current facilities requirements and operations and maintenance plan that contains the information necessary to operate the building efficiently. The plan must include the following:

- a sequence of operations for the building;
- the building occupancy schedule;
- equipment run-time schedules;
- setpoints for all HVAC equipment;
- set lighting levels throughout the building;
- minimum outside air requirements;
- any changes in schedules or setpoints for different seasons, days of the week, and times of day;
- a systems narrative describing the mechanical and electrical systems and equipment;
- a preventive maintenance plan for building equipment described in the systems narrative; and
- a commissioning program that includes periodic commissioning requirements, ongoing commissioning tasks, and continuous tasks for critical facilities.

DATA CENTERS ONLY

For small projects with computer room peak cooling loads less than 2,000,000 Btu/h (600 kW) or a total computer room peak cooling load less than 600,000 Btu/h (175 kW), the CxA may be a qualified employee of the design or construction team.

BEHIND THE INTENT

The commissioning (Cx) process is an integrated set of activities intended to ensure that the project meets both the design intent and the owner's operational needs. An owner's goals and objectives should drive the project team. The value of Cx lies in its power to verify that those goals and objectives are met and that building systems perform as intended.

A properly executed Cx process clearly expresses the owner's project requirements, often leading to fewer change orders and system deficiencies, fewer corrective actions implemented while contractors are on-site, improved planning and coordination, reduced energy consumption during building operation, and overall lower operating costs. Another potential benefit of Cx is occupants' health and comfort because of better temperature and ventilation control. For a mission-critical facility like a data center, the most significant benefit is the reduced risk of information technology (IT) equipment downtime caused by power or cooling system design or performance issues, faulty installation or calibration, or software programming errors that go undetected until after the building is on line.

The qualified commissioning authority (CxA) chosen to represent the owner's needs should be brought in early in the design process. As a third party, the CxA can verify early on that the architects' and engineers' designs meet the owner's project requirements. During the construction phase, the commissioning team, led by the CxA, will verify that contractors install and program the systems correctly according to the design.

STEP-BY-STEP GUIDANCE

STEP 1. DEVELOP OWNER'S PROJECT REQUIREMENTS

The owner, with the help of the design team and other stakeholders, should develop the initial owner's project requirements (OPR) in the predesign stage (see the Integrative Process Credit and *Further Explanation, Owner's Project Requirements*).

- This document establishes the owner's goals and the building's intended function and operation.
- The owner will use this document as the foundation for all design, construction, acceptance, and operational decisions.
- The OPR must include all systems to be commissioned plus the building envelope, even if full envelope commissioning is not pursued.

STEP 2. DEVELOP BASIS OF DESIGN

Create a basis of design (BOD) to provide clear technical guidance for the project. Start this in the schematic design phase and update it throughout the design and construction process (see *Further Explanation, Basis of Design*).

- The BOD is the project team's interpretation of the OPR.
- Any revisions to the OPR should also be reflected in the BOD so that both documents align.
- The BOD must include all systems to be commissioned plus the building envelope, even if full envelope commissioning is not pursued. The project engineer, architect, structural engineer, and other team members must work together to document building envelope thermal performance, load-bearing capabilities, and construction.

STEP 3. ENGAGE COMMISSIONING AUTHORITY

Identify a CxA with the proper experience and credentials to develop and implement effective commissioning. Though the CxA must be engaged by the design development phase, earlier engagement allows the CxA to be involved in the development of the OPR and BOD and see the design intent through to completion.

- The CxA should have direct experience with at least two similar projects and must have been involved from the early design phase through at least 10 months after occupancy begins (see *Further Explanation, Commissioning Authority Qualifications*).
- CxA requirements differ depending on the scope and size of the project. The project team should engage a CxA that has appropriate qualifications for the goals of the program.

- The CxA will lead, review, and oversee the Cx process for all systems to be commissioned, including both Fundamental and Enhanced commissioning activities if Enhanced Commissioning is pursued (see *Further Explanation, Systems to Be Commissioned*).
- Work with the CxA to determine the systems that need to be commissioned for compliance with the OPR and the credit requirements.

Exception: For projects pursuing Enhanced Commissioning Option 2, envelope commissioning, the building envelope commissioning agent (BeCxA) may be completely independent of the lead CxA, and oversight of envelope commissioning activities by the lead CxA is not required as long as the BeCxA meets all of the enhanced commissioning credit requirements for the Commissioning Authority relative to the envelope systems that will be commissioned.

The use of the phrase “lead, review and oversee” defines a high level of participation while providing some flexibility for fitting the process to the project.

Therefore, at a minimum, the lead commissioning agent should be participating in ALL commissioning activities including BOTH fundamental and enhanced commissioning activities. The exact level of leading, reviewing, and overseeing can vary based on individual project scenarios. However, for enhanced commissioning, the entity selected as the lead CxA must complete the following tasks at a minimum:

Fundamental commissioning tasks to be performed by lead CxA:

- Review owner’s project requirements and basis of design during the early design phase.
- Conduct commissioning design review prior to mid-construction documents.
- Confirm incorporation of Cx requirements into construction documents.
- Develop or approve construction checklists.
- Develop or approve system test procedures.
- Witness at least a portion of the mechanical, electrical, plumbing, and (if applicable) renewable system functional testing that verifies installation and performance of commissioned systems. Refer to ASHRAE Guideline 0 for additional guidance.
- Review an issues log throughout the Cx process. If the CxA does not directly update the log, the CxA must approve all updates to the log on a continuous basis.
- Report findings directly to the owner throughout the process.
- Develop or approve the summary commissioning report.

Enhanced Commissioning Tasks to be performed by lead CxA:

- Review contractor submittals applicable to systems being commissioned.
- Develop or approve systems manual updates and delivery.
- Verify operator and occupant training delivery and effectiveness.
- Perform seasonal testing
- Develop or approve an ongoing commissioning plan
- Develop or approve a monitoring-based commissioning plan
- Review building operation within 10 months after substantial completion.

STEP 4. DEVELOP PRELIMINARY COMMISSIONING PLAN

Establish a preliminary plan for the Cx to outline the scope of commissioning and systems to be tested (see *Further Explanation, Cx Plan*).

- Project roles and responsibilities, the commissioning team’s project directory, and schedule of commissioning activities should all be included in the Cx plan.
- The Cx plan is a living document that is updated throughout the life of the project and will become the basis for the final commissioning report.

STEP 5. REVIEW OPR, BOD, AND DESIGN DOCUMENTS

The CxA completes a review of the OPR, BOD, and design documents to verify that the program’s goals are properly included in the design documents.

- The intent of the review is to have a third party, acting as an advocate for the owner, ensure that the BOD reflects the OPR and that the design documents reflect the BOD and the OPR.
- The review should be conducted on middesign documents so that the project team has time to make any necessary changes.
- Earlier and additional reviews at other project milestones are advisable and often beneficial to project performance but are not required.
- Record the review comments in an issues log that details the drawing set or document version that was used for performing the review (see *Further Explanation, Issues Log*).

STEP 6. DEVELOP CX REQUIREMENTS AND INCORPORATE INTO CONSTRUCTION DOCUMENTS

Before construction begins, develop commissioning requirements based on the systems included in the design and incorporate them into the construction documents.

- Cx specifications inform the contractors of their roles and responsibilities throughout the commissioning process.
- ASHRAE Guideline 0–2005, Table L-1, identifies titles, contents, and scopes for each commissioning-related specification section and may be used as guidance (see *Further Explanation, Example Issues Log*).

STEP 7. UPDATE OPR, BOD, AND CX PLAN

If necessary, the owner should update the OPR, the design team should update the BOD, and the CxA should update the Cx plan. Items such as design changes, value engineering modifications, new or reassigned team members, or updated operating conditions would warrant an update.

STEP 8. CONDUCT CX KICKOFF MEETING

Assemble the team of stakeholders and hold a kickoff meeting to introduce the team members, review roles and responsibilities, and review all remaining Cx activities. The CxA should provide information on the process and requirements for the following:

- Installation verification (construction) checklists
- Functional performance tests
- Issues log
- Team meetings
- Contractors' and subcontractors' participation on the Cx team
- Schedule

The CxA should update and redistribute the Cx plan as necessary. The CxA is also responsible for setting up periodic Cx meetings, developing a communication protocol, and managing the schedule for all Cx-related activities.

STEP 9. DEVELOP CONSTRUCTION CHECKLISTS

The CxA, the design team, or the contactor prepares construction checklists (also known as installation verification checklists and prefunctional checklists) for the project.

- Checklists provide confirmation to the CxA that the systems have been installed, started up, programmed, tested, and balanced, and that the team is ready to proceed with functional testing.
- In general, contractors are responsible for filling out the checklists and returning them to the CxA.
- Construction checklists must be completed for all equipment, assemblies, and systems included in Cx scope. Sampling strategies are not permitted.

STEP 10. CONDUCT PREFUNCTIONAL INSPECTIONS

Communicate with the contractors to determine the exact schedule for prefunctional inspections to verify proper installation and handling of systems to be commissioned. Several activities that can be considered prefunctional inspections include site visits, field observations, and review of start-up forms, construction checklists, and complete test-and-balance reports.

- The CxA may conduct site visits as necessary to inspect the installation of individual systems and components. Site visits are an important opportunity to observe equipment installation and identify issues before a system becomes difficult to access or change.
- It is good practice to document the site visit findings in a field observation report that is distributed to the relevant parties. The CxA should report any noncompliance to the owner and project team for them to help resolve.
- The number of site inspections depends on the project's size and scope.

STEP 11. DEVELOP FUNCTIONAL TEST SCRIPTS

The CxA, with the design team or contractor, must write and develop the functional test scripts for the project.

- Functional testing scripts typically follow the sequence of operations developed by the engineer. If a controls contractor created the sequence of operations, the design engineer must approve the controls submittal to ensure it adheres to the BOD.

- Provide contractors and design engineers with the functional tests before testing to allow them the opportunity to review the scripts, verify proper operating modes, and comment on any modifications to match actual operation (see *Further Explanation, Functional Performance Tests*).

STEP 12. EXECUTE FUNCTIONAL TESTING

Perform functional performance testing once all system components are installed, energized, programmed, balanced, and otherwise ready for operation under part- and full-load conditions.

- Some systems may require deferred or seasonal testing or verification for proper operation in each mode.
- The systems or modes that require seasonal or deferred testing must be noted in the Cx report. A report addendum discusses the deferred testing results can then be issued.
- The functional performance testing follows the functional performance test scripts developed by the CxA in Step 11.
- The CxA generally oversees the testing; the contractors execute the testing.
- Sampling strategies may be implemented for functional testing. An acceptable sampling rate is “10 or 10%,” meaning that for multiple units of the same type with the same components and sequences (e.g., fan coil units or variable air volume systems), the commissioning team may test only 10 units or 10% of the units, whichever is greater.
- When possible, include the building engineer or owner in the testing execution to provide training for future operation of the systems.

STEP 13. DOCUMENT FINDINGS

Use the issues log to track any deficiencies discovered and any benefits identified through functional testing.

- The CxA is responsible for documenting the test results and maintaining the issues log.
- Documentation should include the status and responsible party for the correction or improvement actions.

STEP 14. PREPARE CX REPORT

The CxA should write the Cx report after installation inspections and functional performance test verification. The report covers all components of the commissioning process, including the following:

- Executive summary of commissioning process and results, system deficiencies identified and resolution, and outstanding issues
- Project directory
- Cx process overview
- Owner’s project requirements
- Basis of design
- Submittals
- Design review log
- Cx specifications
- List of systems commissioned
- Installation verification checklists
- Functional performance tests
- Issues log, detailing open and closed issues

STEP 15. COMPILE CURRENT FACILITY REQUIREMENTS AND OPERATIONS AND MAINTENANCE PLAN

Prepare and maintain a current facility requirements (CFR) and operations and maintenance (O&M) plan that contains the information necessary to operate the building efficiently. This information is covered in the OPR, BOD, and functional test scripts, but more information may be taken from specific submittals or equipment operations and maintenance manuals. The plan must include the following:

- Sequences of operation for the building
- Building occupancy schedule
- Equipment run-time schedules
- Setpoints for all HVAC equipment
- Lighting levels throughout the building
- Minimum outside air requirements
- Changes in schedules or setpoints for different seasons, days of the week, and times of day

- Systems narrative describing the mechanical and electrical systems and equipment
- Preventive maintenance plan for building equipment described in the systems narrative
- Cx program that includes periodic Cx requirements, ongoing Cx tasks, and continuous tasks for critical facilities

FURTHER EXPLANATION

SYSTEMS TO BE COMMISSIONED

The rating system refers to commissioning of HVAC&R systems "as they relate to energy, water, indoor environmental quality, and durability." That is, energy- and water-consuming equipment must operate efficiently and according to the design intent and owner's operational needs.

Efficient operations can be defined as the controlling of equipment such that it uses the minimum amount of energy or water to maintain setpoints and comfort levels. Control is generally accomplished via a building automation system and per the sequences of operation, with setpoints that are correct for the design and equipment schedules.

For indoor environmental quality, the equipment must meet the OPR, BOD, and environmental codes and standards. For durability, the equipment must not cause unnecessary wear and tear on the system.

Systems that must be commissioned for this prerequisite include the following:

- Mechanical, including HVAC&R equipment and controls
- Plumbing, including domestic hot water systems, pumps, and controls
- Electrical, including service, distribution, lighting, and controls, including daylighting controls
- Renewable energy systems

The envelope must be covered in the OPR and BOD, but full envelope commissioning is not required unless the project team pursues EA Credit Enhanced Commissioning, Option 2.

Systems that are not required to be commissioned under this prerequisite but may be added to the Cx scope at the request of the owner include the following:

- Envelope
- Life safety systems
- Communications and data systems
- Fire protection and fire alarm systems
- Process equipment

COMMISSIONING AUTHORITY (CXA) QUALIFICATIONS

The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy. The similar scope of work may be defined by the size of building, the types of equipment being commissioned, or the function of the space. However, the appropriate or acceptable level of "similar experience" should be defined by the owner. Examples include the following:

- New construction commercial building, less than 100,000 square feet (9 290 square meters), with direct expansion rooftop units.
- New construction commercial building, more than 100,000 square feet (9 290 square meters), with built-up air-handling units and chilled water central plant.
- New construction school, less than 100,000 square feet (9 290 square meters), with mixed-mode ventilation and steam boilers.
- New construction refrigerated warehouse with ammonia chillers for process cooling, solar thermal domestic hot water heating, photovoltaic solar panels and commercial-grade wind turbine.

If the project is pursuing fundamental commissioning only, the CxA may be a qualified employee of the owner, an independent consultant, an employee of the design or construction firm who is not part of the project's design or construction team, or a disinterested subcontractor of the design or construction team. Special circumstances include the following:

- For projects smaller than 20,000 square feet (1 860 square meters), the CxA may be a qualified member of the design or construction team.
- If specialized knowledge of specific systems is required (e.g., manufacturing, data centers), the CxA may be a qualified employee of the design or construction team, provided the project has a computer room peak cooling load of less than 2,000,000 Btu/h (600 kW) or a total computer room peak cooling load less than 600,000 Btu/h (175 kW).
- If an owner requires a single contract through one entity (such as a government agency contracting through a general contractor), the CxA may be a qualified employee of the design or construction team for this prerequisite. If the project team is also attempting the enhanced commissioning credit, however, the CxA must be independent of the design or construction firm.

In all cases, the CxA must report findings directly to the owner.

TABLE 1. Who can be the CxA?

Can ...	who is ...	be CxA for ...	
		fundamental Cx?	enhanced Cx?
an employee of the architecture or engineering firm	a member of the design team (e.g., a project architect, engineer, or energy modeler who is also the HVAC designer)	No, unless project is under 20,000 ft^2 (1 860 m^2)	No
	not a member of the design team (e.g., a LEED administrator or energy modeler who is not participating in the design)	Yes	No
a subconsultant to the architecture or engineering firm	a member of the design team (e.g., a project engineer subcontracted to the architect)	No, unless project is under 20,000 ft^2 (1 860 m^2)	No
	not a member of the design team (e.g., a LEED administrator, Cx specialist, energy modeler)	Yes	Yes
an employee or subcontractor of the general contractor or construction manager	a member of the construction team	No, unless project is under 20,000 ft^2 (1 860 m^2)	No
	not a member of the construction team	Yes	No
an employee of the owner or an independent consultant contracted to the owner		Yes	Yes

OWNER'S PROJECT REQUIREMENTS

The owner, CxA, and project team must complete the OPR before any contractor submittals for Cx equipment or systems are approved. Ideally, the initial document is completed at the early stages of predesign. Updates during the design and construction process are the primary responsibility of the owner.

The OPR details the functional requirements as well as the expectations of the building's use and operation. The intention is to document the owner's requirements and objectives for the project to verify that those goals are carried through the life of the project. There is no required format; an OPR outline might include the following:

- **Key project requirements.** Items that the Cx process will focus on and that the owner has deemed critical to the project.
- **Occupant requirements.** Functions, number of occupants, and schedules for the building.
- **Budget considerations and limitations.** The expected cost restrictions and considerations for the project's design, construction, and commissioning process.

- **Target goals.** The owner's overall goals, such as energy efficiency and sustainability.
- **Performance criteria.** The standards by which the project will be evaluated by the Cx team. Each criterion should be measurable and verifiable. Potential topics include general, economic, user requirements, construction process, operations, systems, and assemblies.
- **Operations and maintenance requirements**. Established criteria for ongoing operations and maintenance, as well as training requirements for personnel.

BASIS OF DESIGN

The design team must document the basis of design before any contractor submittals for commissioned equipment or systems are approved. Updates during the design and construction process are the primary responsibility of the design team.

The BOD explains how the construction and other details will execute the OPR. The intention is to document the thought processes and assumptions behind design decisions made to meet the OPR. There is no required format; a BOD outline might include the following:

- **Systems and assemblies.** A general overview of the systems and assemblies and how they are intended to meet the OPR.
- **Performance criteria and assumptions**. The standards that the system was designed to meet and the expectations regarding system operation and maintenance, both linked to the OPR.
- **Descriptions.** A description of the general building, envelope, HVAC, electrical, water, and other systems, and a statement of operation that describes how the facility is expected to operate under various situations and modes.
- **Governing codes and standards.** Specific codes, standards, and guidelines considered during the design of the facility and the designer's response to these requirements.
- **Owner directives.** Assumptions regarding usage of the facility.
- **Design development guidelines.** Concepts, calculations, decisions, and product selections; the specific design methods, techniques, and software used in design; information regarding ambient conditions (climatic, geologic, structural, existing construction) used during design; and specific manufacturer makes and models used as the basis of design for drawings and specifications.
- **Revision history.** A summary of changes made throughout the project phases.

CX PLAN

The commissioning team develops the Cx plan with input from the project team. Updates during the design and construction process are the primary responsibility of the CxA.

The Cx plan begins with a program overview:

- Goals and objectives
- General project information
- Systems to be commissioned

It describes the Cx team:

- Team members, roles, and responsibilities
- Communication protocol, coordination, meetings, and management

Finally, it summarizes the Cx process activities:

- Reviewing the OPR
- Reviewing the BOD
- Developing systems functional test procedures
- Verifying system performance
- Reporting deficiencies and the resolution process
- Accepting the building systems

ISSUES LOG FOR THE DESIGN REVIEW

It is useful to include the following information in the design review issues log:

- Date of the review
- Drawing number or page where the issue was found
- Comments
- Party responsible for addressing the issue
- Response
- Date the issue was closed

FUNCTIONAL PERFORMANCE TESTS

The functional performance test reports typically have the following sections:

- **Date and time of test**
- **Individuals present during testing**
- **Visual inspection observations.** Before testing, the CxA should perform a visual inspection and document any issues or relevant observations.
- **Sensor checks.** The sensors are checked individually to make sure they are reading properly and are in the correct locations, per the design documents.
- **Device checks.** Each device is checked to verify that it can open, close, modulate, start, stop, energize in stages, etc.
- **Operating mode tests.** A system is run through each type of operating mode including but not limited to start up, shutdown, capacity modulation, emergency and failure modes, alarm scenarios, occupied mode and unoccupied mode, and interlocks with other equipment.
- **Results.** Indicate whether the system passed, failed, or requires retesting.

PROJECT TYPE VARIATIONS

Data Centers

Select a CxA who meets the credit requirements for commissioning data centers.

The OPR should address the overall energy efficiency goals of the project, including the partial- and full-load power usage effectiveness (PUE). Information on how the data center will be operated and by whom will help ensure quality operation of complex systems. Clear and concise documentation of the BOD—including the cooling systems' level of power, redundancy, reliability, and ability to support data center operations and energy efficiency during preventive or unscheduled maintenance—will help the CxA evaluate performance.

PUE should be evaluated at both start-up and full-load conditions, to correspond to modeled performance. Critical equipment should be tested in both normal and failure modes. Include this information in the final commissioning report. A wide variety of methods may be used to simulate and evaluate whether the system performs as expected. For data centers, it is highly recommended that partial- and full-load testing use commercially available heaters specifically designed for this purpose, to simulate the actual IT equipment's heat load.

District Energy Systems

All downstream equipment is included in the scope of this prerequisite. Such equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls. All upstream equipment is excluded from the scope of this prerequisite.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible.

TABLE 2. Example Issues Log

LEED design review of commissioned systems				
Mechanical				
Comment number	**Sheet**	**Comment**	**Design team response**	**Final review comment, status**
M-1	01M-0.0	LEED EA Credit Advanced Energy Metering is being pursued. Verify proper metering devices are installed.	Metering equipment is being installed to monitor (on floor-by-floor basis) lighting, HVAC, computer power, water heating. We will also be installing water meter on main domestic water line and on cooling tower makeup line. Additionally, building already has monitoring for VFDS, chiller efficiency, cooling load, economizer cycles, static pressures, OA volumes, and process energy systems.	
M-2	BOD	BOD discusses using demand-controlled ventilation in conference rooms as well as return ducts to "monitor" outside air for each floor to comply with ASHRAE 62.1. Clarify how "monitoring" of outside air is achieved and how it's going to be reset based on demand.	Central outside air riser supplies floor-by-floor VAV boxes that measure outside air delivery via integral flow measurement. See comment 4 below for sequence of operation.	
M-3	08M-2.0	Note 4 indicates, "install CO_2 sensors per LEED EQ Credit Enhanced Indoor Air Quality Strategies" but BOD states that CO_2 sensors will be used to maintain ASHRAE 62.1. Note 4 also states that CO_2 levels must be maintained at 400 ppm or less in most critical zone. ASHRAE 62.1 allows for CO_2 levels to be controlled up to 1400 ppm or more depending on type of space. Codes sometimes restrict this down to 1000 ppm. Should include EQ credit requirements under specification section. "Maximum allowable CO_2 levels" should be defined.	New CO_2 sensors for high-occupancy spaces along with existing return air CO_2 sensors will be monitored by BAS. If any zone rises to more than 700 ppm above 400 ppm ambient CO_2 threshold, OA damper will be opened in stages with appropriate time delays using PID control to satisfy critical zone CO_2 setpoint. We will add this credit to sustainable design requirements listing.	
E-1	01E-2.0	No lighting controls, including occupancy sensors or daylight sensors, appear to be provided for lobby. BOD indicates that all lighting within perimeter will have daylight sensors and step dimming. Clarify how this lighting will be controlled.	Design intent is to provide daylight sensors and step dimming. Design documents will be modified to reflect this.	
P-1	BOD	LEED criteria for sink faucet do not match description of SK-1 or SK-2.	Will update document.	
P-2	BOD	SH-1 and SH-1A identified in BOD were not included on plumbing drawings.	Will be included in later design as required.	

REQUIRED DOCUMENTATION

Documentation	All projects
CxA previous experience	X
Confirmation of OPR and BOD contents	X
List of systems to be commissioned	X
Verification of CxA activities and reviews	X
Cx plan	X
Documentation of testing and verification	X
CFR, O&M plan	X
Cx report	X

RELATED CREDIT TIPS

Integrative Process Credit. Early analysis of energy- and water-related systems can affect site parameters, programming, geometry, envelope and façade treatments, HVAC capacities and quantities, lighting control strategies, landscape irrigation design, or fixture specifications. The related credit can inform the OPR, BOD, and design documents.

EA Credit Advanced Energy Metering. Meeting the related credit requirements will help projects teams achieve the ongoing commissioning portions of this prerequisite.

EA Credit Renewable Energy Production. Renewable energy systems installed on-site must be commissioned under this prerequisite.

EA Credit Enhanced Commissioning. If a project team wishes to pursue Enhanced Commissioning, confirm that the CxA chosen for this prerequisite is appropriate. Additionally, since this prerequisite's fundamental commissioning activities and documents include the building envelope (one component of enhanced commissioning), teams may find it feasible to pursue the related credit.

CHANGES FROM LEED 2009

- LEED v4 now requires the CxA to be engaged before the design development phase is complete.
- The electrical and plumbing scopes have been expanded.
- Elements of envelope commissioning are now incorporated in the OPR and BOD.
- One design review and one operations and maintenance plan are now required.

REFERENCED STANDARDS

ASHRAE Guideline 0–2005, The Commissioning Process: ashrae.org

ASHRAE Guideline 1.1–2007, HVAC&R Technical Requirements for the Commissioning Process: ashrae.org

NIBS Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process: wbdg.org/ccb/NIBS/nibs_gl3.pdf

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

basis of design (**BOD**) the information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines

commissioning (**Cx**) the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements

commissioning authority (**CxA**) the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

downstream equipment the heating and cooling systems, equipment, and controls located in the project building or on the project site and associated with transporting the thermal energy of the district energy system (DES) into heated and cooled spaces. Downstream equipment includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

operations and maintenance (**O&M**) **plan** a plan that specifies major system operating parameters and limits, maintenance procedures and schedules, and documentation methods necessary to demonstrate proper operation and maintenance of an approved emissions control device or system

owner's project requirements (**OPR**) a written document that details the ideas, concepts, and criteria determined by the owner to be important to the success of the project

systems manual provides the information needed to understand, operate, and maintain the systems and assemblies within a building. It expands the scope of the traditional operating and maintenance documentation and is compiled of multiple documents developed during the commissioning process, such as the owner's project requirements, operation and maintenance manuals, and sequences of operation.

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE PREREQUISITE

Minimum Energy Performance

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, HEALTHCARE, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

OPTION 1. WHOLE-BUILDING ENERGY SIMULATION

Demonstrate an improvement of 5% for new construction, 3% for major renovations, or 2% for core and shell projects in the proposed building performance rating compared with the baseline building performance rating. Calculate the baseline building performance according to ANSI/ASHRAE/IESNA Standard 90.1–2010, Appendix G, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), using a simulation model.

Projects must meet the minimum percentage savings before taking credit for renewable energy systems.

The proposed design must meet the following criteria:

- compliance with the mandatory provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.);
- inclusion of all energy consumption and costs within and associated with the building project; and
- comparison against a baseline building that complies with Standard 90.1–2010, Appendix G, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

Document the energy modeling input assumptions for unregulated loads. Unregulated loads should be modeled accurately to reflect the actual expected energy consumption of the building.

If unregulated loads are not identical for both the baseline and the proposed building performance rating, and the simulation program cannot accurately model the savings, follow the exceptional calculation method (ANSI/ASHRAE/IESNA Standard 90.1–2010, G2.5). Alternatively, use the COMNET Modeling Guidelines and Procedures to document measures that reduce unregulated loads.

RETAIL ONLY

For Option 1, Whole-Building Energy Simulation, process loads for retail may include refrigeration equipment, cooking and food preparation, clothes washing, and other major support appliances. Many of the industry standard baseline conditions for commercial kitchen equipment and refrigeration are defined in Appendix 3, Tables 1–4. No additional documentation is necessary to substantiate these predefined baseline systems as industry standard.

OR

OPTION 2. PRESCRIPTIVE COMPLIANCE: ASHRAE 50% ADVANCED ENERGY DESIGN GUIDE

Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

Comply with the HVAC and service water heating requirements, including equipment efficiency, economizers, ventilation, and ducts and dampers, in Chapter 4, Design Strategies and Recommendations by Climate Zone, for the appropriate ASHRAE 50% Advanced Energy Design Guide and climate zone:

- ASHRAE 50% Advanced Energy Design Guide for Small to Medium Office Buildings, for office buildings smaller than 100,000 square feet (9 290 square meters);
- ASHRAE 50% Advanced Energy Design Guide for Medium to Large Box Retail Buildings, for retail buildings with 20,000 to 100,000 square feet (1 860 to 9 290 square meters);
- ASHRAE 50% Advanced Energy Design Guide for K–12 School Buildings; or
- ASHRAE 50% Advanced Energy Design Guide for Large Hospitals. Over 100,000 square feet (9 290 square meters)

For projects outside the U.S., consult ASHRAE/ASHRAE/IESNA Standard 90.1–2010, Appendixes B and D, to determine the appropriate climate zone.

OPTION 3. PRESCRIPTIVE COMPLIANCE: ADVANCED BUILDINGS™ CORE PERFORMANCE™ GUIDE

Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.1-2010, with errata (or USGBC approved equivalent standard for projects outside the U.S.).

Comply with Section 1: Design Process Strategies, Section 2: Core Performance Requirements, and the following three strategies from Section 3: Enhanced Performance Strategies, as applicable. Where standards conflict, follow the more stringent of the two. For projects outside the U.S., consult ANSI/ASHRAE/IESNA Standard 90.1-2010, Appendixes B and D, to determine the appropriate climate zone.

3.5 Supply Air Temperature Reset (VAV)
3.9 Premium Economizer Performance
3.10 Variable Speed Control

To be eligible for Option 3, the project must be less than 100,000 square feet (9 290 square meters).

Note: Healthcare, Warehouse or Laboratory projects are ineligible for Option 3.

DATA CENTERS

Whole-Building Energy Simulation
Demonstrate a 5% improvement in the proposed performance rating over the baseline performance rating. To determine total energy cost savings, create two models, one for building energy cost and the other for IT equipment energy cost. Calculate the baseline building performance according to ANSI/ASHRAE/IESNA Standard 90.1–2010, Appendix G, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), using a simulation model for the whole building and data center modeling guidelines.

Determine the power utilization effectiveness (PUE) value of the proposed design.

For this prerequisite, a minimum of 2% of the 5% energy savings must come from building power and cooling infrastructure.

Projects must meet the minimum percentage savings before taking credit for renewable energy systems.

The proposed design must meet the following criteria:

- compliance with the mandatory provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.);
- inclusion of all energy consumption and costs within and associated with the building project; and
- comparison against a baseline building that complies with ANSI/ASHRAE/IESNA Standard 90.1–2010, Appendix G, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), and data center modeling guidelines.

For data centers, regulated energy includes cooling units for computer and data processing rooms, critical power conditioning equipment, critical distribution equipment, heat rejection plants, and mechanical and electrical support rooms.

Include in process loads both the unregulated load and the IT equipment load. The IT load comprises critical systems and electrical power transformation, which may include servers, storage and networking power use, and operations affecting monthly server CPU utilization percentages.

Develop two sets of IT load models using two scenarios, one at the maximum estimated IT load rating and the second at the startup IT rating expected at the time of commissioning.

Document the energy modeling input assumptions for unregulated loads. Unregulated loads should be modeled accurately to reflect the actual expected energy consumption of the building.

If unregulated loads are not identical for both the baseline and the proposed building performance rating, and the simulation model cannot accurately model the savings, follow the exceptional calculation method (ANSI/ASHRAE/IESNA Standard 90.1–2010, G2.5) to document measures that reduce unregulated loads.

BEHIND THE INTENT

An optimized building design can substantially reduce energy use—often for a modest initial cost with a short payback period—when it includes load reduction, improved mechanical system efficiency, and smart operational strategies. An integrated building design can lower operating and maintenance costs and improve indoor air quality, thermal comfort, and access to daylight. Either a prescriptive or a performance approach may be used to attain such results.

A simplified, prescriptive approach—applicable to smaller buildings and certain building types, such as offices, retail stores, and schools—presents a limited set of system choices with mandatory performance characteristics. Best suited to projects with smaller budgets, straightforward design, and packaged equipment, the prescriptive approach provides energy-saving guidance for many simple buildings with typical energy systems. Not all projects will be eligible for a prescriptive approach, which can be inflexible, given that all listed requirements must be achieved to attain the prerequisite. Two prescriptive options are available, depending on building size and other factors.

Alternatively, the performance path offers a more flexible, tailored way to evaluate the interactive effects of efficiency measures. This option uses energy modeling to simulate the energy performance of the building as a whole. Design teams can then assess complex systems and make efficiency trade-offs among systems and components that the prescriptive options do not allow.

Partnering with the design team, qualified energy modelers can interpret the results of these complicated analyses to maximize the benefits to the project. When initiated early in the design process, an energy simulation serves as a design tool instead of a compliance check. One of the greatest benefits of early energy modeling is better integration of interrelated design issues, which encourages dialogue about assumptions concerning building components and systems. Information on energy use and costs thereby plays a bigger role as design decisions are made.

ASHRAE 90.1–2010 was chosen as the standard on which to base the requirements because it continues to push building design toward greater energy efficiency. Specifically, a study by the U.S. Department of Energy showed an average improvement of 18% across all building types[1] when ASHRAE 90.1–2010 was applied instead of ASHRAE 90.1–2007.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE CLIMATE ZONE

Identify the project's climate zone according to ASHRAE 90.1–2010, Appendix B (see *Further Explanation, Climate Zone Determination*).

STEP 2. REVIEW AND ADDRESS ASHRAE MANDATORY REQUIREMENTS

Early in the design process, review the mandatory provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.). Read through Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 to understand how the building design must respond to these requirements.

- Typically, the architect is responsible for Section 5.4, Building Envelope; the mechanical engineer and plumbing designer are responsible for Sections 6.4, HVAC, and 7.4, Service Water Heating; and the electrical engineer is responsible for Sections 8.4, Power, and 9.4, Lighting. Compliance with Section 10.4 requires coordination across multiple disciplines.
- Ensure that the project complies with the mandatory measures throughout the design, construction, and commissioning process, particularly when major design decisions are implemented.
- Confirm that compliant components are included in the final construction documents.

1. *ANSI/ASHRAE/IES 90.1–2010 Final Determination Quantitative Analysis, p. 29, https://www.energycodes.gov/sites/default/files/documents/BECP_Final QuantitativeAnalysisReport901-2010Determination_Oct2011_v00.pdf* (accessed July 11, 2014).

STEP 3. IDENTIFY ENERGY USE TARGET FOR BUILDING

Set an energy goal for the project early in the design process. Identifying an energy goal can help prioritize efficiency strategies, integrate systems, reduce first costs, and improve building performance.

- For EA Prerequisite Minimum Energy Performance, Option 3, the energy performance target must be established using ENERGY STAR's Target Finder and must be greater than a score of 90.
- For EA Credit Optimize Energy Performance, the target must be established as energy use intensity (EUI) in kBtu per square foot-year (kWh per square meter-year) of source energy use.
- Consider using ENERGY STAR's Target Finder to develop the EUI goal that will meet the credit requirements.

STEP 4. SELECT ONE OPTION

Select the appropriate option for the project (see *Further Explanation, Selecting an Option*). Review the requirements for EA Credit Optimize Energy Performance before making a selection, and consult Figure 1.

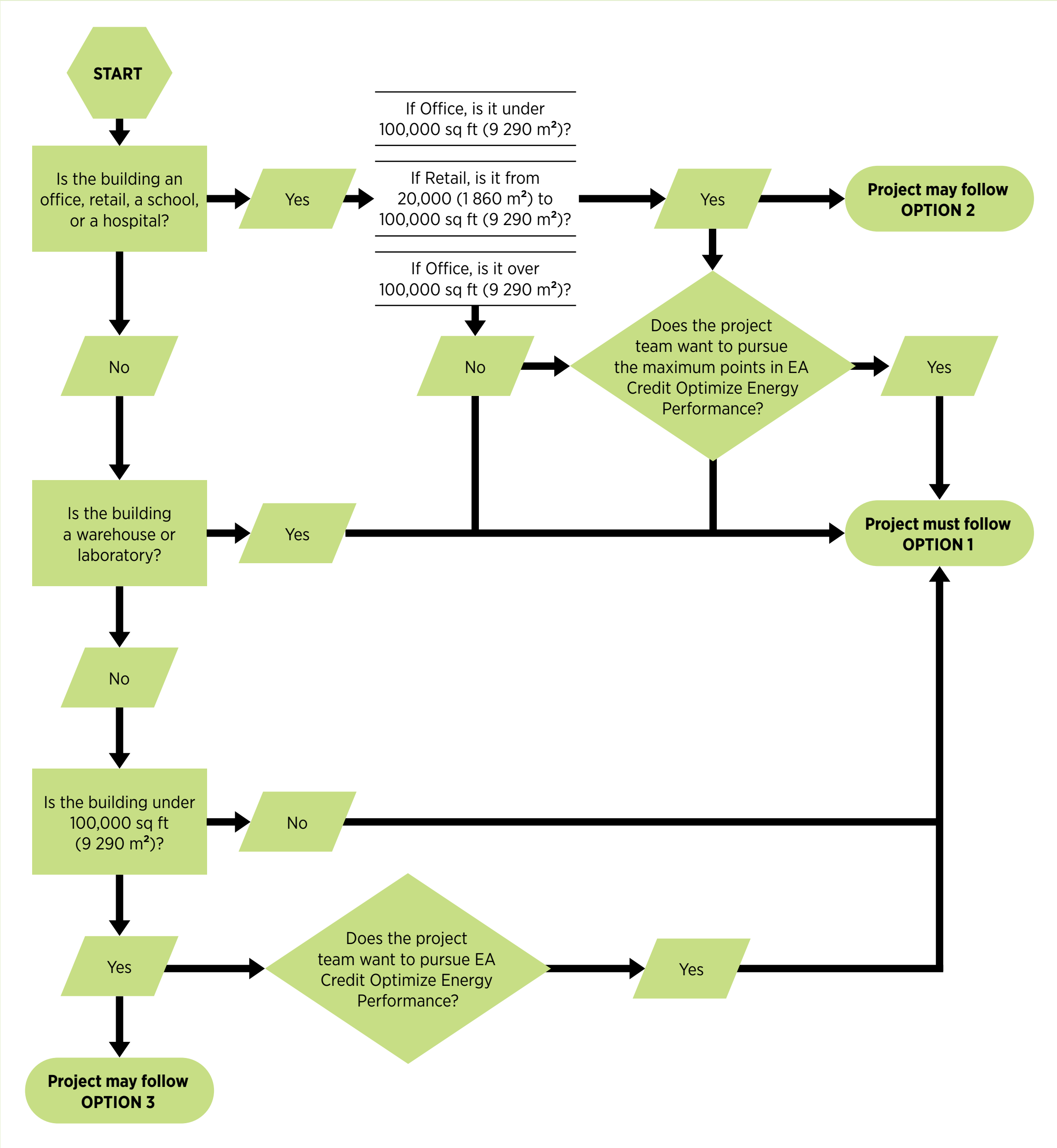


Figure 1. Selecting option

- Option 1 is available to all projects. Consider this option if the project team wants to continually review the energy effects of design decisions, or if the team is pursuing EA Credit Optimize Energy Performance, since energy modeling makes the project eligible to earn more points.
    - Select Option 1 if the building or building systems are complex and cannot comply with standard prescriptive requirements.
    - Select Option 1 if the project includes on-site renewable energy and intends to use the energy produced for additional points in EA Credit Optimize Energy Performance.
- Option 2 is for projects that have minimal opportunity or no need for unique designs and systems, beyond the simple upgrades to mechanical, envelope, and lighting systems that are listed in the ASHRAE prescriptive components. Under this option, project teams will use ASHRAE 50% Advanced Energy Design Guide (AEDG) for HVAC and service water-heating systems. Project teams may pursue a limited number of points under EA Credit Optimize Energy Performance. The eligible project types for Option 2 include the following:
    - Small to medium office buildings, less than 100,000 square feet (9 290 meters)
    - Medium to large box retail buildings, 20,000 to 100,000 square feet (1 860 to 9 290 square meters)
    - School buildings, any size
    - Large hospitals, more than 100,000 square feet (9 290 square meters)
- Option 3 uses the Advanced Buildings™ Core Performance™ Guide and offers an alternative for projects that are less than 100,000 square feet (9 290 square meters) and not a school, healthcare, warehouse, or laboratory. The Core Performance Guide requires that the project comply with prescriptive criteria and also demonstrate that a process is in place for considering energy efficiency alternatives early in the design phase. Projects that use Option 3 cannot achieve points under EA Credit Optimize Energy Performance.

Option 1. Whole-Building Energy Simulation

STEP 1. REVIEW PREREQUISITE AND CREDIT REQUIREMENTS

Thoroughly review the criteria and referenced standards for both EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance before beginning the simulation.

- The prerequisite and credit are integrally linked. Teams that intend to pursue the credit should focus on the expanded scope necessary for credit achievement.
- Buildings that meet the requirements for earning points under the credit, including mandatory requirements and excluding any credits from renewable energy, automatically achieve the prerequisite.
- Review the Integrative Process Credit to identify the requirements for concept-level energy modeling.

STEP 2. IDENTIFY ENERGY MODELER

Engage an energy modeler to perform the energy analysis.

- It is recommended that the qualifications of the energy modeler be carefully reviewed to ensure that the simulation will be performed accurately and according to the prerequisite requirements.
- Qualified energy modelers who have experience with numerous simulations for a variety of building types can help the design team interpret the results to develop an efficient building design (see *Further Explanation, Energy Modeler Qualifications*).

STEP 3. DEVELOP PRELIMINARY ENERGY MODEL

Consider creating preliminary energy models to analyze building design configuration and heating and cooling load reduction strategies. The preliminary models use information from the design to create a rough projection of energy usage in various scenarios (see *Further Explanation, Developing a Preliminary Energy Model*).

- A preliminary energy model is not required; however, developing an early model of the proposed design will help the design team explore the energy consequences of design options and will provide an early estimate of energy performance.
- An analysis of various efficiency measures, which may take the form of a preliminary model, is necessary for the achievement of the related credit.

- When evaluating energy usage in different scenarios, consider strategies for lighting and daylighting, envelope, orientation, and passive conditioning and ventilating systems, in terms of projected energy savings and capital costs as they relate to all building systems. If pursuing the Integrative Process Credit, evaluate these parameters at a concept level early in design.

STEP 4. MODEL POTENTIAL HVAC SYSTEM TYPES

After building design configuration and load reduction strategies have been assessed and implemented, use the energy model to analyze the performance of HVAC system alternatives for the project (see *Further Explanation, Modeling HVAC Systems*).

- For best HVAC system performance, ensure that the system is properly sized. More effective system types, such as radiant heating and cooling or displacement ventilation, may be feasible when the loads are smaller, so begin the analysis by exploring ways to reduce the load.
- Analysis of HVAC systems in early design is optional for this prerequisite but is required for achievement of the related credit.

STEP 5. DEVELOP ENERGY MODEL FOR PROPOSED DESIGN

Once the HVAC system and other design parameters are established, build or update the proposed building energy model to reflect the anticipated design (see *Further Explanation, Building the Proposed Energy Model*).

- Update the proposed model to reflect changes that occur throughout the design process to optimize energy performance and assist with design decisions.
- Ensure that all efficiency strategies are analyzed well before design documents are finalized.

STEP 6. CREATE BASELINE ENERGY MODEL

Build a baseline model that reflects the minimum requirements according to ASHRAE 90.1–2010, Appendix G (see *Further Explanation, Building the Baseline Energy Model*).

- When modifications are made to the proposed energy model, update the baseline accordingly.
- Consider constructing the baseline model early in the design process so that the design team can see the effect of design changes on the percentage savings relative to ASHRAE 90.1. This will contribute toward achieving more points under the related credit.
- Use the energy modeling inputs and quality control checklists spreadsheet (Appendix G) to help create the baseline model. This tool was designed to help project teams create a baseline model in alignment with Appendix G requirements.

STEP 7. UPDATE BASELINE AND PROPOSED MODELS BASED ON FINAL DESIGN

Update the proposed energy model to reflect final construction details and specifications and make any necessary corresponding updates to the baseline model (see *Further Explanation, Finalizing the Energy Models*).

- For elements or systems that cannot be readily modeled by the software, use the exceptional calculation method or COMNET modeling guidelines for unregulated loads (see *Further Explanation, Exceptional Calculation Method* and *Common Issues with Energy Modeling*).

STEP 8. DETERMINE ENERGY COST SAVINGS

Compare the proposed model with the baseline model to determine the anticipated energy cost savings (see *Further Explanation, Energy Cost Savings*).

- Ensure compliance with the prerequisite criteria for energy savings based on the building type (i.e., new construction, major renovation, or core and shell).
- Energy costs offset by on-site renewable energy systems do not count toward energy savings for compliance with the prerequisite. Renewable energy may be included in the model for achievement of points under the related credit.

Option 2. Prescriptive Compliance: ASHRAE 50% Advanced Energy Design Guide

STEP 1. SELECT APPROPRIATE GUIDE AND ENSURE AREA REQUIREMENTS ARE MET

Choose the appropriate building type (office, retail, school, or hospital) from the ASHRAE 50% Advanced Energy Design Guides (AEDG) and review the area requirements. If the project does not meet both building type and size criteria, the team must select Option 1 or Option 3.

STEP 2. ASSESS ASHRAE PRESCRIPTIVE REQUIREMENTS

Work with the architect and engineers to assess the prescriptive requirements of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.) and ensure that the design will comply with envelope, HVAC, service water-heating, and lighting requirements, per Sections 5.5, 6.5, 7.5, and 9.2.2.

The ASHRAE 90.1–2010 prescriptive requirements should not be confused with the requirements of the AEDGs. Although projects must meet only the HVAC and service water-heating prescriptive requirements of the applicable AEDG to earn this prerequisite, all the ASHRAE 90.1–2010 prescriptive requirements must be met, including building envelope, HVAC, service water heating, and lighting.

- Ensure that the lighting calculations include all task lighting except where specifically exempted by ASHRAE 90.1, and appropriately account for the total luminaire wattage for each fixture consistent with ASHRAE 90.1 requirements. Note that the luminaire wattage is not necessarily the sum of the lamp wattages but accounts for the ballast factor (standard luminaires) and the total circuit power or current-limited power (track lighting).

STEP 3. ASSESS HVAC AND SERVICE WATER HEATING EQUIPMENT PRESCRIPTIVE REQUIREMENTS

Work with the mechanical and plumbing engineer to ensure that the project's HVAC and service water-heating equipment will meet all the prescriptive requirements of the applicable AEDG. Specify qualifying equipment in the construction documents.

- The HVAC scope includes equipment efficiency, economizers, ventilation, and ducts and dampers as discussed in AEDG, Chapter 4, Design Strategies and Recommendations by Climate Zone.
- Consider the capacity needs for the project and identify potential equipment that will meet those requirements. AEDG does not address some types and sizes of equipment, and these constraints may make certain equipment inappropriate for the project.
- As a best practice, use the AEDG compliance checklists to track the requirements, review this list with the project team, and include these requirements in the OPR (see EA Prerequisite Fundamental Commissioning and Verification).
- Once the design is complete, a project that cannot meet all AEDG requirements will find it difficult to switch to Option 1 or Option 3; therefore, these requirements should be established early in design.

STEP 4. CONFIRM THAT CREDIT CRITERIA WILL BE MET, IF APPLICABLE

If the project team is planning to achieve points under the related credit, consider the appropriate additional AEDG requirements. Points are available for complying with additional requirements not included in this prerequisite (see EA Credit Optimize Energy Performance, Option 2).

Option 3. Prescriptive Compliance: Advanced Buildings™ Core Performance™ Guide

STEP 1. ASSESS ASHRAE PRESCRIPTIVE REQUIREMENTS

Work with the design team to understand the prescriptive requirements of ANSI/ASHRAE/IESNA Standard 90.1–2010 to ensure that the design will comply. This also includes Sections 5.5 (envelope), 6.5 (HVAC), 7.5 (service water heating), and 9.2.2 (lighting).

STEP 2. REVIEW REQUIREMENTS IN SECTION 1, DESIGN PROCESS STRATEGIES

Develop an implementation strategy for achieving the requirements for Section 1, Design Process Strategies, as outlined in the Core Performance Guide (CPG).

- Consider the scheduling necessary to accommodate additional meetings and design time during the design process.
- Consider the scheduling and resource implications of postconstruction activities, such as system verification, operator training and documentation, and ongoing measurement.
- Projects that select Option 3 must meet all criteria listed in Section 1 of the CPG. Many of these criteria are components of other credits and prerequisites. Sections 1.2, 1.3, 1.5, and 1.6, for example, are addressed elsewhere in the rating system and are therefore not described here.
- For Sections 1.2, 1.5, and 1.6, see EA Prerequisite Fundamental Commissioning and Verification and EA Credit Enhanced Commissioning.
- For Section 1.3, see the Integrative Process Credit.

STEP 3. DISCUSS CPG REQUIREMENTS AND IMPLEMENTATION IN DESIGN TEAM MEETINGS

Engage the design team in discussions about meeting the requirements of all three sections of the CPG, implementing strategies for achieving the ENERGY STAR Target Finder goal, and documenting the process to ensure that the design intent is clearly communicated.

STEP 4. REVIEW PRESCRIPTIVE REQUIREMENTS

Starting early in the design process, review the required prescriptive elements outlined in Section 2, Core Performance Requirements, and the three required elements from Section 3, Enhanced Performance Strategies. Consider alternatives for lighting, HVAC, envelope, and water-heating systems

Engage appropriate design team members to confirm compliance with each prescriptive criterion. Projects must meet all prescriptive requirements.

- Consider the effects of continuous air barriers, below-grade exterior insulation, and enhanced economizer operation as well as common upgrades, such as improved insulation for walls, roofs, and windows.
- In addition to meeting the requirements of the CPG, projects must meet all local energy code requirements or the prescriptive requirements of ASHRAE 90.1–2010, whichever is more stringent.

STEP 5. ANALYZE PASSIVE AND ACTIVE ENERGY LOAD REDUCTION OPPORTUNITIES

As described in Section 1 of the CPG, as part of design development, analyze at least three alternative building configurations to maximize passive reduction of building energy loads. When a preferred configuration has been selected, perform an analysis of the mechanical systems.

- Undertake and document load calculations. Consider referencing ASHRAE 55 to identify thermal comfort design conditions.
- In the first iteration of load calculations, include fan-sizing calculations based on zone-by-zone loads.
- Perform a second set of load calculations using part-load conditions. Describe features of the design that will enable efficient operation at these conditions.
- Document the passive and active analyses and calculations according to Sections 1.3 and 1.4 of the CPG. Teams pursuing the Integrative Process Credit do not need to document Section 1.3 separately.

STEP 6. DESIGN TO MEET SECTION 2, CORE PERFORMANCE REQUIREMENTS

Select the optimal design indicated by the load calculations and confirm that each of the requirements listed in Section 2 of the CPG are met or exceeded. If any design revisions require upgrades to envelope or lighting components, redo HVAC load calculations.

- Confirm with the architect that envelope-related efficiency measures included in the plans and specifications meet or exceed the CPG requirements.
- Confirm with the mechanical engineer that the specifications of the mechanical system meet or exceed the CPG requirements.
- Confirm with the electrical engineer or lighting designer that lighting power densities calculations do not exceed the CPG requirements.
- Sections 2.3, 2.7, 2.9, and 2.11 are addressed elsewhere in the rating system and are therefore not covered here. However, teams must demonstrate compliance with each section and meet the LEED requirements as well if they are more stringent than the CPG.
- For Sections 2.3 and 2.11, see EQ Prerequisite Minimum Indoor Air Quality Performance and EQ Credit Enhanced Indoor Air Quality Strategies.
- Sections 2.7 and 2.9 are already mandated through the prescriptive requirements of ASHRAE 90.1–2010, as indicated in the criteria for Option 3 of this prerequisite.

STEP 7. DESIGN FOR COMPLIANCE WITH SECTION 3, ENHANCED PERFORMANCE STRATEGIES

Work with the mechanical engineer to include the following three strategies from the CPG Section 3, Enhanced Performance Strategies, in the plans and specifications, as applicable:

- 3.5 Supply Air Temperature Reset (VAV). Confirm that the selected air-handling units can reset temperature and that the building automation system (BAS) can process inputs that allow proper reset operation, such as humidity, outdoor air temperature, and VAV damper position.
- 3.9 Premium Economizer Performance. Confirm that the controls can accommodate a dedicated thermostat stage, that appropriate sensors are installed in the correct location within the air streams, and that the BAS can adequately implement the requirements.
- 3.10 Variable Speed Control. Confirm that pumps serving variable flow systems and VAV fans having a motor of 5 horsepower (3.73 kW) or larger can be upgraded to VFD with performance characteristics matching those listed in the standard.

STEP 8. INCLUDE DESIGN CRITERIA IN OWNER'S PROJECT REQUIREMENTS

Develop a checklist of all the requirements needed to comply with the CPG, review this list with the project team, and include these requirements in the OPR (see EA Prerequisite Fundamental Commissioning and Verification).

FURTHER EXPLANATION

CALCULATIONS

If a project consists of both an existing building renovation and new construction, use Equation 1 to determine the appropriate target percentage savings for meeting the prerequisite or achieving a specific point goal:

EQUATION 1. Target energy savings for additions to existing buildings

$$\text{target percentage} = \left\{ \frac{\text{existing floor area}}{\text{total floor area}} \times \text{target percentage of savings for existing building} \right\} + \left\{ \frac{\text{new floor area}}{\text{total floor area}} \times \text{target percentage of savings for new building} \right\}$$

CLIMATE ZONE DETERMINATION

Determining the right climate zone for the project is essential, since the requirements are specific to each climate zone. ASHRAE 90.1–2010 defines eight climate zones (Miami is in climate zone 1; Anchorage is in climate zone 8) and three climate types: A (moist), B (dry), and C (marine).

To find the project's climate zone and type, consult ASHRAE 90.1–2010, Appendix B, for the appropriate state and county. If the project's county is not listed, use the climate zone listed for the state as a whole. For projects outside the U.S., see *Further Explanation, International Tips*.

SELECTING AN OPTION

Determining which option is most appropriate for the project requires knowing the extent of energy performance feedback desired during the design process.

- If detailed feedback is important during the design process, then the performance option (1) may be appropriate. Energy modeling generates information on the potential savings associated with various efficiency measures, both in isolation and in combination with other measures. Often this includes estimates of overall energy use or cost savings for the project, which can help gauge progress toward an energy savings goal or achievement of points under the related credit.
- If the owner or design team requires only limited feedback, then one of the prescriptive options (2 or 3) may be more appropriate. These options are best suited for projects with standard systems and provide only limited feedback, in that all efficiency measures must be incorporated to achieve the prescribed threshold for energy performance.

Performance path

The following factors could indicate that Option 1 would be advantageous to the project:

- Neither of the prescriptive pathways is available to the project because of the building's type or size.
- The project has an HVAC system that is not covered by one of the prescriptive options.
- The project team wants to explore the energy performance and load reduction effects of several envelope and lighting designs and mechanical systems.

- The project team is planning to maximize the number of points available through EA Credit Optimize Energy Performance.
- The project team wants to achieve efficiency trade-offs between systems, offsetting the lower efficiency of one system by the improved efficiency of another.
- The owner is interested in commercial building federal tax credits or state, local, or utility incentives that require energy modeling. The modeling requirements for such incentive programs may be different from the ASHRAE 90.1–2010 requirements, however.
- The owner wants an estimate of the carbon reductions or lower operating costs (energy savings, demand charge savings) from energy strategies, beyond a simple calculation for individual energy conservation measures.

Before undertaking energy modeling as part of the performance path, consider the timing of the simulation preparation and presentation, and understand the costs and benefits of energy modeling as it relates to the project. When energy modeling is conducted late in design, its value is very limited, except as a compliance tool: the model can only estimate the energy savings of the design.

In contrast, if initiated early and updated throughout the design process, energy modeling can be a decision-making tool, giving feedback as part of the larger analysis of building systems and components. The best value will be seen when energy modeling is used as a tool in an integrated design process because it enables a more informed, cost-effective selection of efficiency strategies.

Develop clear expectations for the presentations of modeling results and their integration into the project schedule. Ideally, iterations of the model will be presented to the team during each stage of design, beginning as early as possible, when the project goals are incorporated into preliminary plans. Updates should be presented as the design is developed further to incorporate engineering and architectural details, and again when the construction documents are being prepared.

Regardless of the project design phases, energy modeling can still be performed as the design progresses. However, the potential benefit of energy modeling decreases as the design becomes finalized and opportunities for incorporating changes are lost (see *Further Explanation, Energy Modeling Process Overview*). Ask the project's energy modeler to provide a schedule that integrates energy modeling into the design process, with appropriate milestones.

To develop an accurate and compliant energy model, it is important that the energy modeler read and understand ASHRAE 90.1–2010 (Appendix G in particular) in its entirety, not just the portions that apply to the project. This will enable a more complete understanding of the energy modeling protocols and methodologies required for LEED projects (see *Further Explanation, ASHRAE 90.1, 2010 versus 2007*). The energy modeler should also consider reading the ASHRAE 90.1–2010 User's Manual, which expands on the Appendix G requirements.

Prescriptive paths

The following factors could indicate that Option 2 or Option 3 would be advantageous to the project:

- The project type is covered under one or both prescriptive options and incorporates conventional systems and energy efficiency strategies.
- The project budget and timeline would benefit from simplified decision making and analysis during the project design.
- The additional cost of energy modeling would not be warranted.

Although the prescriptive paths are applicable to some large projects, such as schools and hospitals, they were designed primarily for smaller projects, for which the cost of energy modeling would represent a high percentage of the project budget.

The prescriptive paths are available only for projects that meet certain criteria. Review the project's eligibility for the ASHRAE 50% Advanced Energy Design Guides and/or the Advanced Buildings Core Performance Guide. If neither prescriptive option fits the project type, the team must pursue Option 1.

If the project is eligible for both of the prescriptive options, determine which is more appropriate based on the specific option requirements as well as future credit goals. The building type, for example, may not match those in the AEDGs, or the CPG prescriptive requirements may align better with the project's goals and design.

Option 2, ASHRAE 50% AEDG, delivers a 50% savings over ASHRAE 90.1–2004 when all requirements in all categories are met. A project must meet all the HVAC and service water-heating requirements to earn the prerequisite under Option 2.

Option 3, Advanced Buildings CPG, achieves 20% to 30% savings over ASHRAE 90.1–2004, depending on climate zone and building type. Have the mechanical engineer review the applicable AEDG requirements for the project type. If the project is expected to have unique systems, potential equipment is not listed, or the system capacity is not likely to not fall within the ranges in the AEDG, then the project team cannot pursue Option 2, and must pursue Option 1 or Option 3.

ENERGY MODELER QUALIFICATIONS

The energy modeler should have the following competences:

- Comprehensive understanding of all the building systems related to energy performance and the information needed to construct a model using the selected software
- Ability to understand and explain capabilities and limitations of modeling software in regards to the strategies the team would like to pursue
- Awareness of how much time the design team needs to provide information, feedback, and responses to the modeling exercise
- Experience with design phase modeling
- Ability to demonstrate how energy modeling can be used to perform cost benefit analysis
- Experience in modeling projects using ASHRAE 90.1, Appendix G, performance rating method, or a thorough understanding of this approach
- Ability to perform quality control to ensure that the modeling inputs accurately reflect the proposed design and Appendix G baseline
- Ability to evaluate the simulation results for reasonableness in relation to the energy modeling inputs, including energy consumption by end-use, cost, and the performance savings claimed
- Ability to validate the model through review of the actual utility bills during the occupancy phase

DEVELOPING A PRELIMINARY ENERGY MODEL

Although not required for this prerequisite, preparation of a preliminary model can facilitate achievement of the related credit, which requires analysis of efficiency measures. Past analyses of similar buildings or published data, such as the AEDGs, may also be used to guide decision making, though the results will be less project-specific. A preliminary model includes design elements identified during schematic design and design development and generates a preliminary estimate of energy consumption and an end-use profile.

Evaluate how changes to the following elements affect HVAC sizing, energy consumption, lighting, renewable energy opportunities, and other aspects of energy performance:

- Program and operations (multifunctioning spaces, operating schedules, space allotment per person, teleworking, reduction of building area, operations and maintenance)
- Site conditions (shading, exterior lighting, hardscape, landscaping, adjacent site conditions)
- Massing and orientation
- Envelope (insulation values, window-to-wall ratios, glazing characteristics, shading, and window operability)
- Lighting levels and interior surface reflectance
- Thermal comfort range options
- Passive conditioning and natural ventilation strategies

When examining alternative strategies, also consider the effect on human performance. For example, increasing daylighting may cause glare.

Typical steps in preliminary energy modeling are as follows:

1. Gather information about building loads and systems. Investigate case studies of similar building in similar climates and contact local utilities for energy rates and demand charges. Determine applicable building energy codes, including any local variations. For existing buildings, review drawings, specifications, operations and

maintenance manuals, commissioning reports, energy audit reports, and utility bills. The AEDGs may provide useful information regarding design practices specific to building types and climate zones.

2. Engage the design team early to investigate opportunities for load reduction. Coordinate with the architect to identify options for envelope insulation values, building orientation, and shading—variables that can affect load, especially on externally load-dominated buildings. Some strategies, such as building massing and orientation, are most effectively evaluated during the concept phase of design, before the preliminary energy model, and is not required for this prerequisite. However, a concept-level mass model is a component of the Integrative Process Credit.
3. Analyze several design alternatives to investigate the combined load reduction potential of multiple strategies. How strategies alter energy consumption varies by building type and climate zone. Examine energy use by end use and heating and cooling load distribution to identify effective load reduction and energy efficiency opportunities.
4. Investigate interconnected strategies. The additional costs of high-performance envelope elements may be offset by smaller, less costly HVAC systems. For example, energy modeling could evaluate the effect of a fenestration and shading configuration, with daylight harvesting controls, on cooling, heating and fan loads, HVAC system capacities, and total building energy consumption and cost. A life-cycle cost analysis for this scenario would indicate the net increase or decrease in capital costs and the potential savings over multiple years. When evaluating the capital cost, consider trade-offs between the higher capital cost for the shading and daylight harvesting controls and the lower capital costs for a smaller HVAC system.
5. Use the model to compare potential performance with the project's energy goals.

MODELING HVAC SYSTEMS

Although not required for this prerequisite, an evaluation of HVAC system alternatives can help the design team optimize energy consumption. This exercise is a requirement for achievement of points under the related credit.

The modeler should analyze the performance of several efficient HVAC systems to understand the potential energy savings associated with each one. This information enables the design team to compare life-cycle costs, rather than just first costs. The life-cycle cost analysis should follow the analysis of load reductions, which may affect the life-cycle cost.

The chosen HVAC system can then be further optimized through additional energy modeling that analyzes the potential efficiency gains of the system components and/or assigns different systems to different zones.

Typical steps for HVAC system type modeling include the following:

1. Coordinate with the mechanical engineer, since decreased loads may affect mechanical system sizing or potential system types. Compare high-efficiency HVAC systems with typical systems for reductions in operating costs (energy, maintenance). Weigh this against the higher first costs of more efficient equipment. Evaluate the potential for reducing the first cost of HVAC equipment by reducing the loads. Include not only the smaller equipment but also the infrastructure related to HVAC—ductwork, piping, controls, and in some cases, building volume or floor area for these components.
2. For the selected system, analyze and optimize additional HVAC energy efficiency measures, including equipment efficiency, energy recovery, economizers, and demand-controlled ventilation.
3. Coordinate with the architect and structural engineer, since different system types may influence space, height, or structural requirements. For example, under-floor air-conditioning may influence the exterior envelope design and could increase or decrease the height of the building.

BUILDING THE PROPOSED ENERGY MODEL

An energy model of the proposed design is required for prerequisite compliance under Option 1. A team that has already prepared a preliminary model may update it to reflect the newest design information throughout the project.

Create or update proposed building characteristics based on the latest information and specifications on systems, assemblies, and equipment in the current design. This can be accomplished as early as design development to estimate projected savings, and later updated when the construction documents are complete. Then analyze remaining efficiency strategies that the team would like to consider before the design documents are finalized. For example, the proposed energy model could be used to evaluate the performance and cost implications of value engineering decisions.

BUILDING THE BASELINE ENERGY MODEL

Developing a baseline energy model is a detailed process that requires a good working knowledge of ASHRAE 90.1–2010, Appendix G, and familiarity with the relevant sections of the standard. The baseline model represents a typical design for a building of the same size and use as the proposed building. It meets but does not exceed the performance requirements of ASHRAE 90.1–2010 and is used as a comparison to calculate the percentage energy cost savings for the project design.

In general, baseline development begins by changing the inputs for all the components, assemblies, and systems of the proposed design energy model to minimally compliant input values, in accordance with 90.1–2010 Appendix G. Determine or update baseline values for each system, assembly, and piece of equipment for the appropriate climate zone, building type, and fuel type(s).

If the energy simulation software automates some or all the baseline generation, review the automated baseline model inputs against the expected baseline values and confirm consistency (see *Further Explanation, Common Issues with Energy Modeling*).

Preparation of the initial baseline model is best undertaken during the design development phase, after major design decisions have been made, so that modeling can evaluate whether the project is likely to meet energy savings targets (or achieve points under the related credit). The baseline model will typically need to be updated based on the final project design.

FINALIZING THE ENERGY MODELS

Update the proposed model based on the information and specifications for systems, assemblies, and equipment in the final construction documents. Confirm that all efficiency measures claimed have been incorporated into the design. Include all energy consumption and costs within and associated with the building project.

Ensure that assumptions used in earlier versions of the model are replaced with actual data from the construction documents. For example, if proposed chiller control sequences were assumed in the preliminary model, use the actual control sequences from the construction documents for the final version. Update the baseline model as necessary based on the project's final construction documents, including changes in occupant density, required outdoor airflow, thermostat setpoints, and system or fuel types. The model will have to be updated again if any changes during construction affect efficiency measures.

Schedules must be modeled correctly for both the proposed and baseline models (see *Further Explanation, Schedules*).

Perform a quality control check to verify that all Appendix G and LEED modeling guidelines have been followed. Record both the proposed and baseline values in the Appendix G energy modeling inputs and quality control checklists spreadsheet. This record of energy conservation measures is a good tool for confirming that proposed building characteristics and baseline values have been selected properly.

Document the input assumptions for receptacle and process loads. These loads should be modeled accurately to reflect the actual expected energy consumption of the building. Per ASHRAE 90.1–2010, Table G3.1-12, receptacle and process loads must be modeled identically in both the proposed and baseline models, unless there are specific efficiency requirements listed in Sections 5 through 10 that allow a less stringent baseline requirement (e.g., motor efficiency).

If the project claims savings for variations in power requirements, schedules, or control sequences, the burden of proof is on the project team to document that the design represents a significant departure from conventional practice. If an energy efficiency measure cannot be explicitly modeled, the team may use Section G2.5, Exceptional Calculation Method (see *Further Explanation, Exceptional Calculation Method*).

Verify the final energy cost savings. Evaluate the energy savings by end use for reasonableness based on the differences in the modeling inputs between the baseline and proposed models (see *Further Explanation, Energy Cost Savings*). Use Figure 2 to help verify proposed energy savings.

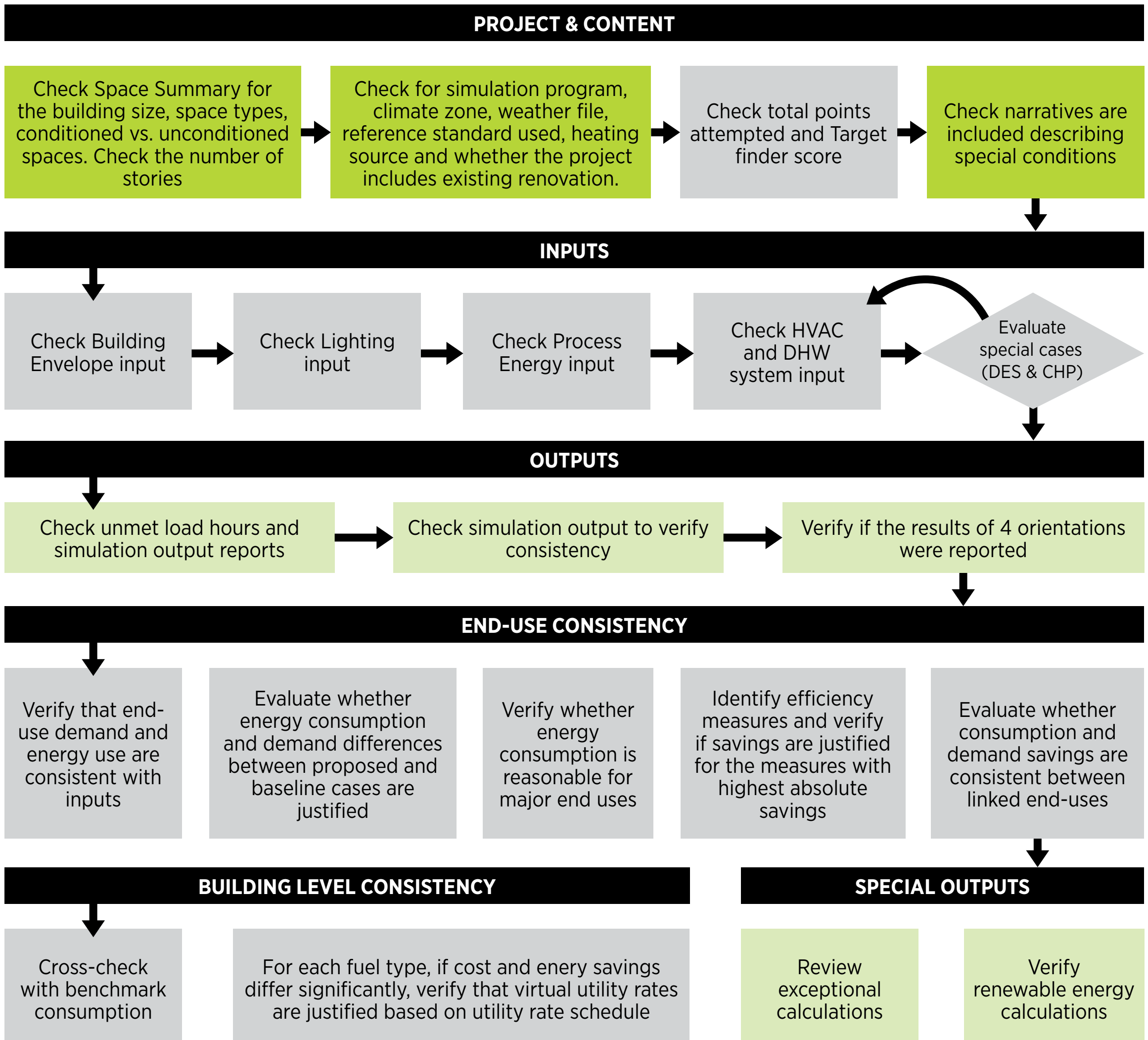


Figure 2. Steps to verify proposed energy savings

Model Inputs   Model Outputs   Consistency

SCHEDULES

For optimal results, ensure that the schedule inputs into the model accurately reflect the project building's operation. If anticipated operating schedules are unknown, helpful guidance for determining model inputs for occupancy, lighting, HVAC system, receptacle power, and service hot water consumption values can be found in the ASHRAE 90.1–2010 User's Manual, Appendix G.

Schedules must be identical in both the baseline and the proposed cases unless documented in an exceptional calculation or specifically allowed by ASHRAE 90.1–2010 Appendix G (see *Further Explanation, Exceptional Calculation Method*).

Certain space types may require specific schedules based on anticipated operation and may vary by space type. For example, a server room may have different temperature schedules than an occupied space.

Exceptions to Section G3.1.1 may require modeling of a different baseline HVAC system type in spaces with schedules that vary significantly from the rest of the building.

Different lighting schedules may be used for a project with both office and retail occupancy when the space-by-space method is used or when the building area method is used with multiple building type classifications. Different schedules cannot be used, however, if an average lighting power density is applied to the whole project.

Ventilation and infiltration schedules should also be adjusted to ensure the same amount of outside air delivery and infiltration between baseline and proposed cases, except for specific exceptions allowed by Appendix G.

ENERGY COST SAVINGS

For EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance, modeled energy savings must be reported on an energy cost basis using actual utility rates or the state's average energy prices.

Using energy cost savings as a metric for overall building energy efficiency is important for several reasons. It aligns with the energy modeling procedures in ASHRAE 90.1–2010, Appendix G, and provides a uniform metric for all fuel types. It captures the relative effects of various efficiency measures on energy demand and long-term operating costs—valuable metrics for the owner in determining the overall cost-effectiveness of selected efficiency strategies. And finally, the energy cost savings metric can help designers understand energy consumption because in many cases, cost and carbon emissions of each fuel source are closely correlated.

EXCEPTIONAL CALCULATION METHOD

In ASHRAE 90.1–2010, Appendix G, Section G2.5, an exceptional calculation method (ECM) is used when the simulation program that is generating the energy model is incapable of modeling a certain design, material, or device of the proposed design. LEED has adopted and slightly expanded use of exceptional calculations to cover any savings claimed for a nonregulated load, defined as any building load, end use, or control without an Appendix G baseline modeling requirement that allows the load, end use, or control to be modeled differently in the proposed and baseline buildings.

Energy savings limitations

Section G2.5 indicates that exceptional calculation methods cannot constitute more than half of the difference (i.e., savings) between the proposed and baseline buildings. This will be enforced for the ASHRAE definition of an ECM. However, in LEED, this rule will not be applied to savings attempted on nonregulated loads unless the nonregulated load cannot be modeled in the simulation program.

Elements that cannot be simulated by modeling program

One type of ECM is creating a representation of an element that cannot be modeled directly by the chosen energy modeling software. Examples include innovative external shading devices, under-floor air systems, and the heat recovery performance of a variable refrigerant flow system. Whether a particular strategy is considered an ECM may depend on the modeling program and whether the energy modeler can simulate an approximation of the system in the software. If the methodology for approximation has not been previously published by ASHRAE or USGBC as an acceptable modeling path, it is the responsibility of the energy modeler to submit a narrative explanation describing the simulation and providing the calculations for the energy savings if necessary.

Documentation for nonregulated loads

Examples of nonregulated load savings include manufacturing equipment not regulated by 90.1–2010, a unique manufacturing process, or any refrigeration or kitchen equipment (including operation) not specifically covered in the LEED Appendix 3. Retail Process Load Baselines, Tables 1–4. Energy savings for nonregulated loads require additional documentation. ASHRAE 90.1–2010, Table G3.1-12, indicates that "variations of the power requirements, schedules, or control sequences" are allowed by the "rating authority," provided the proposed design "represents a significant verifiable departure from documented conventional practice." Project teams must document the following information to prove that the savings represent a departure from conventional practice and are not required by local code:

- A narrative describing all baseline and proposed assumptions
- The calculation methodology used to determine the savings
- A document verifying that the efficiency measure is not conventional practice. This is generally accomplished either by documenting the baseline comparison system/schedule/control as standard practice, or by showing that the savings claimed for the efficiency measure are incentivized by a local utility program. Examples of documents used to verify that the efficiency measure is not conventional practice may include the following:
  - A recent study with researched tabulations or monitored data establishing standard practice for the given application in similar newly constructed facilities
  - A new-construction utility or government program that provides incentives for the measure
  - A document showing the systems used to perform the same function in similar facilities built within the past five years; these systems are treated as the baseline system in the analysis, and evidence must show how the energy use for the baseline and proposed buildings is determined

Alternatively, the project team may use any of the prescriptive requirements from ASHRAE 90.1–2010 as the baseline requirement without further justification to substantiate conventional practice, but only for the specific component.

Additional guidance

Sources of typical efficiency measures include the COMNET manual, which has a calculation methodology for determining savings for process or receptacle loads, especially savings from ENERGY STAR equipment. These are offered in Section 6.4.5, Receptacle and Process Loads, and Appendix B.

Always provide a narrative explanation of the methodology used to calculate savings for exceptional calculation methods. Separate calculations are not necessary when the energy saving are found easily in the modeling results.

Changes from earlier versions of ASHRAE and LEED

Some efficiency measures that no longer need to be modeled using an exceptional calculation method include garage fan demand-controlled ventilation, low-flow water fixtures, kitchen equipment, and kitchen ventilation.

- Enclosed parking garage ventilation. Modulating fan airflow rates based on contaminant levels are now required to be installed, unless certain exceptions apply, per Section 6.4.3.4.5. Any design that goes beyond these minimum baseline requirements may be counted. Two factors can affect the energy consumption:
  - The baseline fan power (in energy per flow) must be consistent with the proposed installed fan power at full-load conditions. The project team may count higher fan motor efficiencies in the proposed building.
  - The ventilation rate, and thus fan power, can also be reduced if the project team's design allows the fans to reduce the ventilation rate below 50%. The baseline ventilation rate must be set at the minimum requirements of ASHRAE 62.1–2010, which is 0.75 cfm per square foot (3.8 L/s per square meter). This must be the baseline ventilation rate, regardless of any local code.

The same requirements apply to demand-controlled ventilation for outdoor air control sequences that provide ventilation for building occupants.

- Low-flow service water-heating fixtures. The flow rates given in WE Prerequisite Indoor Water Use Reduction set the allowable baseline values. Provide sufficient information to justify energy savings from efficient fixtures and appliances that use hot water.
- Kitchen equipment. All project types may count energy savings from efficient refrigeration equipment, cooking and food preparation, clothes washing, and other major support appliances. LEED Appendix 3. Retail

Process Load Baselines Tables 1–4, defines the baseline conditions. Provide sufficient information to justify all the savings. Savings for a piece of equipment (or its operation) not covered in Appendix 3 must be modeled using the ECM described above.

- Kitchen ventilation. ASHRAE 90.1–2010 now addresses kitchen ventilation, so it is no longer considered a nonregulated load. Section G3.1.1, exception (d) requires a kitchen with more than 5,000 cfm (2360 L/s) of total exhaust airflow to be modeled with its own separate system. Include demand ventilation on 75% of the exhaust air, and reduce exhaust and replacement air by 50% for half the kitchen occupied hours in the baseline design. Additionally, the maximum exhaust flow rates for hoods must meet the requirements of Section 6.5.7.1.3. The exhaust flow rate must be modeled identically in the baseline and proposed case at design conditions unless Appendix G indicates otherwise. Any design that goes beyond these minimum baseline requirements may be counted. Provide sufficient information to justify all kitchen ventilation savings, with consistent assumptions and operating schedules. Project teams that count kitchen ventilation savings must separate the savings from each end use (e.g., fan, heating, cooling) when reporting the energy outputs.

ASHRAE 90.1-2010 VERSUS 2007

The referenced standard for building the baseline model for this prerequisite has been updated to ASHRAE 90.1–2010, which represents a substantial increase in efficiency from the previous version, ASHRAE 90.1–2007. The major changes are described in Tables 1 and 2.

TABLE 1. Comparison of ASHRAE 90.1 mandatory requirements, 2007 and 2010

Building envelope requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Air barriers 5.4.3.1.2	NA	Continuous on entire building envelope

HVAC requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Garage fans 6.4.3.4.5	NA	Auto-adjust fan speed with contaminant levels to 50% or less of capacity
Chiller efficiencies 6.4.1.1	NA	Increased for all chiller types
Single-zone VAV 6.4.3.10	NA	Required to have VFD or two-speed motors for DX >9.2 tons (32.3 kW), and chilled water AHUs >5 hp (3.7 kW) fan motors
Water and evaporatively cooled unitary AC units and heat pump efficiency Table 6.8.1A and B	NA	3–5% more stringent
PTAC and PTHP efficiency increased 6.4.1.1; Table 6.8.1D	12 EER (3.52 COP)	13.8 EER (4.05 COP)
Water to water heat pump, CRAC, and VRF Table 6.8.1B; Table 6.8.1K; Table 6.8.1J respectively	Not covered	Now covered by 90.1

Power requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Automatic receptacle control 8.4.2	NA	At least 50% of all receptacles installed in private offices, open offices, and computer classrooms must be controlled by automatic control device

Lighting requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Threshold for retrofit compliance 9.1.2	Alterations that involve less than 50% of connected lighting load in space or area need not comply with lighting power density or auto-shutoff requirements, provided that such alterations do not increase installed LPD	Less than 10% of connected load
Lighting power density 9.4.5; 9.4.6	NA	Reduced; average 17% in space types, more for retail display lighting
Automatic shutoff 9.4.1.1	Required in buildings >5,000 ft^2 (465 m^2)	Required in all spaces
Additional control 9.4.1	All spaces to have general lighting controls, manual or automatic	All spaces are required to have vacancy sensors or occupancy sensors to 50% or less of lighting power
Space controls 9.4.1.2	Classrooms, conference rooms, and break rooms must have occupancy sensor or time switch that turns light off within 30 minutes	More space types added, including offices, restrooms, dressing rooms, and training, copy, and storage rooms
Light level reduction 9.4.1.2	None	Spaces must have controls that reduce power level by 30–70% of connected load in addition to off mode.
Lighting in daylit zones 9.4.1.4	None	Automatic, multilevel daylighting controls installed in sidelit areas >250 ft^2 (23 m^2) and toplit areas >900 ft^2 (84 m^2)
Parking garage lighting 9.4.1.3	None	Auto-shutoff, power must be reduced by 30% when no motion for 30 minutes, auto-daylight control on perimeter
Exterior lighting 9.4.1.7	Lighting must be controlled by photosensor or time switch	At night light must either be off or operated at reduced level
Functional testing 9.4.4	None	All installed controls must be tested

TABLE 2. Comparison of ASHRAE 90.1 prescriptive requirements, 2007 and 2010		
Requirement	**ASHRAE 90.1–2007**	**ASHRAE 90.1–2010**
Economizer exemptions Table 6.3.2	Only for unitary equipment, EER/SEER (COP/ SCOP) rating	For all HVAC system types, must meet % efficiency improvement, now required in most climate zones
Lighting power density 9.2.1	NA	Reduced, average 17% in space types, more for retail display lighting

COMMON ISSUES WITH ENERGY MODELING

Thoroughly review both ASHRAE 90.1–2010 and the 90.1–2010 User's Manual. The manual presents extended explanations and also includes examples of the concepts and requirements within the standard. Table 3 addresses many of the most common issues but is not a comprehensive list.

TABLE 3. Common issues with energy modeling, by ASHRAE 90.1 section	
Scope	
Inclusion of unfinished spaces in project scope	Unfinished spaces must be included in the energy model if they are part of the project scope of work. In core and shell projects, a large portion of the space may be unfinished; in new construction and major renovation projects these spaces must not make up more than 40% of the total space. In addition, all projects other than core and shell that have incomplete spaces must submit a letter of commitment, signed by the owner, confirming that the remaining incomplete spaces will satisfy the requirements of each prerequisite and credit achieved by this project if and when completed by the owner.
Modeling HVAC, lighting, hot water systems for unfinished spaces	Refer to ASHRAE 90.1–2010, Tables G3.1.6(c), G3.1.10(c) and (d), and G3.1.11(c), for unfinished space modeling requirements. If a lighting, HVAC, or service hot water system has not yet been designed, the system required in the baseline building for that unfinished space must also be modeled in the proposed building. Refer to Table G3.1.8 on how to model thermal zones for such space. Example 1. A two-story office building has a ground-floor retail area that is entirely unfinished. The building contains a chase for future ductwork and a location on the roof for the mechanical equipment for the future tenant, but no system exists or has been specified. In this case, the proposed HVAC system for that space must be modeled using the same HVAC system type, capacity ratios, efficiencies, and controls as those modeled for the baseline building. Example 2. The same hypothetical two-story office building now includes chilled and hot water connections for the future unfinished retail space. A portion of the HVAC system has been designed. The proposed building may be modeled as a system that uses the chilled and heating hot water (e.g., 4-pipe fan coil unit). However, because the air-handling units and terminal distribution have not yet been designed, the cooling and heating capacities, design fan volume, minimum volume, fan power, fan controls, etc., must be modeled identically in both the baseline and proposed model, and equal to the requirements of the baseline model.
Additions to existing buildings	Project teams wishing to certify an addition to an existing building must follow the Appendix G requirements in Table G3.1.2, the most important of which is (b). If the existing building will be excluded, then the HVAC system serving the addition to the building must be entirely separate from the systems serving the existing building. Refer to the table for all requirements.
Building envelope	
Baseline building envelope	Construction type and maximum U-factors for baseline walls, roofs, and floors are specified by Table G3.1-5 Baseline (b). The constructions for walls, roofs, and floors are specified by the standard and do not depend on the proposed design. For example, if a building will have concrete masonry walls, the baseline model will still have steel-framed walls.
Existing building envelope	For an existing building that was conditioned before major renovation and will be conditioned postrenovation, the baseline building envelope should reflect the existing conditions, before the scope of work (Table G3.1-5 Baseline (f)). However, for an existing building (or spaces in the building) that was previously unconditioned and is being renovated to include conditioning, the baseline building envelope (or the envelope for any previously unconditioned spaces in the building) must be modeled as if the building is new construction (i.e., according to Table 5.5).
Proposed model U-values	The proposed model must reflect the building as designed or built. To the extent possible, construction assemblies need to match the dimension and U-value inputs in the model. Apply Appendix A to the proposed envelope. Provide the assembly U-value, rather than a point U-value, by determining the overall construction assembly U-value that takes into account for thermal bridging as shown in Appendix A. Ensure that window U-values are input as the assembly U-value, which takes into account the U-value of the framing system. The center-of-glass value is not acceptable.
Baseline model U-values, semi-exterior surfaces	For the baseline envelope properties, use the semiheated requirements to model surfaces that adjoin unconditioned spaces to conditioned spaces (e.g., a wall separating a semiheated warehouse from a conditioned office) or semiheated space to conditioned space (e.g., the slab separating an unconditioned parking garage from the conditioned ground floor of the building). Figure 5.1 in 90.1–2010 illustrates this requirement.

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section

HVAC	
Baseline HVAC system selection	The HVAC system for the baseline model must be selected based on requirements in ASHRAE 90.1–2010, Section G3.1.1. The system selected will depend on the proposed building type, size, and heat source. Building type must be based on predominant conditions (i.e., those that account for the majority or plurality of the building area), and no space types can be excluded from the model. Building size is determined from conditioned area. Once the floor area of the predominant condition is known, consult Table G3.1.1A to determine the predominant baseline HVAC system. Section G3.1.1 also specifies whether HVAC systems must be modeled with a system per floor or a system per thermal block. Systems 1–4 are modeled with one system per thermal block and systems 5–10 with one system per floor, using systems 9 and 10 where applicable. When multiple floors have identical thermal blocks, those floors may be combined in the energy model. Note that a floor with a roof and a floor without a roof do not have identical thermal blocks and cannot be combined. A multistory building with identical thermal blocks would need to be modeled with no fewer than three floors: a ground floor, a middle floor with appropriate multiplier, and a top floor. There are six exceptions to the baseline HVAC system determination. These exceptions are mandatory and must be taken if they are applicable to the project. G3.1.1 exception (a). Check for nonpredominant conditions, such as nonresidential in a primarily residential building, or where a portion of a building is supplied by electric heat but the rest is from fossil fuels. The area of nonpredominant conditions can be deducted from the total area when determining the baseline HVAC system. If nonpredominant conditions apply to more than 20,000 ft^2 (1860 m^2), use exception (a) and select an additional baseline HVAC system type to serve those spaces. Example. A 210,000 ft^2 (19 510 m^2) multifamily high-rise has 23,000 ft^2 (2140 m^2) of ground-floor retail space. The residential units are served by heat pump units with supplemental electric heat, and the retail areas are served by a split DX unit with fossil fuel furnace. The required baseline HVAC system for the residential spaces would be System 2–PTHP, but for the retail areas it would be System 3–Packaged DX with fossil fuel furnace, since the nonresidential spaces meet the 20,000 ft^2 (1860 m^2) exception (a) in G3.1.1. G3.1.1 exception (b). If using systems 5, 6, 7, 8, 9 or 10, individual zones with atypical thermal loads or occupancy profiles must be modeled with individual single-zone systems of type 3 or 4, according to exception (b). Examples for this include computer server rooms, natatoriums, and school gymnasiums. If this exception is not properly incorporated into the baseline model, the model results may show an unusually high number of unmet load hours or significantly oversize the baseline case systems. A good practice is to check the baseline output reports and verify that the thermal loads for each thermal block do not vary by more than 10 Btuh/ft^2 (31.5 W/m^2) from the average of the other thermal zones on the floor, and adjust the baseline model as necessary to include this exception.
Baseline HVAC system selection (laboratory spaces)	G3.1.1 exception (c). If laboratory spaces in the building have a total laboratory exhaust rate greater than 5,000 cfm (2360 L/s), a single system of type 5 or 7 must be modeled to serve only those spaces. Section G3.1.2.11 requires exhaust air energy recovery in accordance with Section 6.5.6.1, which is likely to include laboratories.
Baseline HVAC system selection (kitchens)	G3.1.1 exception (d). If kitchens in the building have a total exhaust hood airflow rate greater than 5,000 cfm (2360 L/s), system type 5 or 7 must be modeled and must include demand-controlled ventilation.
Baseline HVAC system selection: heated-only storage or circulation spaces	G3.1.1 exception (e). Heating-only systems serving rooms not exhausting or transferring air from mechanically cooled spaces, such as storage rooms, stairwells, or mechanical rooms, should be modeled as system 9 or 10. G3.1.1 exception (f). When the predominant system is type 9 or 10, any fully conditioned spaces (such as an small, fully conditioned office in a heated-only warehouse) should be modeled using the appropriate system type for the size, number of floors, occupancy type, and heating type for the nonpredominant area of the building.
Baseline HVAC system fuel type	Any project with a combination of fossil fuel and electric heat serving the same space must use the fossil fuel baseline HVAC system (systems 1, 3, 5, and 7) unless it meets one of the exceptions to G3.1.1. Example. A building has been designed with electric water-source heat pumps for the space loads. A 100% outdoor air gas-fired rooftop unit provides ventilation. The spaces are served by both electric heating from the heat pumps and ventilation air from the gas-fired unit; therefore, the spaces are considered hybrid heating and must model the baseline HVAC system type as “Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat” (from Table G3.1.1a). In the case of electric heating equipment designed with a fossil fuel preheat coil, or a backup fossil fuel boiler, the intent is that the equipment will be used; thus it is considered hybrid heating, and the team must use the fossil fuel baseline heating system.

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section	
HVAC (Continued)	
Baseline fan power	The baseline fan power is calculated according to Section G3.1.2.10, which indicates that the system fan power is based on the supply airflow and distributed to supply, return, exhaust, and relief fans. If the proposed system has additional return, exhaust, and/or relief fans, the team may not adjust the baseline model to account for the additional fan power. Section G3.1.2.10 also includes Table G3.1.2.9, whose value A is calculated according to Section 6.5.3.1.1 using pressure drop adjustments. Pressure drop adjustments may not be taken for system types 1, 2, 9, or 10. The calculations are straightforward, but a common issue involves pressure credits. Table G3.1.2.9 allows pressure drop adjustments for evaporative coolers or heat recovery devices only when they are required in the baseline building system. Also, the pressure drop adjustment is applicable only to the design airflow through each device. For example, if only the ventilation air is filtered with a MERV 13 filter, then only the ventilation airflow rate may apply the 0.9 in. w.c. (224.2 Pa) adjustment, not the entire supply airflow rate. Pressure credit may be taken only for those systems present in the proposed building. For fully ducted return or exhaust air systems, the credit for fan power allowance cannot be based on plenum return. The credit can be applied only when the return is fully ducted; systems that have a combination of ducted and nonducted may not use this pressure credit. For return or exhaust airflow control devices (which maintain a specific pressurization relative to other spaces), a project team claiming this credit in spaces other than a laboratory, hospital, or similar space type must provide evidence of this control device. The credit may be applied only for the amount of airflow passing through the control device. A project team using the modeling software to automatically determine the baseline building fan power must ensure that the correct allowance has been calculated. Publicly available fan power calculators can be used to verify and determine the correct fan power.
Proposed HVAC system sizing	Table G3.1.1(a) requires that the proposed building be consistent with the design documents, including envelope, lighting, HVAC, and service hot water systems. Additionally, all end-use load components within and associated with the building must be modeled. Table G3.1.10(b) requires that the HVAC model be consistent with the design documents. All modeled HVAC system parameters (e.g., fan volumes, fan powers, efficiencies, heating and cooling capacities) must be consistent with the mechanical schedules and drawings. The simulation should never be allowed to automatically size the HVAC system for the proposed case model when there is a complete design.
Heat pumps (operation)	Section G3.1.3.1 describes the operation of baseline building heat pumps. The heat pump and auxiliary heat should operate together at low-temperature conditions, with the compressor as the lead machine. The outside air cutoff temperature for the compressor must be no greater than the temperature associated with the low-temperature heating efficiency requirements of Table 6.8.1B (17°F) (–8.3°C). The HSPF rating for packaged heat pump units smaller than 65,000 Btu/h (19 kW) and packaged terminal heat pumps accounts for electric auxiliary operation and includes test conditions at 17 degrees F (–8.3°C). The heat pump efficiency curves in the model should reflect the heat pump ratings that account for simultaneous operation of the electric resistance and heat pump elements below 40°F (4.4°C).
Unitary heating and cooling efficiencies	Use the correct Table 6.8.1 to determine equipment efficiencies: Table 6.8.1A for system types 3, 5 and 6 Table 6.8.1B (with electric resistance heating section) for system Type 4 Table 6.8.1D for system types 1 and 2 These efficiencies are based on the capacity of each system individually, not a sum of all units. It is important to correctly adjust efficiencies of each piece of equipment to separate fan power at AHRI rating conditions, per Section G3.1.2.1. Most simulation software programs can perform this step automatically.
Humidity controls	Humidification must be modeled identically in the baseline and the proposed models, since it is not addressed in Appendix G. Use the exceptional calculation method if claiming savings. If the proposed design includes dehumidification controls, they must be modeled as designed. Dehumidification controls may be modeled in the baseline only if one of the exceptions to Section 6.5.2.3 applies. Exception (d) for process dehumidification does not apply to computer rooms. Table G3.1.4 requires that identical schedules be used in both models, and this includes humidity setpoints. A problem may arise if the proposed building has a dedicated outdoor air system (DOAS) that maintains proper humidity. PTAC or small DX systems in the baseline design may not be able to maintain both temperature and humidity simultaneously in the same way that the proposed system can. The project team may then incur a penalty for higher humidity levels in the baseline building. In this situation, model a DOAS in the baseline design using the same volume of outdoor air as for the proposed design, but with the same efficiency and efficiency curves as the baseline HVAC systems. Additionally, the baseline fan power allowance would be separated between the DOAS and the baseline system using the same ratio as the proposed system.

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section	
Ventilation	
Ventilation rate inputs	Table G3.1.10(b) requires that the proposed building ventilation rate be consistent with the rate indicated on the mechanical schedule. Section G3.1.2.6 requires that the ventilation rate be identical between the proposed and baseline buildings and states that reduced ventilation "is not considered an opportunity for energy savings under the Performance Rating Method"; ventilation is energy neutral, per the User's Manual. However, there are exceptions to this requirement.
Ventilation (above minimum required)	Exception (c) penalizes projects for providing more ventilation air to the space than is required by ASHRAE 62.1–2010 or a local code, whichever requires more ventilation air. If the proposed project provides outdoor air in excess of the amount required, the baseline must be modeled with the required ventilation rates, which will be lower than the proposed ventilation rate. This creates an "energy penalty" for the additional fan and conditioning energy. For various reasons, however, it is common practice to specify slightly more ventilation air than required. A project team that has specified up to 5% more total ventilation air than required may model identical ventilation rates. If exhaust requirements dictate the amount of ventilation air that must be provided to the building, as indicated in Section 5.9.2 of ASHRAE 62.1–2010, provide an explanation, documentation, and calculations as necessary to show that exhaust requirements exceed the minimum ventilation flows, and model the ventilation rate identically in both buildings.
Demand-control ventilation and nighttime ventilation requirements	Exception (a) allows credit for demand-control ventilation when it is not required by Sections 6.3.2(p) or 6.4.3.9. If demand-control ventilation is being modeled for credit, Table G3.1.4 (baseline) indicates that schedules may be modified and allowed to differ to take it into account, provided the schedules are approved by the rating authority. In this instance, project teams must submit both proposed and baseline ventilation schedules. ASHRAE 90.1, Section 6.4.3.4.3, requires shutoff dampers that automatically shut during unoccupied periods when the HVAC system cycles on and off to meet loads except when ventilation reduces energy costs (e.g., night purge), or when ventilation must be supplied to meet local requirements (such as minimum flow requirements for hospital or chemical storage rooms during unoccupied periods). Therefore, the demand-control ventilation schedules presented for both the baseline and proposed cases should show zero outside airflow during unoccupied periods unless the supplemental documentation supports that ventilation during unoccupied periods reduces energy cost or is required by local code, in which case the baseline and proposed ventilation rates during unoccupied periods must be modeled with identical flow rates. Additionally, the baseline ventilation flow must be modeling using minimum required rates.
Ventilation (zone air distribution effectiveness)	Exception (b) allows for lower ventilation rates in the proposed building for efficient ventilation system designs that have high zone air distribution effectiveness (E_z >1.0), as determined by ASHRAE 62.1–2010. In this case, the baseline ventilation levels can be based on the proposed calculations, only with reduced zone air distribution effectiveness (E_z = 1.0). This makes the baseline outdoor airflow rates higher than the proposed outdoor airflow rates, so ventilation calculations must be submitted to claim the exception for a higher E_z in the proposed case. If a lower ventilation flow rate is an aspect of the design, the project team must provide ventilation rate procedure calculations for both the proposed and baseline designs, with the proposed design using the actual E_z value and the baseline design using an E_z value of 1.0 in each zone where the E_z value is greater than 1.0, but equal to the proposed building for all other zones where the E_z value is not greater than 1.0. If ASHRAE 62.1, Section 6.2, Ventilation Rate Procedure, is not used for the ventilation design, then this exception may not be used. Credit may not be taken, via ventilation flows, for any other ventilation design, such as a 100% outdoor air unit. Additionally, credit may not be taken for increased system ventilation efficiency, E_v, of a proposed ventilation system compared with a baseline ventilation system; Appendix G does not allow this. The only exception would be a different E_v value due to an E_z greater than 1.0, as described above.
Natural ventilation	The ASHRAE User's Manual indicates that an exceptional calculation method is not required for natural ventilation and gives some further examples. Perform sufficient analysis to document that loads can be met when credit is taken for passive cooling and natural ventilation using a simulation tool capable of ensuring thermal conditions are met with natural ventilation. A simple load calculation is not sufficient.

COMMON ISSUES WITH ENERGY MODELING (CONTINUED)

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section

	Service water heating
Hot water demand	Hot water demand savings from low-flow fixtures must be derived from WE Prerequisite or Credit Indoor Water Use Reduction calculations.
	Lighting
Lighting power density, method	Lighting power must be determined using the same categorization procedure (building area or space-by-space method) in both the proposed and baseline designs.
Lighting power density, multifamily	ASHRAE 90.1–2010 does not allow credit for lighting within dwelling units. Therefore, the lighting within these units must be modeled identically in both cases unless an exceptional calculation method is pursued. If credit is attempted, the lighting must meet prescribed illuminance levels. Refer to the ENERGY STAR's Multifamily High Rise Program Simulation Guidelines for examples.
Lighting power density, luminaire wattage	Table G3.1.6 requires that the proposed lighting power include all components shown on the plans and be determined in accordance with Sections 9.1.3 and 9.1.4. Ensure that the lighting calculations include all task lighting except where specifically exempted by ASHRAE 90.1 and that all power used by the luminaires, including lamps, ballasts, transformers, and controls, is taken into account. For track and other flexible lighting systems, use the specified wattage of the transformer supplying the system. The sum of lamp wattages will not necessarily meet the requirements of G3.1.6.
Lighting power density, additional lighting power	ASHRAE 90.1, Section 9.6.2, addresses the use of additional lighting power for decorative lighting, in retail areas, or when additional controls have been installed. Additional lighting is allowed only when using the space-by-space method and if it is "installed and automatically controlled, separately from the general lighting, to be turned off during nonbusiness hours." Therefore, the general lighting system must be separate and capable of providing general illumination to the space, and the additional lighting must have automated controls that shut it off during nonbusiness hours even when the general lighting remains on. In retail applications, a common mistake is that the lighting may not be used for any purpose other than to highlight the merchandise. Project teams can model the additional lighting power up to what has actually been designed, and no more; the baseline building must be modeled equal to what has been designed or up to the lighting allowance from ASHRAE 90.1, Section 9.6.2, whichever is less (i.e., credit may not be taken for unclaimed additional lighting power). Note that only the sales area can be used in the lighting power allowance. For example, do not use the entire project floor area (which may include space with other purposes, such as checkout areas, corridors, or dressing rooms) to determine the allowance. ASHRAE 90.1–2010 now allows an additional lighting power allowance based on the application of additional controls and using the control factors found in Table 9.6.2. This additional allowance may be used anywhere in the building and is based on the total wattage in the given space to which the control method is being applied. Unlike the retail allowance, this allowance is earned with the application of the control methods and may be added to the baseline whether or not the project designs up to the full allowance.
Automatic lighting controls	ASHRAE 90.1, Table G3.1(g), indicates that only automatic lighting controls, such as occupancy sensors, that are in addition to the required minimum control (Section 9.4.1) may be taken for credit. One of the most common errors is taking credit for an occupancy sensor located in a conference room; this is already a requirement of the baseline building. ASHRAE 90.1–2010 lists additional spaces that must have occupant sensors or timer switches that automatically turn off lighting. ASHRAE 90.1–2010 has added requirements for the lighting system and controls for buildings. Project teams are encouraged to read the standard, the User's Manual, and the lighting compliance forms to ensure that all mandatory measures have been met; these are prerequisites to LEED certification.
Exterior lighting	Exterior lighting is divided into allowances for tradable and nontradable surfaces. No credit may be taken for lighting reductions on nontradable surfaces. A lighting power allowance cannot be claimed in the baseline building for surfaces that are not provided with lighting in the actual design, and lighting fixtures cannot be double-counted for different exterior surfaces.
	Energy rates
Energy rates	Project teams must consistently use either actual utility rates or their state's average energy prices, published by the U.S. Department of Energy's Energy Information Administration for commercial building customers. The sources may not be mixed.

RATING SYSTEM VARIATIONS

Core and Shell

Energy cost savings are based on a building's total annual energy consumption, rather than on the owner's scope of work, so the owner of a core and shell project may have only a limited opportunity to improve energy savings. The thresholds for the prerequisite are therefore adjusted from 5% to 2%.

In a typical core and shell building, the owner provides base-building HVAC, whereas the tenant often installs light fixtures and other equipment. If the energy use of the base-building HVAC accounts for only a third of the overall building energy use, the building owner must find sufficient savings within that third needed to meet the prerequisite or require additional savings of the tenant in the lease agreement (see *Further Explanation, Common Issues in Energy Modeling*).

Because the owner cannot control the effect of future improvements on the total energy consumption of the core and shell project, for LEED energy modeling, items such as lighting or equipment loads for areas that are under the tenants' control must be identical in the proposed building and in the baseline, as specified by Appendix G. However, projects can claim credit for energy reductions in tenant spaces if those reductions (such as lighting power density reductions or improved HVAC efficiency) are required through a tenant lease agreement or other legally binding document. For example, if a 20% reduction in lighting power density is required by the tenant lease agreement, those savings can be claimed in the proposed model.

Zoning must be identical between the baseline and the proposed models. If HVAC zones are not defined in a tenant space, energy modelers should follow ASHRAE 90.1–2010, Table G.3.1.8:

- A typical rectangular floor plate must be composed of at least five zones: one perimeter zone for each orientation and one interior zone.
- Separately zone spaces such as mechanical rooms or bathrooms that can be confidently identified as differing from typical tenant use.
- To easily distinguish between energy use from owner and tenant spaces, projects must model separate electric meters for tenant lighting and plug loads.

Retail

Option 1. For projects using whole-building energy simulation, include all relevant process loads in the energy model and ensure that they are modeled accurately. Typical retail process loads include refrigeration equipment, cooking and food preparation, ice machines, display lighting for merchandise, clothes washing, and other major support appliances. Compare the energy consumption of each piece of equipment with the value indicated in Appendix 3, Tables 1–4. If the item is not included and the project team wishes to take credit, the exceptional calculation method must be followed.

For hard-wired refrigeration, the modeling software may be used if the system can be modeled explicitly. Otherwise, a thermodynamically similar component model must be used, in accordance with Table G3.1.13. An example of this would be an analysis prepared using 8760 hourly weather data.

For commercial kitchen equipment and refrigeration defined in Appendix 3, Tables 1–4, no additional documentation is necessary to substantiate these predefined baseline systems as industry standard. Supporting documentation is still needed to verify that the proposed equipment includes the claimed energy-efficient features.

Option 2. If the project team is using prescriptive compliance, ASHRAE 50% AEDG, and intends to earn points under EA Credit Optimize Energy Performance, also comply with the prescriptive measures in Appendix 3, Tables 1–4, for 90% of total energy consumption for all process equipment.

Data Centers

The guidance in this section is geared toward dedicated data centers and is not applicable to server closets or other small computer rooms. Mixed-use data centers, in which the data center takes up only a portion of the building space, may use this information as the basis of an exceptional calculation method.

The power requirements and energy use of the IT equipment in a data center typically dwarf the energy use of the cooling system and must be considered for optimizing energy use. The energy consumption of a data center's cooling system typically ranges from 15% to 25% of its total energy use, whereas in other commercial buildings, the HVAC energy consumption approaches 50% of the total energy consumption.[1]

1. *U.S. Department of Energy, 2011 Buildings Energy Data Book, March 2012.*

Data centers use special systems and equipment, such as large uninterruptible power supply (UPS), whose energy efficiency requirements are not defined by ASHRAE 90.1. Some of these systems will cause inefficiencies that can cascade through the power delivery chain, leading to increased energy usage in systems beyond those that support IT and, in most cases, creating additional cooling loads.

Stipulations for equipment reliability and maintenance often result in redundant equipment and systems. And the typical phased installation schedule for IT equipment (e.g., servers, storage, and networking gear) results in power and cooling systems that operate at a fraction of the design load. To gain a more accurate understanding of energy usage, teams should demonstrate the effects of partial-load conditions on the overall energy efficiency of the data center.

Modeling requirements

Energy modeling is required for all data center projects. As with other building types, projects must meet the minimum percentage savings before taking credit for renewable energy systems. The energy models are used to determine the data center's predicted power usage effectiveness (PUE) (see *Power Usage Effectiveness*, below).

The PUE must be reported for two operating conditions: one assuming a fully fit-out data center with all anticipated IT equipment, and one assuming the initial IT equipment loads in the project. This requires the project team to submit the results of one additional energy model beyond the two required by ASHRAE 90.1, Appendix G, for all data center projects.

IT equipment energy and electrical infrastructure energy savings

Because of the high process loads associated with IT equipment and its electrical infrastructure, many project teams look to these traditionally unregulated energy end uses for energy savings. Though not required, if the project team is attempting to claim energy savings from these end uses, the data center calculator may provide a simplified method (see *Data Center Calculator*, below).

The reduced energy consumption of the IT and electrical equipment can help reduce HVAC energy usage. Project teams have the option of claiming the process load savings in isolation or creating an additional energy model based on the adjusted loads to capture the associated HVAC energy savings.

To determine total energy cost savings, it may be necessary to create more than just the three energy models required. Below is a list of the models that may need to be created. The specific requirements of each model are detailed below.

1. Proposed model with full IT loading (normal performance rating method, PRM, model)
2. Proposed model with initial IT loading
3. ASHRAE model with full IT loading (normal PRM model)
4. ASHRAE model with initial IT loading (optional)
5. ASHRAE model with "baseline" IT loading (optional)

Although 5% energy savings is still required to meet the prerequisite requirements, a minimum of 2% energy cost savings must come from building systems, independent of IT equipment, and need to be demonstrated between models 1 and 3 (model 2 is used for the initial loading PUE condition).

If the project team is claiming energy savings related to the IT systems, the total energy savings are calculated between models 1 and 5. Alternatively, the project team may calculate the percentage savings based on the average of the savings under full IT loading (model 1 and either model 3 or 5) and the savings under initial IT loading (models 2 and 4). Although this is not required, it is intended to reward project teams for minimizing the losses associated with operating redundant equipment at low partial loads during initial IT loading.

Proposed model with full IT loading (model 1)

The model of the building's energy cost must include all regulated energy end uses as listed in the prerequisite criteria, as well as any unregulated energy that is building-specific. The proposed design must use the IT loads and schedule developed for the project. The IT loads should be at the values for the intended final buildout of the facility. All electrical system components—examples include incoming transformers, switchgear, UPS systems, and power distribution units—must be modeled. Power losses associated with this equipment should be assigned to the spaces that house the equipment as an electrical load and as a thermal load input to the energy model. Model the quantity of power and cooling equipment designed to run during normal operation to include the effects of operating redundant equipment at partial loading on energy use.

In addition to the ASHRAE 90.1 mandatory compliance requirements, provide energy efficiency data for the following items:

- Generator block heaters (wattage required to keep the block at the design temperature)
- Power distribution wiring
- Battery charging

Submit documentation for the following items, showing efficiency data at initial and full system loading points (loading values are a percentage of total IT load):

- Service transformers
- Switchgear
- Uninterruptible power systems
- Power distribution units

Proposed model with initial IT loading (model 2)

This model represents the proposed data center operating at its intended initial buildout. The proposed model with initial IT loading should contain everything that is in the proposed model with full IT loading, with the following modifications:

- The proposed model with initial IT loading must use the IT loads and schedule as developed for the project, at the expected initial loading of the data center.
- All electrical system components that will be installed in the first phase of the data center must be modeled. The losses associated with this equipment should be calculated based on their partial loading while taking into account any redundant equipment. Use the USGBC data center calculator to help with the calculation of the electrical losses for this equipment based on the partial loading conditions.

Model the quantity of power and cooling equipment designed to run during normal operation to include the effects of operating redundant equipment at partial loading on energy use.

ASHRAE model with full IT loading (model 3)

The baseline system airflow must be sized based on a 20°F (approximately 11°C) difference between the supply air and the return air.

ASHRAE model with initial IT loading (model 4)

This model is necessary only if the project team is claiming savings for the efficiency of the electrical support infrastructure when operating at low partial loads, as is common during initial startup. This model should be very similar to the ASHRAE model with "baseline" IT loading (model 5), except that the IT loads are reduced by the same percentage as in the proposed model with initial IT loading, and the losses due to the electrical infrastructure are calculated based on this IT loading. The USGBC data center calculator can help with the calculation of the electrical losses for this equipment based on the partial-load conditions.

ASHRAE model with "baseline" IT loading (model 5)

This model is used to calculate IT energy savings due to low-energy servers, virtualization, and efficient electrical system design. In contrast to the standard application of exceptional calculation methods to the proposed model, for data center projects, the exceptional calculation is applied to the baseline (model 3). Rather than reducing the energy used in the proposed design, the baseline is increased to reflect the energy usage typical of a data center.

For IT equipment, the USGBC data center calculator provides baseline documentation; if used, additional justification for the baseline IT loads is not necessary. IT equipment input is defined as the IT load as measured at the point of connection of the IT device to the electrical power system. IT equipment input captures the actual power load of the IT device exclusive of any power distribution losses and loads beyond IT devices, such as rack-mounted fans.

The losses associated with all UPS equipment, including that which serves mechanical equipment to achieve continuous cooling during a loss of power (e.g., pumps, air-handling units, and compressors), is considered not part of the IT energy usage but part of the energy consumption required to operate the data center.

If a hydronic cooling system is used for IT cabinets or computers, the energy consumed by the fans built into the cabinet and coolant distribution pumps should be considered HVAC energy use, not IT energy use.

Data center calculator

The data center calculator provided by USGBC creates a representative IT energy baseline based on the proposed design. The calculator consists of two main modules: one for the efficiency of the server equipment that comprises the IT system and one for the efficiency of the electrical system that delivers power to the IT system.

The calculator provides values that can be used as inputs for the electrical system energy consumption and heat loss for the proposed model with initial IT loading to calculate the initial PUE. The calculator generates the following two sets of values that may be used to determine energy savings:

- Annual energy consumption savings values, which can then be claimed directly, in isolation of any effects the reduced electrical load would have on the HVAC system
- Input values for the ASHRAE model with "baseline" IT loading and the ASHRAE model with initial IT loading that can then be used during simulation

The calculator's IT systems module compares energy use of a proposed IT equipment design with a predefined baseline. The current calculator analyzes energy use of computer servers only. Mainframes, storage, and networking equipment are not included in the overall energy demand calculation (as it relates to the reduction in energy). To claim savings from other types of IT equipment, the exceptional calculation method must be used.

Based on the entered values for total IT load and percentage breakdowns, the calculator generates kilowatt (kW) values for servers, storage, and networking equipment. The kW number for the servers, combined with the server utilization and the average power draw of the server, is used to calculate the number of physical servers that will be in the data center. Server power is based on ENERGY STAR's Computer Server Qualified Product List. If the number of physical servers and their power draw are known, enter these values.

Next, enter the percentage of servers that will host virtual machines in the data center and the average consolidation ratio. This rate of virtualization is used to calculate the server utilization percentage and then compared with a typical virtualization rate, which is used to calculate the number of servers in the baseline case.

Finally, indicate whether a power management strategy will be used. This input takes the percentage of servers that can go into sleep mode and the percentage of the time those servers can be in sleep mode. With these inputs, the calculator determines the energy demand for the IT system in kW and also generates the annual energy use in kWh of both the baseline case and the proposed case.

If desired, the calculated server demand value for the baseline IT load can be entered into the ASHRAE model, with baseline IT loading as the server demand in the data center. The baseline model should use the same schedules as the proposed model.

The data center calculator's electrical systems module uses the peak demand of the IT system to determine the size and power draw of the equipment. Peak IT demand values are automatically imported from the IT systems module. For the purposes of the calculator, the electrical system comprises the following elements:

- Incoming utility service transformer
- Uninterruptible power supply
- Power distribution unit

Based on the topology selected by the user, some of the energy that flows through the component is lost as heat, which must be included in the building energy model.

The heat loss differs at varying loads. Although it is important to benchmark operation at 100% load, it may be more important to benchmark at partial loads because electrical and cooling equipment, especially legacy equipment, will have much lower efficiencies at partial loads.

After determining the efficiency of the baseline electrical system, the calculator provides annual energy consumption in kWh. If desired, the losses associated with the system can be assigned to the supporting infrastructure rooms of the appropriate energy models.

Power usage effectiveness

PUE is the metric for characterizing and reporting the overall infrastructure efficiency of a building. Determine the PUE value of the proposed design using Equation 2.[2] This calculation should be performed twice: once for the proposed initial loading model and once for the proposed model with full IT loading.

EQUATION 2. Power usage effectiveness

$$\text{PUE} = \frac{\text{total data center energy consumption or power}}{\text{IT energy consumption or power}}$$

For example, if a facility uses 2,000,000 kWh of total energy, of which 1,600,000 kWh is attributable to IT equipment, its PUE is as follows:

$$\text{PUE} = \frac{2{,}000{,}000 \text{ kWh}}{1{,}600{,}000 \text{ kWh}} = 1.25$$

PROJECT TYPE VARIATIONS

Healthcare, Warehouses, and Laboratories

These projects are not eligible to pursue Option 3.

District Energy Systems

Projects that are served by district energy systems (DES) may demonstrate compliance with EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance by following one of the following methods.

- Option 1, Whole-Building Energy Simulation. The project team may choose Path 1 ASHRAE 90.1-10 Appendix G, Path 2 Full DES performance accounting, or Path 3 Streamlined DES modeling. The modeling path chosen by the project team may depend on the relative efficiency of the DES to which the project is connected, how much DES information is available, or whether an energy model already exists for the system.Whenever possible, incorporate system and equipment performance parameters directly into the energy simulation. Potential methods include developing efficiency curves and scheduling equipment operation and curves. Postprocessing of DES performance is acceptable if reasonable simulation methods are not available or are too onerous. All postprocessing methodologies must be fully documented.
- Option 2 Prescriptive Compliance: ASHRAE 50% AEDG, and Option 3 Prescriptive Compliance: Advanced Buildings Core Performance Guide. The project team must include or exclude effects of upstream DES equipment as specified in the applicable referenced standard for the selected option. If the referenced standard does not specify either approach, the upstream effects must be excluded.

All Options: Scope of DES Equipment Inclusion

All downstream equipment must be included in the scope of EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. Downstream equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls. Upstream equipment is included or excluded depending on the chosen option and path.

Option 1, Path 1. ASHRAE 90.1–2010, Appendix G

Model the proposed and baseline designs using purchased energy according to ASHRAE 90.1–2010, Appendix G.

Energy rates

All virtual DES energy rates must be identical in the baseline and proposed cases. If tariffs or rates are not available from the district plant serving the project, such as for campus or military plants, calculate the rates based on the virtual electric and fossil fuel rates from the model.

2. *Recommendations for Measuring and Reporting Overall Data Center Efficiency, Version 2, Measuring PUE at Data Centers.*

If a flat rate structure, in which the cost per unit of energy is the same throughout the year and there are no demand charges, is being used for all energy sources, then those flat rates become the virtual energy rates for the project.

If all energy rate structures are not flat, a preliminary run of the Option 1 baseline case energy model must first be completed to identify the virtual electric and fossil fuel rates for the project. For this preliminary run only, the rate for the DES-supplied energy may be left blank or entered as any value.

Once all the virtual energy rates are known for electricity and fossil fuel, calculate the virtual DES rates for both the baseline and proposed case per the values in the minimum energy performance calculator.

Exception: to obtain the virtual fuel rate when the connected building does not use fossil fuel but the DES central plant does, use a flat rate consistent with the central plant rates or the historical average local market rates. No preliminary model run is needed. Input the virtual DES rates into the modeling software for each DES source and use for the remainder of the process. Alternatively, calculate the DES energy costs directly by multiplying the DES energy consumption for each DES source by its virtual DES rate.

Energy Rates for Path 1:

If tariffs or rates are not available from the district plant servicing the project (e.g. for campus or military plants), calculate the rates based on the virtual electric and fossil fuel rates from the model:

- If a flat rate structure is being used for all energy sources (meaning the cost per unit energy is the same throughout the year, and there are no demand charges), then these flat rates simply become the virtual energy rates for the project.
- Otherwise, if all energy rate structures are not flat, then a preliminary run of the
- Option 1 Baseline Case energy model must first be completed to identify the virtual electric and fossil fuel rates for the project. For this preliminary run only, the rate for the DES-supplied energy may be left blank, or may be entered as any value.
- Once all the virtual energy rates are known for electricity and fossil fuel, the virtual DES rates for both the Baseline and Proposed Case are then derived as follows:

District Chilled Water Rate:

$$\frac{\text{Units of \$}}{(\text{Btu x }10^6)} = \begin{array}{c}\text{Virtual Electric Rate}\\ \text{(in \$/kWh)}\end{array} \times 71$$

$$\frac{\text{Units of \$}}{\text{ton-hour}} = \begin{array}{c}\text{Virtual Electric Rate}\\ \text{(in \$/kWh)}\end{array} \times 0.85$$

$$\frac{\text{Units of \$}}{\text{kWh}} = \begin{array}{c}\text{Virtual Electric Rate}\\ \text{(in \$/kWh)}\end{array} \times 0.24$$

District Hot Water Rate:

$$\frac{\text{Units of \$}}{(\text{Btu x }10^6)} = \begin{array}{c}\text{Virtual Fuel Rate}\\ \text{(in \$/(Btu x }10^6\text{))}\end{array} \times 1.59 + \begin{array}{c}\text{Virtual Electric Rate}\\ \text{(in \$/kWh)}\end{array} \times 3$$

$$\frac{\text{Units of \$}}{\text{kWh}} = \begin{array}{c}\text{Virtual Fuel Rate}\\ \text{(in \$/kWh)}\end{array} \times 1.59 + \begin{array}{c}\text{Virtual Electric Rate}\\ \text{(in \$/kWh)}\end{array} \times 0.01$$

$$\frac{\text{Units of \$}}{\text{therm}} = \begin{array}{c}\text{Virtual Fuel Rate}\\ \text{(in \$/therm)}\end{array} \times 1.59 + \begin{array}{c}\text{Virtual Electric Rate}\\ \text{(in \$/kWh x 0.3}\end{array}$$

District Steam Rate:

$$\frac{\text{Units of \$}}{(\text{Btu x }10^6)} = \text{Virtual Fuel Rate (in \$/(Btu x }10^6)) \times 1.81 + \text{Virtual Electric Rate (in \$/kWh)} \times 3$$

$$\frac{\text{Units of \$}}{\text{kWh}} = \text{Virtual Fuel Rate (in \$/kWh)} \times 1.81 + \text{Virtual Electric Rate (in \$/kWh)} \times 0.01$$

$$\frac{\text{Units of \$}}{\text{therm}} = \text{Virtual Fuel Rate (in \$/therm)} \times 1.81 + \text{Virtual Electric Rate (in \$/kWh x 0.3)}$$

- Exception: to obtain the virtual fuel rate when the connected building does not use fossil fuel but the DES central plant does, use a flat rate consistent with the central plant rates or the historic average local market rates (no preliminary model run is needed). The virtual fuel rates must match in the Baseline and Proposed Case.
- The virtual DES rates are then input into the modeling software for each DES source and used for the remainder of the process. Alternatively, the virtual DES rates may be used to calculate the DES energy costs directly by multiplying the DES energy consumption for each DES source by its virtual DES rate. All virtual DES energy rates must be identical in the Baseline and Proposed Case.

Option 1, Path 2. Full DES Performance Accounting

Path 2 is available to projects connected to DES that wish to account for average efficiency across a smaller time step. The energy model scope accounts for both downstream equipment and upstream equipment and requires calculation of the district energy average efficiencies using either modeling or monitoring.

Energy rates

All DES energy rates must be identical in both the baseline and the proposed cases. Use local rates as they would normally apply to the building for the energy sources under consideration. For energy sources used by the DES but not normally available to the building, such as diesel fuel, use the rates charged to the DES. If this information is not available, use representative market rates.

Exception: For DES plants that operate under specific and atypical rate structures and actively take advantage of those rates through strategies such as load management or energy storage, use the rate structures as they apply to the DES.

Baseline building plant

Model the baseline case with an on-site plant that is compliant with ASHRAE 90.1–2010, Appendix G, baseline requirements for site-generated thermal energy. Model the baseline building plant with conventional equipment using performance parameters and efficiencies per ASHRAE 90.1–2010, using energy sources corresponding to the DES.

Proposed building plant

Model the proposed case with a virtual DES-equivalent plant. Model a virtual plant with the same efficiencies as the entire upstream DES heating, cooling, and combined heat and power (CHP) systems, including all distribution losses and energy use. Equipment efficiencies, distribution losses, and distribution pumping energy may be determined using any of the following methods:

- Monitored data
- Engineering analysis
- Default values

Efficiencies and losses may be determined and modeled at any level of time resolution, from hourly to annual. However, the time resolution must be sufficiently granular to capture and reasonably represent any significant time- or load-dependent interactions between systems, such as thermal storage or CHP.

Monitoring and analytical methods may be combined as necessary and appropriate.

Monitoring data for heating, cooling, pumping, and cogeneration may be used only if the thermal loads that are monitored represent at least 90% of the load on the campus or district plant predicted after building occupancy.

Whether using monitoring or an analytical method, the methodologies must be fully documented. The following specific requirements apply.

Heating and cooling plants

Efficiencies, whether determined through monitoring or analytically, must include all operational effects, such as standby, equipment cycling, partial-load operation, internal pumping, and thermal losses.

Thermal distribution losses

Use monitored data or an engineering analysis.

Monitored data determine the distribution losses for the DES by measuring the total thermal energy leaving the plant and comparing it with the total thermal energy used by the buildings connected to the DES. Rate the plant efficiency accordingly in the energy model:

$$\%\text{ plant efficiency} \times \left\{ 100\% - \%\text{ distribution loss} \right\}$$

An engineering analysis takes into consideration all distribution losses between the DES and the building. For distribution main losses, use a prorated amount based on load. For dedicated branch losses, use the total losses of the branch that feeds the building, including heat losses and steam trap losses. Compare the total losses with the total load of the building to get a percentage distribution loss relative to load and downgrade the plant's efficiency accordingly in the energy model.

Pumping energy

Whether through monitored data or engineering analysis, determine pumping energy for the project by prorating the total pump energy of the DES by the ratio of the annual thermal load of the building to the total annual DES thermal load. Model the pump energy as auxiliary electrical load. Pumping energy must be determined or estimated where it applies (i.e., there is no default value).

Default efficiencies and losses

Actual efficiency performance data on the DES serving the project building is preferred. If the project team cannot obtain or determine the actual performance data, use the following default values. These values are conservative and are intended to represent a DES with relatively low efficiency; a well-designed, well-operated DES generally performs better.

- DES heating plant: 70% (higher heating value, HHV) for the total boiler plant average efficiency
- DES cooling plant: coefficient of performance (COP) of 4.4 for the total cooling plant average efficiency (including cooling towers and primary pumps)
- Thermal distribution losses including minor leaks or condensate losses:
    - Chilled water district cooling, 5%
    - Hot water district heating, 10%
    - Closed-loop steam systems, 15%
    - Open-loop steam systems, 25%

For steam systems that are partially open and partially closed, prorate between the above 15% and 25% losses in accordance with the fraction of expected or actual condensate loss.

The above guidance assumes that DES-generated heat is used for heat in the connected building, and DES-generated cooling is used for cooling in the connected building. If the DES produces heating that is then converted to cooling for the connected building using absorption chillers or other similar technology, this guidance must be modified (see *CHP Modeling Guidance*).

Option 1, Path 3. Streamlined DES Modeling

Path 3 is applicable for simple district energy systems. The energy model scope accounts for both downstream equipment and upstream equipment and also requires calculation of the district energy average efficiencies using either modeling or monitoring.

Energy rates

Use the streamlined DES modeling in the calculator provided by USGBC to allocate the energy costs to the results of the model for each district energy source, in lieu of the purchased energy rates, to determine the baseline and proposed case energy costs.

Baseline building plant

Calculate the average annual efficiency values for each district energy fuel source used to generate and distribute the thermal energy based on ASHRAE 90.1–2010, Appendix G, baseline case requirements. These values depend on the ASHRAE 90.1–2010 system type that would be selected for the building if the baseline case were modeled with on-site equipment. The calculations for baseline cost per district energy source are the same as those for the proposed case model, except that the average efficiency is constant.

Proposed building plant

Determine a single value for average annual efficiency, including thermal losses and distribution energy, for each district fuel energy source used to generate and distribute the thermal energy. For example, for chilled water:

$$\text{COST(CHW)}_{\text{BUILDING}} = \text{CHW}_{\text{BUILDING}} \times \sum_{i} (\text{Cost}_i \times \eta_i)$$

where

$\text{COST(CHW)}_{\text{BUILDING}}$	=	proposed case cost of chilled water
$\text{CHW}_{\text{BUILDING}}$	=	building energy model metered data for chilled water consumption
i	=	each fuel source used at the district plant to generate or distribute chilled water (e.g. electricity, diesel oil)
Cost_i	=	virtual energy rate for each fuel source (in $/unit energy). This should match the proposed case virtual energy rate for fuel sources present in the building, and should be supported by local energy tariffs for fuel sources not present in the building.
η_i	=	average efficiency calculated for each fuel source

Special Situations for DES Energy Models

CHP Modeling Guidance

The baseline case is modeled as described in ASHRAE 90.1, Appendix G, and as summarized in the steps for each path. The baseline model assumes separate production of electricity and thermal energy. Although not modeled as CHP, the baseline case is charged with extra energy use for CHP energy accounting purposes in some situations.

The proposed case may be modeled in various ways.

- The average electricity generation, fuel input, and heat recovery of the CHP must be determined, or the defaults for electric and thermal efficiency (below) must be used in conjunction with capacity ratings of the equipment.
- Calculate annual electricity generation using one of the following methods:
  - Monitor the total annual gross electricity generation. Also monitor the total annual parasitic loads, such as the annual electricity used for cooling the intake air for a turbine. Calculate the net annual electricity generation by subtracting all parasitic loads from the annual gross electricity generated.
  - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators. Apply measured or estimated load profiles as process loads to reflect the estimated total electric and thermal loads on the district energy CHP system. Use the total energy generated and total fuel input from this analysis. Any parasitic loads must be included in the analysis and subtracted from the annual electricity generation.
- Calculate annual fuel input using one of the following methods:
  - Monitor the total annual fuel input to the generators.
  - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators.
- Calculate waste heat recovery using one of the following methods:
  - Monitor the total waste heat recovered.
  - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators. Model the thermal equipment served by the CHP waste heat, such as boilers and absorption chillers, using the installed equipment capacities, efficiencies, and efficiency curves, and reflecting the total heating and cooling loads on the plant as a process load. Use the energy modeling outputs to identify the total heat recovered.

For baseline CHP electricity output, follow the general procedures described in this section for the proposed case, and adjust the results as follows depending on the results of the DES electricity allocation and the total modeled electricity use of the building in the Path 2 or Path 3 proposed case, including the electricity consumption of district plant equipment serving the building:

- Scenario A. If the building's allocation of CHP-generated electricity is less than or equal to its modeled electricity consumption, no adjustment is necessary. The baseline building is charged with the energy used by its (non-CHP) systems at market rates using standard procedures.
- Scenario B. If the building's allocation of CHP-generated electricity exceeds its modeled electricity consumption, the amount of excess CHP electricity allocated to the building is considered process energy in the energy model. Adjust the input fuel associated with this excess CHP electricity in the baseline case as described in CHP fuel input.

For the proposed design's CHP electricity output, allocate the electricity generation to the building based on the fraction of thermal loads to the building for the DES sources that use recovered waste heat. For each DES source supplied to the building, determine the fraction of the recovered waste heat applied to that source as well as the amount serving the project building. For relatively simple DES systems, in which the recovered waste heat is used directly in the DES, and for which waste heat serves only heating loads in the connected buildings, use the formula for simple systems:

$$CHP\_ELEC_{BLDG}(\text{simple systems}) = (X_{HEAT} \times BLDG_{HEAT}) \times CHP\_ELEC_{TOTAL}$$

where

CHP_ELEC_{BLDG}	=	CHP electricity generation allocated to building
X_{HEAT}	=	fraction of CHP plant's total production of waste heat applied to the DES directly
$BLDG_{HEAT}$	=	fraction of total district heat provided to building
CHP_ELEC_{TOTAL}	=	total CHP electricity generated at DES plant

For CHP plants in which a portion of the recovered heat is used to drive absorption chillers that provide cooling through a DES chilled-water loop, or a portion of the recovered heat is used for a third, separate district energy source (e.g., if the building connects to both a steam loop and a hot-water loop), calculate the electricity generation assigned to each building using the formula for heat recovery-driven chillers.

$$CHP\_ELEC_{BLDG}\,(\text{heat recovery-driven chillers}) = (X_{HEAT} \times BLDG_{HEAT}) + (Y_{CHW} \times BLDG_{CHW}) + (Z_{SOURCE} \times BLDG_{SOURCE}) \times CHP\_ELEC_{TOTAL}$$

where

CHP_ELEC_{BLDG}	=	CHP electricity generation allocated to building
X_{HEAT}	=	fraction of CHP plant's total production of waste heat applied to the DES directly
$BLDG_{HEAT}$	=	fraction of total district heat provided to building
Y_{CHW}	=	fraction of CHP plant's total production of waste heat applied to producing chilled water in DES
$BLDG_{CHW}$	=	fraction of total district chilled water provided to building
Z_{SOURCE}	=	fraction of third district energy source provided to building
$BLDG_{SOURCE}$	=	fraction of third district energy source provided to building
CHP_ELEC_{TOTAL}	=	total CHP electricity generated at DES plant

When modeling CHP fuel input, allocate the CHP input fuel to the project building based on a proration and assignment of the total input fuel according to the results of the CHP electricity allocation described above for CHP electricity output. Use the prevailing energy rates as they apply to the project. Any additional energy used by the proposed design is also charged at market rates.

For the proposed case (all projects), calculate the CHP input fuel allocated to the building as follows:

$$\text{Proposed BLDG}_{FUEL} = \left(\frac{\text{CHP\_ELEC}_{BLDG}}{\text{CHP\_ELEC}_{TOTAL}}\right) \times \text{CHP}_{FUEL}$$

where

Proposed CHP_ELEC_{BLDG}	=	proposed case CHP input fuel allocated to building
CHP_ELEC_{TOTAL}	=	CHP electricity generation allocated to building (from previous calculations)
CHP_{FUEL}	=	total CHP electricity generated at DES plant
CHP_ELEC_{TOTAL}	=	total CHP fuel input for electricity generation at DES plant

For the baseline (scenario B in CHP electricity output only): calculate the CHP input fuel allocated to the building as follows:

$$\text{Baseline BLDG}_{FUEL} = \left(\frac{\text{PROCESS\_ELEC}_{BLDG}}{\text{CHP\_ELEC}_{TOTAL}}\right) \times \text{CHP}_{FUEL}$$

with

$$\text{PROCESS\_ELEC}_{BLDG} = \text{CHP\_ELEC}_{BLDG} - \text{PROPOSED\_ELEC}_{BLDG}$$

where

Baseline BLDG_{FUEL}	=	baseline case CHP input fuel charged to building
$\text{PROCESS\_ELEC}_{BLDG}$	=	amount of allocated CHP electricity in excess of building's modeled annual electricity consumption (treated as process energy in model)
CHP_ELEC_{TOTAL}	=	total CHP electricity generated at DES plant
CHP_{FUEL}	=	total CHP fuel input for electricity generation at DES plant
CHP_ELEC_{BLDG}	=	CHP electricity generation allocated to building (from previous calculations)
$\text{PROPOSED\_ELEC}_{BLDG}$	=	modeled electricity consumption for building from proposed case

The model must include CHP generator default efficiencies. Actual efficiency performance data on the CHP serving the project building is preferred, based on either ongoing operations (existing CHP) or design specifications (new CHP). If the project team cannot obtain the actual performance data, use the following default seasonal performance values. These values are conservative, intended to represent a CHP system with relatively low efficiency. A well designed, maintained, and operating CHP system will generally offer better performance than the defaults listed below.

- Generator electrical efficiency, 22%
- Generator thermal efficiency, 25%
- Single-effect absorption chillers, 0.60 COP
- Double-effect absorption chillers, 0.90 COP
- Absorption cooling plant electrical efficiency, including cooling towers and primary pumps, 40 COP

Service water heating

If service water is heated in full or in part by DES-supplied heat, consider modeling the energy source as purchased energy to hold the DES cost-neutral for service water heating. If desired, project teams using Path 2 or Path 3 may use an exceptional calculation method to document DES-related savings from service water heating. Project teams that elect to document savings must fully justify and support the annual energy consumption and cost in both the baseline and the proposed models. Use a reasonable, well-founded purchased energy rate in the models, such as the actual rate paid to the DES supplier or a virtual rate.

Heating converted to cooling

Sometimes the district or campus system heating energy supply is converted to chilled water using absorption chillers or other similar technologies to serve cooling loads. In this circumstance, the equipment that converts heating to cooling may reside within the DES itself, (i.e., DES provides cooling to the building) or within the connected buildings (i.e., DES provides heating to the building; building converts heating to cooling). When the equipment that converts DES-supplied heat into cooling is part of the LEED project's scope of work, the DES guidance is modified for Option 1, Whole Building Simulation, as follows:

- Model the district heating source servicing the chilled water generation equipment as follows:
  - For Path 1, use purchased heat in both the baseline and proposed cases.
  - For Path 2 or 3, use a virtual upstream DES plant for the proposed case and compare it with code-compliant on-site equipment for the baseline case.
- For Path 1, model absorption chillers in the baseline case as follows:
  - When the purchased heating is hot water with average supply temperatures below 300°F (148.9°C), the chillers must be modeled as single-effect absorption chillers (0.7 COP).
  - When the purchased heating is steam or hot water with average temperatures greater than or equal to 300°F (148.9°C), the chillers must be modeled as double-effect absorption chillers (1.0 COP).
  - If the building peak cooling load is less than 300 tons (1050 kW), model one water-cooled absorption chiller.
  - If the building peak cooling load is between 300 tons (1050 kW) and 600 tons (2100 kW), model two water-cooled absorption chillers, sized equally.
  - If the building peak cooling load is more than 600 tons (2100 kW), model a minimum of two water-cooled absorption chillers, with chillers added such that no chiller is larger than 800 tons (2800 kW), all sized equally.
  - For a project with both absorption chillers driven by purchased hot water and electric chillers on site, the type and quantity of absorption chillers must be as identified above, and the type and quantity of electric chillers must be as in Table G3.1.3.7 (or DX equipment as specified), but the total capacity ratio of electric to absorption cooling must be identical to that of the proposed design.
  - For a project including both district chilled water and absorption chillers on-site driven by purchased heating, the type and quantity of absorption chillers must be as identified above, and purchased cooling must also be modeled in accordance with the district energy modeling guidance. However, the total capacity ratio of the on-site cooling to purchased cooling must be identical to that of the proposed design.
- Model the baseline case cooling towers, pumps, chilled water loop configurations, and loop temperature controls as indicated in Appendix G.
- Model the absorption chillers in the proposed case based on the as-designed type and capacity of chillers.

Other atypical systems

DES also often incorporate unconventional features, such as thermal storage, ground or surface water cooling, and waste heat recovery. These features should be incorporated into the proposed virtual plant to the greatest extent practical using the general principles presented in this guidance.

MULTIFAMILY ENERGY MODEL SIMULATION GUIDELINES

Simulation Software

All LEED Multifamily Midrise projects are required to use simulation software that complies with the requirements in ASHRAE Standard 90.1-2010, Section G2.2. This includes the ability to perform hourly simulations, taking into account variations in occupancy, lighting, thermostat settings, etc. ASHRAE 90.1-2010 G2.2 includes various stipulations for the simulation software. Section G2.2.1 requires that a qualified simulation program explicitly model all of the following:

- 8,760 hours per year;
- Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat setpoints, and HVAC system operation;
- thermal mass effects;
- ten or more thermal zones;
- part-load performance curves for mechanical equipment;
- capacity and efficiency correction curves for mechanical heating and cooling equipment;
- air-side economizers with integrated control; and
- baseline building design characteristics specified in ASHRAE 90.1–2010, Section G3.

Qualified, commonly used modeling software for ASHRAE 90.1–2010 includes – but is not limited to – the following: DOE-2-based modeling programs (eQuest, EnergyPro, VisualDOE), HAP, TRACE, VisualDOE, EnergyPro, EnergyGauge, and EnergyPlus.

See 'Submittal Documentation' for the submittal requirements particular to a subset of different software pieces.

Residential Simulation Guidelines

This section provides mandatory modeling guidelines for multifamily projects. These guidelines are designed to supplement the procedures in ASHRAE Std. 90.1-2010, Appendix G, with the interest of providing clarification and consistency in the modeling process.

TABLE 2.3.1. SIMULATION GUIDELINES FOR MULTIFAMILY PROJECTS

Proposed Design	Baseline Design
Building Envelope	
Proposed design envelope components shall reflect the full assembly U-value, rather than a point U-value, taking into account thermal bridging. Appendix A must be used to determine thermal properties of the proposed design envelope. All penetrations including those for balconies should be accounted for in the assembly U-value. Refer to the ASHRAE 90.1-2010 User's Manual for further guidance.	Residential envelope requirements in Std. 90.1-2010 Table 5.5 apply only to dwelling units (which includes floor cavities below dwelling units). Corridors, stairwells, lobbies, and other residential-associated (but non-unit) spaces may be considered 'nonresidential'.
If present, all HVAC envelope penetrations (e.g. through-wall AC sleeves and PTAC/PTHP penetrations) shall be modeled with the U-factor required in 90.1-2010, Table 5.5 for vertical glazing with metal framing (all other).	The envelope U-factor shall not be adjusted to account for HVAC envelope penetrations.
	When the proposed design is a wood-framed building, fenestration in the baseline design shall be based on prescriptive requirements for vertical glazing with nonmetal framing within Std. 90.1-2010 Table 5.5. When the proposed design is a non-wood-framed building, fenestration in the baseline design shall be based on prescriptive requirements for vertical glazing with metal framing within Std. 90.1-2010 Table 5.5.
	Doors within the proposed design that are more than 50% glass shall be treated as 100% vertical fenestration within the baseline design. Doors within the proposed design that are 50% or less glass shall be treated as opaque doors within the baseline design.
Lighting	
In-unit lighting shall be included in the performance rating calculations and based on hard-wired lighting fixtures. Lighting energy savings credit may be claimed for reduced power density only if the fixtures are capable of meeting the recommended light levels for the given space type, per the IESNA Lighting Handbook. For areas without hard-wired fixtures, or areas that do not meet the IESNA lighting levels, the LPD shall be set as equal to the baseline design LPD. Modeled lighting power must include power consumed by the ballasts as well as the bulbs. Fixtures with screw-based sockets may be modeled based on the actual installed lights, *not the maximum labeled wattage for that fixture*, on the condition that they are visually verified by a third-party rater.	In-unit lighting shall be included in the performance rating calculations, and the baseline design LPD shall be set as 0.9 W/ft^2.
Dwelling unit spaces shall be modeled as lit for 2-3 hours per day. Corridors, stairwells, and lobbies shall be modeled as lit for 24 hours/day. Other non-unit spaces shall be modeled as lit to reflect the automatic control requirements in 90.1-2010 Section 9.4.1. Modelers are encouraged, but not required, to use ASHRAE default schedules for these other non-unit spaces. Garage lighting shall be modeled as lit for 18 equivalent full load hours per day, to reflect the garage lighting control requirement in 90.1-2010 Section 9.4.1.3.	Lighting schedules shall be set equal to those in the proposed design.

Proposed Design	Baseline Design
Credit for automatic control devices shall be reflected in the proposed design lighting power density calculations, (not schedules), per the following: Corridors – 25% power adjustment reduction Stairwells – 35% power adjustment reduction Lobbies – 10% power adjustment reduction All other – use power adjustment reductions from Std. 90.1-2010 Table G3.2 No adjustment should be made for spaces where lighting controls are already required by Std. 90.1-2010. Credit is only available for sensors that reduce lighting to zero power within 30 minutes of all occupants leaving the zone.	No adjustment should be made to schedules or LPD values based on lighting controls.
Exterior Lighting	
Exterior lighting is divided into allowances for tradable and nontradable surfaces. No credit may be taken for lighting reductions on nontradable surfaces.	A lighting power allowance cannot be claimed in the baseline design for surfaces that are not provided with lighting in the proposed design, and allowances cannot be double-counted for different exterior surfaces that overlap (for example, walkways through uncovered parking areas).
Façade and landscape lighting shall be modeled as lit for no more than 6 hours/day, to reflect ASHRAE Std. 90.1-2010 Section 9.4.1.7, part (b). All other exterior lighting shall be modeled as lit for 6 hours/day at 70% power and no more than 6 hours/day at full power, to reflect the requirements in 90.1-2010 Section 9.4.1.7.	Lighting schedules shall be set equal to those in the proposed design.
If private balconies are specified with lighting, they shall be modeled as lit for 2-3 hours per day.	Private balconies shall be modeled using the same schedule as used in the proposed design. Private balconies can be treated as Tradable, using “Other doors”, or as Nontradable, using “Building façades”.
HVAC	
	Spaces within the proposed design that have electric space heating but natural gas pre-heat of outside air are considered to have fossil/electric hybrid heating system for the purpose of Table G3.1.1A.
	Residential-associated spaces (i.e. corridors, stairwells, lobbies, amenity spaces, and other spaces that primarily serve the residents) may be considered non-residential area OR residential area when determining applicability for that do not meet Exception (a) or Exception (e) of Section G3.1.1 Exception (a). If the total non-residential area is less than 20,000 square feet, the non-residential spaces shall be modeled with the same HVAC system type (System 1 or 2) as the in-unit spaces. If classified as a residential space, Residential-associated spaces that have a different heating source than the in-unit spaces exceeding 20,000 square feet or building area perand satisfy Exception (a) of Section G3.1.1 shall be modeled with the appropriate residential system type (System 1 or 2), per Table G3.1.1A.
The following setpoints shall be used for dwelling unit spaces: Heating: 12-7am: 70 degrees; 7am – 11pm: 72 degrees; 11pm-12am: 70 degrees Cooling: 12-9am: 78 degrees; 9am – 3pm: 80 degrees; 3pm – 12am: 78 degrees	Heating and cooling setpoints shall be equal to those in the proposed design.
The HSPF rating for packaged heat pump units smaller than 65,000 Btu/h (19 kW) already accounts for electric auxiliary operation. The heat pump efficiency curves used in the model should reflect the heat pump ratings that account for simultaneous operation of the electric resistance and heat pump elements below 40 degrees F.	Per Section G3.1.3.1, for baseline designs with System 2 (PTHP) or System 4 (PSZ-HP), auxiliary heat shall be energized only when outdoor air temperature is below 40 degrees F. Below 40 degrees F, the heat pump and auxiliary heat shall be modeled to operate together, with the compressor as the lead machine. The heat pump should only be set to cut off when the outside air temperature drops below 17 degrees F for system type 4 (Packaged heat pump), or down to 35 degrees F for system type 2 (Packaged terminal heat pump).
No performance credit or adjustments to the model should be taken to reflect improvements in the proposed design distribution system (piping or ductwork) unless or until explicit approval is given by GBCI.	
If needed, use the following SEER to EER conversion: EER = –0.026 x SEER2 + 1.15 x SEER If needed, using the following heating efficiency conversions: Heat Pump: COP = 1.48E-7 x COP47 x Q + 1.062 x COP47 Other systems: COP = -0.0296 x HSPF2 + 0.7134 x HSPF	Use the EER and COP values from Std. 90.1, Section 6.

Proposed Design	Baseline Design
Ventilation & Infiltration	
The modeled outside air rate shall be equal to the sum of the infiltration and mechanical ventilation rates. Measured infiltration (i.e. envelope leakage) rates are not used. Default infiltration rates of the software tool may be used.	The infiltration rate shall be equal to the rate used in the proposed design. The baseline design mechanical ventilation rate shall be modeled as equal to the rates allowed by ASHRAE 62.2 (in dwelling units) or 62.1 (outside dwelling units), or the applicable local codes, whichever is more stringent.
The mechanical ventilation rate shall account for both whole-house fans and local exhaust fans (bathroom and kitchen fans), and reflect specified fan capacities and control schedules. If not specified, local exhaust fans should be assumed to run 2 hours per day (or may be converted to an equivalent 24-hour runtime if combined with whole-unit ventilation).	The baseline design mechanical ventilation rate shall be modeled as equal to the rates allowed by ASHRAE 62.2 (in dwelling units) or 62.1 (outside dwelling units). This creates a penalty for proposed designs that overventilate.
Ventilation controls required by ASHRAE 90.1-2010, Section 6.4.3.4 (mandatory provision) shall be represented in the model. For example, per Section 6.4.3.4.2, both outdoor air supply and exhaust systems shall be equipped with motorized dampers to automatically shut when the systems or spaces are not in use. This shall be reflected such that outside air rates in applicable common spaces (e.g. community rooms, offices, laundry rooms) are zero during unoccupied periods unless the supplemental documentation supports that ventilation during unoccupied periods reduces energy cost or is required by local code.	Mechanical ventilation schedules should be equal to those used in the proposed design, unless the following exception is met: The proposed design includes demand control ventilation (see Appendix G) that is approved by GBCI. Note: exhaust ventilation in kitchens and bathrooms with manual control or interlocked with lighting switch does not qualify as demand control ventilation.
Fans	
In the proposed design, all fans (air-handling unit, ventilation, exhaust, etc.) shall be modeled using actual equipment specifications and project conditions and parameters. Note: heat and energy recovery ventilation systems tend to increase the pressure drop in the ductwork, leading to increased fan energy consumption. This increase shall be explicitly modeled in the proposed design, as appropriate.	PTAC/PTHP fans serving dwelling units shall be modeled to run continuously. Baseline design fan power is determined by Standard 90.1, Section G3.1.2.10; PTAC/PTHP fan power shall be modeled as 0.3 W/CFM. Range hoods up to 500 CFM shall be modeled in the baseline design as 0.43 W/CFM. Large bathroom and utility fans (80+ CFM) shall be modeled in the baseline design as 0.43 W/CFM. Smaller bathroom and utility (80CFM and less) shall be modeled in the baseline design as 0.83 W/CFM. Fan energy use associated with the proposed design whole-unit ventilation system must be omitted; the continuous PTAC/PTHP fan is assumed to operate as the de facto ventilation system in the baseline design. No heat or energy recovery shall be modeled.
Supply and exhaust fans that are installed for a purpose other than providing whole-unit ventilation, such as bathroom and kitchen local exhaust fans, laundry make-up air fans, trash room exhaust, etc. shall be modeled as process loads. Kitchen and bathroom fans that are activated with manual controls or interlocked with lighting switches (i.e. not running continuously or being used to meet 62.2 whole-house ventilation requirements) should be modeled to run for 2 hours/day.	Supply and exhaust fans that serve a purpose other than providing whole-unit ventilation shall be modeled as process loads, and follow the same schedules used in the proposed design.
Garages that are at least 30,000 ft^2 and/or include any space heating or cooling shall be modeled with ventilation runtimes of 8.4 hours/day (to reflect the requirements in Std. 90.1-2010, Section 6.4.3.4.5). Garage fan power shall be calculated based on design specifications. Garages that are 30,000 ft^2 or smaller and include no heating or cooling shall be modeled with ventilation runtimes of 24 hours/day. If the proposed design includes contaminant sensors that meet the requirements of Std. 90.1-2010, Section 6.4.3.4.5, the following options exist Option 1: Model the baseline design with a garage fan power of 0.30 W/CFM, a schedule of 24 hours/day, and an air flow rate of 0.75 CFM/ft^2. Model the proposed design with a garage fan power based on design specifications, a schedule of 8.4 hours/day, and an air flow rate based on the proposed designs. Option 2: Model both the baseline and proposed design with the same garage fan power (W/CFM) and fan air flow rates (CFM/ft2), based on the design specifications. Model both the baseline and proposed design with a schedule of 8.4 hours/day.	Garages that are at least 30,000 ft^2 and/or include any space heating or cooling shall be modeled with ventilation runtimes of 8.4 hours/day (to reflect the requirements in Std. 90.1-2010, Section 6.4.3.4.5); the garage fan power shall be modeled as equal to the proposed design garage fan power. Garages that are 30,000 ft^2 or smaller and include no heating or cooling shall be modeled with ventilation runtimes of 24 hours/day. If the proposed design includes contaminant sensors that meet the requirements of Std. 90.1-2010, Section 6.4.3.4.5, the following options exist: Option 1: Model the baseline design with a garage fan power of 0.30 W/CFM, a schedule of 24 hours/day, and an air flow rate of 0.75 CFM/ft^2. Model the proposed design with a garage fan power based on design specifications, a schedule of 8.4 hours/day, and an air flow rate based on the proposed designs. Option 2: Model both the baseline and proposed design with the same garage fan power (W/CFM) and fan air flow rates (CFM/ft2), based on the design specifications. Model both the baseline and proposed design with a schedule of 8.4 hours/day.

Proposed Design	Baseline Design
Domestic Hot Water	
Hot water consumption associated with dwelling units shall be determined according to the exceptional calculation methodology detailed in the "Typical Exceptional Calculations" section. Hot water use reduction may be reflected in the proposed design, per that methodology, for low-flow showerheads, low-flow faucets, ENERGY STAR dishwashers, and ENERGY STAR clothes washers. The results of the exceptional calculation must be converted to hourly values within the model, using the appropriate hourly load profile as recommended by the energy modeling software tool.	Hot water consumption associated with dwelling units shall be determined according to the exceptional calculation methodology detailed in the "Typical Exceptional Calculations" section.
If a hot water recirculation system is present in the proposed design, it must be represented (along with the associated pumps and pump energy) in the model; no credit can be awarded.	Same as proposed design.
Hot water setpoint capable of delivering 120 degree water at the point of use shall be used.	The hot water setpoints shall be equal to those used in the proposed design.
Receptacles & Other Plug Loads	
Dishwashers, clothes washers, and clothes dryers shall not be included if they are not specified for the project.	The number of dishwashers, clothes washers, and clothes dryers shall match those in the proposed design.
Non-lighting dwelling unit receptacle energy use shall be determined according to the methodology highlighted in the "Typical Exceptional Calculations" section. Receptacle energy use reduction may be reflected in the proposed design, per that methodology, for the use of ENERGY STAR appliances. The results of the exceptional calculation shall be converted to the appropriate model inputs (e.g. Watts/ft2) based on the corresponding schedules being used. Non-lighting receptacle energy use outside the dwelling units – including common area kitchens – must be accounted for in the model. The "Typical Exceptional Calculations" section prescribes plug load allowances for non-unit spaces.	Non-lighting dwelling unit receptacle energy use shall be determined according to the methodology highlighted in the "Typical Exceptional Calculations" section. Non-lighting receptacle energy use outside the dwelling units – including common area kitchens – must be accounted for in the model. The "Typical Exceptional Calculations" section prescribes plug load allowances for non-unit spaces.
The (sensible / latent) load fractions for receptacles shall be the following: refrigerators: (1.00 / 0.00) dishwashers: (0.60 / 0.15) clothes washers: (0.80 / 0.00) electric cooking ranges: (0.40 / 0.30) gas cooking ranges: (0.30 / 0.20) electric clothes dryers: (0.15 / 0.05) gas clothes dryers – electric load: (1.00 / 0.00) gas clothes dryers – gas load: (0.15 / 0.05) dwelling unit plug loads: (0.90 / 0.10) non-unit plug loads (1.00 / 0.00)	Same as proposed design.
All elevators specified in the project shall be included in the model, and the associated energy use shall be determined using the methodology in the "Typical Exceptional Calculations" section. 10% of elevator energy usage shall be added to space heat gains.	Same as proposed design.

Exceptional Calculations Required for Residential Projects

All projects are expected to provide certain exceptional calculations, which must conform to the Residential Simulation Guidelines. These include:

- Lighting power density – the proposed design lighting power density for the various space types must be shown, using a spreadsheet or comparable that identifies fixture counts, wattages (including bulb and ballast), credit for lighting controls, etc.
- Hot water consumption – the modeler must complete the Minimum Energy Performance calculator inputs for multifamily service water heating consumption for the baseline and proposed design. The in-unit hot water use calculations provided in the calculator are consistent with those described in the "Typical Exceptional Calculations" section.
- Receptacle energy use – the modeler must complete the Minimum Energy Performance calculator inputs for receptacle energy use in both the baseline and proposed design. Calculations for in-unit receptacle energy use and common area plug load energy use in the calculator are consistent with the methodology described in

the “Typical Exceptional Calculations” section.. Ensure that the energy model schedules for equipment are modeled as stated in the Minimum Energy Performance Calculator.

- Elevator energy use – the modeler must submit calculations related to elevator energy use, following the methodology described in the “Typical Exceptional Calculations” section.

Additional exceptional calculations may also be required, if the project team is seeking credit for measures or strategies that are not explicitly allowed or prescribed by ASHRAE Std. 90.1 or these Simulation Guidelines.

Quality Control

The following is a broad overview of the kinds of quality control that the project modeling team should perform:

Model Inputs

- Coordinate with the project design team to ensure the proposed design reflects final design, specifications, etc. Remove or update aspects of the model that might have remained from earlier iterations of the designs.
- Ensure that all spaces and end-use loads are accounted for within the model.
- Confirm that all aspects of the Simulation Guidelines (see Section 2) were incorporated into the model.
- Confirm that modeling elements within the baseline design conform to ASHRAE Std. 90.1-2010, and any templates, tools, etc. used by the modeling team have been updated to reflect changes from 90.1-2007.
- Where exceptional or supporting calculations are used (e.g. LPD, hot water consumption, appliance energy use), the calculations follow an approved methodologies (see The “Typical Exceptional Calculations” section), and model inputs match up with calculated values.
- As appropriate, the same spaces, surfaces, schedules, etc. were used for both the baseline and proposed design.

Model Outputs

- The energy consumption and cost values reported in the Calculator match with the energy simulation outputs.
- All warning or caution errors have been reviewed and can be explained.
- Proposed and/or baseline cases have no more than 300 hours of unmet load.
- Verify that total energy consumption, energy use intensity, and energy costs are reasonable for both the baseline and proposed design; compare to other similar projects or publicly available data sources (e.g. CBECs).
- Verify that the energy use of different end-use loads seems reasonable and consistent based on the location and parameters of the project (example: if space cooling greatly exceeds space heating in a very cold climate). Identify and review outliers or discrepancies.
- Review the savings rate for each end-use, and evaluate whether each is defensible given the energy measures and strategies employed.
- Where supporting calculations were performed to estimate model inputs, confirm that the model outputs correspond with the calculations (example: if a spreadsheet calculation for total building appliance energy use was used to determine W/ft2 inputs, the simulation output should match with the spreadsheet estimates).

Mixed-use Buildings

LEED does require that all spaces and associated end-use loads within the building must be accounted for in the energy simulation model. This includes residential, as well as nonresidential, unfinished, unconditioned spaces, etc.

In the context of LEED, the term “mixed-use” generally refers to buildings that include spaces that are not designed primarily to serve the residents (e.g. retail, commercial space other than leasing offices).

Baseline HVAC in Nonresidential Spaces

If nonresidential (e.g. office, retail) portions of the building satisfy Exception (a) of 90.1-2010 Section G3.1.1, these areas shall be modeled with the appropriate nonresidential system (Systems 3-8) in Table G3.1.1A. Alternatively, if the nonresidential portions of the building do not meet Exception (a), these areas shall be modeled using the system type of the predominant conditions, which in LEED for Homes would be residential Systems 1 or 2 in Table G3.1.1A.

Modeling Spaces Not Yet Designed

Within LEED, the nonresidential spaces generally take one of two forms:

1. The nonresidential space is included within the design and planning process. In this case, the nonresidential spaces shall be modeled as designed and built.

2. The nonresidential space is a tenant space, and energy features of the space are undetermined through design and construction. In this case, the nonresidential space is classified as "not yet designed" and its energy features shall be modeled as equal to the baseline design and follow the guidance in ASHRAE Std. 90.1-2010, Table G3.1.

ASHRAE Std. 90.1-2010, Table G3.1, Section 1 states "When the performance method is applied to buildings in which energy-related features have not yet been designed (e.g. a lighting system), those yet-to-be designed features shall be described in the proposed design exactly as they are defined in the baseline building design. Where the space classification for a space is not yet known, the space shall be categorized as an office space." Table G3.1 provides similar guidance for specific end uses, including lighting (Section 6), HVAC (Section 10), and service hot water (Section 11).

Gut-rehab Buildings

For gut-rehab buildings, the proposed design should be modeled to reflect the final state of the building after renovations and/or upgrades.

ASHRAE Std. 90.1-2010 does provide some guidance on how to model the baseline design envelope for existing buildings. Table G3.1, part 5(f) states "For existing building envelopes, the baseline building design shall reflect existing conditions prior to any revisions that are part of the scope of work being evaluated."

This requirement applies to the thermal properties and areas of the different envelope components. For example, if the window area is changed as part of the renovation, the pre-retrofit window area shall be modeled in the baseline and the post-retrofit window area shall be modeled in the proposed design. This requirement does not apply to air-tightness; the same leakage must be modeled in the baseline and proposed design. This should also not be interpreted as an exemption for any other envelope-related LEED requirements (e.g. EQ prerequisite: Compartmentalization).

ASHRAE Std. 90.1-2010, Table G3.1, part 5(f) **does not** apply to any the following:

1. New additions to existing buildings. These spaces must be treated as new construction.
2. Buildings or spaces within buildings that were previously unconditioned and are being renovated to include space conditioning. These must be treated as new construction.
3. Spaces that have undergone a change in the space use type (e.g. from non-residential to residential).
4. Any other energy-related features of the buildings, besides the building envelope (e.g. equipment, lighting).

Typical Exceptional Calculations

Hot Water Use Reduction

Baseline design hot water use

The baseline design dwelling unit hot water use shall be calculated using the following formula:

Total hot water use = Occupant use + Dishwasher use + Clothes washers use

Where:

Occupant use = [per-person use] X [# of bedrooms]

And:

Studio apartments are treated as 1 bedroom.

Per-person use = 25 gallons per day for most projects. A lower value (to 12 gallons per day) may be used where consumption is expected to be very low based on occupant demographics (e.g. all-working occupants). A higher value (to 44 gallons per day) may be used where consumption is expected to be very high based on occupant demographics (e.g. no occupants working, low-income).

Where:

Dishwasher use = 1,290 gallons/year X [# of dishwashers]

Where:

Clothes washer use = 2,436 gallons/year X [# of in-unit clothes washers] + 5,903 gallons/year X [# of common area clothes washers]

Proposed design hot water use

The proposed design dwelling unit hot water use shall be calculated using the following formula:

Total hot water use = Occupant use + Dishwasher use + Clothes washers use

Where:

Occupant use = Baseline occupant use x (0.36 + 0.54 x LFS/2.5 + 0.1 x LFF/2.5)

And:

LFS = rated flow rate for the low-flow showerheads specified in the drawings

LFF = rated flow rate for the low-flow faucets specified in the drawings[1]

Where:

Dishwasher use = 860 gal/year x [# of ENERGY STAR dishwashers] +
1,290 gal/year x [# of non-ES certified dishwashers]

Where:

Clothes washer use = 1,127 gal/year x [# of in-unit ENERGY STAR clothes washers] +
2,436 gal/year x [# of in-unit non-ES certified clothes washers] +
2,732 gal/year x [# of common area ENERGY STAR washers] +
5,903 gal/year x [# of common area non-ES certified washers]

Receptacle Energy Use

Baseline design receptacle energy use

Total receptacle energy use in the baseline design dwelling unit service hot water use shall be calculated using the following formulas:

Refrigerator = 529 kWh/yr x [# of refrigerators]

Dishwasher = 206 kWh/yr x [# of dishwashers]

Clothes washer = 81 kWh/yr x [# of in-unit clothes washers] +
196 kWh/yr x [# of common area clothes washers]

Cooking range = 604 kWh/yr x [# of electric ranges] +
45 therms/yr x [# of gas ranges]

Clothes dryer = [418 + 139 x Nbr] kWh/yr x [# of in-unit electric dryers] +
[1,013 + 337 x Nbr] kWh/yr x [# of common area electric dryers] +
[38 + 12.7 x Nbr] kWh/yr x [# of in-unit gas dryers] +
[26.5 + 8.8 x Nbr] therms/yr x [# of in-unit gas dryers] +
[92 + 30.8 x Nbr] kWh/yr x [# of common area gas dryers] +
[64 + 21.3 x Nbr] therms/yr x [# of common area gas dryers] +

Plug loads, in-unit = 1.05 $kWh/yr/ft^2$

Plug loads, corridors, restrooms, stairs, support areas = 0.7 $kWh/yr/ft^2$

Plug loads, offices = 4.9 $kWh/yr/ft^2$

Plug loads, other = 1.6 $kWh/yr/ft^2$

Where:

Nbr = average number of bedrooms in dwelling units
# of [appliance type] = # of [appliance type] installed in the proposed design

Proposed design receptacle energy use

Total receptacle energy use in the proposed design dwelling unit shall be calculated using the following formulas:

Refrigerator = 423 kWh/yr x [# of ENERGY STAR refrigerators] +
529 kWh/yr x [# of non-ENERGY STAR refrigerators]

Dishwasher = 164 kWh/yr x [# of ENERGY STAR dishwashers] +
206 kWh/yr x [# of non-ENERGY STAR dishwashers]

Clothes washer = 57 kWh/yr x [# of in-unit ENERGY STAR clothes washers] +
81 kWh/yr x [# of in-unit non-ENERGY STAR clothes washers] +
138 kWh/yr x [# of common area ENERGY STAR clothes washers] +
196 kWh/yr x [# of common area non-ENERGY STAR clothes washers]

1. *In a case where a project includes multiple different showerhead or faucets, use a weighted-average flow rate for these calculations.*

Cooking range = 604 kWh/yr X [# of electric ranges] +
45 therms/yr X [# of gas ranges]

Clothes dryer = [418 + 139 X Nbr] kWh/yr X [# of in-unit electric dryers] +
[1,013 + 337 X Nbr] kWh/yr X [# of common area electric dryers] +
[38 + 12.7 X Nbr] kWh/yr X [# of in-unit gas dryers] +
[26.5 + 8.8 X Nbr] therms/yr X [# of in-unit gas dryers] +
[92 + 30.8 X Nbr] kWh/yr X [# of common area gas dryers] +
[64 + 21.3 X Nbr] therms/yr X [# of common area dryers]

Plug loads, in-unit = 1.05 kWh/yr/ft^2

Plug loads, corridors, restrooms, stairs, support areas = 0.7 kWh/yr/ft^2

Plug loads, offices = 4.9 kWh/yr/ft^2

Plug loads, other = 1.6 kWh/yr/ft^2

Where:

Nbr = average number of bedrooms in dwelling units
# of [appliance type] = # of [appliance type] installed in the proposed design

Elevator energy use

If the proposed design includes elevators, the associated elevator energy use must be accounted for in both the baseline and proposed design energy models. Two options are provided are available to projects to calculate this energy use.

Option 1: engineering analysis

In order to take credit for energy savings associated with improvements to the elevator system, baseline and proposed design energy estimates must be completed by a design engineer using a simulation based on first principles, traffic models, and engineering data from empirical studies. This energy model must include energy consumed when the elevator is idling and in stand-by as well as the energy consumed when actively transporting the cabs (loaded and unloaded) based on an appropriate traffic model for the building. Some elevator equipment manufacturers will provide these calculations upon request as part of their design assistance service.

If this approach is used, the baseline design elevator should be hydraulic for 4-6 story buildings and geared traction for 7+ story buildings. Assume all of the following for the baseline design elevators: standard efficiency DC motors; variable voltage variable frequency drive; no regeneration of braking power losses; controls based on simple elevator algorithms; hydraulic elevators have no counterweights or hydraulic accumulators; traction elevators are equipped with counterweights sized at 50% of full load capacity; worm gears for geared traction elevators; a 2-to-1 roping scheme.

The analysis must be submitted as an exceptional calculation, with detailed estimates, assumptions, and a brief narrative.

Option 2: default assumptions

This option does not allow the proposed design to take performance credit. The annual energy consumption for both the baseline and proposed design shall be based on Table B.1 below.

TABLE B.1. DEFAULT ELEVATOR ENERGY USE (MWH/YR PER ELEVATOR)

Class	Hydraulic (1-6 stories)	Geared Traction (7-20 stories)	Gearless Traction (21+ stories)
Up to 6 dwelling units	1.91	NA	NA
7-20 dwelling units	2.15	3.15	NA
21-50 dwelling units	2.94	3.15	7.57
51+ dwelling units	4.12	4.55	7.57

INTERNATIONAL TIPS

Option 1. Whole-Building Energy Simulation. If ASHRAE 90.1 is not applicable, Option 1 requirements can be met with a USGBC-approved equivalent standard.

All options. Consult ASHRAE/ASHRAE/IESNA Standard 90.1–2010, Appendices B and D, to find the project's climate zone. Use Table B-2 (Canada) or Table B-3 (International) if the location is listed. For locations not listed in Table B-3, use Table B-4, along with the climate type definitions in Section B2, plus Appendix D to determine climate zone.

For an expanded reference of international locations, ASHRAE 169-2013 Table A-5 (Canada) or Table A-6 (International) may be consulted. ASHRAE 169-2013 subdivides Climate Zone 1 into two climate zones (Climate Zone 1 and Climate Zone 0). Locations listed in ASHRAE 169- 2013 in Climate Zone 1 and Climate Zone 0 should be considered Climate Zone 1 under ASHRAE 90.1-2010.

For example, a team working on a project in Beijing consults ANSI/ASHRAE/IESNA Standard 90.1–2010, Appendix B, to determine the appropriate climate zone. Table B-3 does not give a climate zone for Beijing.

The project team finds Beijing in Table D-3, which lists the values for heating degree-days to base 65°F or 18°C (HDD65 or HDD18) as 5252, and cooling degree-days to base 50°F or 10°C (CDD50 or CDD10) as 4115. The team uses these values to determine Beijing's climate zone as defined in Appendix B, Section B2 and Table B-4.

Beijing is in a "moist climate" because its warmest month has a mean temperature higher than 72°F (22.2°C) and is therefore too warm to be a "marine climate," and annual rainfall data indicate that the city is not in a "dry climate."

Finally, the project team uses the values found in Table D-2 for HDD65 (5252) and CDD50 (4115) in Table B-4 and determines that Beijing is in Zone 4A (mixed-humid) because the CDD50 value is 4500 or less, and the HDD65 value is between 3600 and 5400.

Developed by members of the European Roundtable, this table provides further guidance for project teams in Europe wishing to use European standards in lieu of certain ASHRAE 90.1-2010 mandatory provisions in LEED v4. The guidance covers ASHRAE 90.1-2010 Mandatory Provision Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10. Column 1 of the table references the specific subsection used in ASHRAE 90.1-2010. Column 2 displays the requirement as written in ASHRAE 90.1-2010. Column 3 outlines the compliance pathway available for European projects. Column 4 includes, in some cases, further information about the proposal, differences between the proposal and the ASHRAE requirement, or a reference to further documentation.

Please refer back to the LEED v4 web-based reference guide (Further Explanation > International Tips > Europe) for further information on the regional alternative compliance path.

Additionally, for projects using the Performance Option for compliance with EAp2: Minimum Energy Performance and EAc1: Optimize Energy Performance, the documentation must also use the calculated U-factor for fenestration products including windows and skylights based on either the LBNL Windows 6 program, or a simulation software program that approximates the NFRC rating methodologies. Alternatively, a narrative shall be provided supporting the claim that the fenestration U-factor used in the model is similar to the values that would be achieved using the NFRC rating. The CE-marked fenestration does not account for thermal bridging and seasonal performance in the same way as the NFRC rating, and when accounted for in the energy model, has been observed to lead to savings that exceed those claimed for the same fenestration rated under the NFRC ratings.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3
Appendix G energy modeling inputs	X		
Input-output reports from modeling software	X		
Exceptional calculations (if applicable)	X		
Energy consumption and demand for each building end use and fuel type	X		
Fuels rates	X		
AEDG compliance tables		X	
Target Finder results, summary			X
Confirmation that all aspects of CPG Sections 1 and 2 were met			X
Building configuration analysis			X
Building loads and mechanical system design capacity			X
Insulation installation details			X
Building envelope details			X
Domestic hot water efficiency			X
Narrative or calculations for CPG enhanced performance strategies			X
Data center calculator (if applicable)	X		
Retail process energy calculator (if applicable)	X		

RELATED CREDIT TIPS

EA Credit Optimize Energy Performance. Only Options 1 and 2 of this prerequisite allow the project team to pursue the related credit. Developing an energy model that reduces load and establishes an energy savings goal in an early phase will ensure that the project is eligible to earn points under the related credit for any energy cost savings beyond this prerequisite's minimum threshold. Consider the requirements for the related credit before initiating the energy model to ensure that the project will meet the criteria for both this prerequisite and the related credit.

Integrative Process Credit. Project teams intending to pursue the related credit must create a concept model during predesign to understand how various load reduction strategies affect a building's energy use. The model will inform the project team's approach to achieving this prerequisite through Option 1. The concept model should be prepared during the schematic design phase, while the building orientation and form is still in early development, and before undertaking a preliminary energy model.

EA Credit Demand Response. If the team is pursuing Option 1 of this prerequisite, the energy model can be used to project the peak energy demand and timing. This will provide some insight into the potential energy demands and cost savings when demand response is implemented.

EA Credit Renewable Energy Production. Consider renewable energy production for the project during early design. Although renewables cannot be counted toward this prerequisite, they are a viable energy cost savings measure that can achieve points for two related EA credits, Renewable Energy Production and Optimize Energy Performance.

EA Credit Green Power and Carbon Offsets. If the team is pursuing Option 1 of this prerequisite, the energy model output will be used to calculate the amount of green power required to meet the related credit requirements.

WE Prerequisite Indoor Water Use Reduction. For projects pursuing Option 1 of this prerequisite, hot water demand savings from low-flow fixtures must be derived from the related prerequisite's calculations.

EQ Prerequisite Minimum Indoor Air Quality Performance. For projects pursuing Option 1 of this prerequisite, as-designed ventilation flow rates reported in the related prerequisite must correspond to the inputs in the proposed energy model.

CHANGES FROM LEED 2009

Option 1. Whole Building Energy Simulation

- ASHRAE 90.1–2010 replaces ASHRAE 90.1–2007.
- Process energy is no longer required to make up 25% of overall building energy for the baseline and proposed models.
- Prerequisite compliance must now be achieved without accounting for the cost offset by site-generated renewable energy.
- For data centers, 2% of the required 5% energy cost reductions must come from building power and cooling infrastructure energy use.

Option 2. ASHRAE 50% Advanced Energy Design Guide, and Option 3. Advanced Buildings Core Performance Guide

- For Option 2, the standard for compliance with the prerequisite has been changed from the 30% savings version of the AEDG to the 50% savings version. This represents 50% expected savings over ASHRAE 90.1–2004.
- For Options 2 and 3, the project must now comply with mandatory and prescriptive requirements of ASHRAE 90.1–2010 to achieve the prerequisite.

REFERENCED STANDARDS

ASHRAE 90.1–2010 and ASHRAE 90.1–2010 User's Manual: ashrae.org

ASHRAE 50% Advanced Energy Design Guides: ashrae.org

Advanced Buildings Core Performance Guide: advancedbuildings.net/core-performance

COMNET Commercial Buildings Energy Modeling Guidelines: comnet.org/mgp-manual

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

baseline building performance the annual energy cost for a building design, used as a baseline for comparison with above-standard design

combined heat and power an integrated system that captures the heat, otherwise unused, generated by a single fuel source in the production of electrical power. Also known as cogeneration. (Adapted from U.S. Environmental Protection Agency)

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

downstream equipment the heating and cooling systems, equipment, and controls located in the project building or on the project site and associated with transporting the thermal energy of the district energy system (DES) into heated and cooled spaces. Downstream equipment includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

IT annual energy electricity consumption by information technology and telecom equipment which includes servers, networking, and storage equipment over the course of a year

plug load or **receptacle load** the electrical current drawn by all equipment that is connected to the electrical system via a wall outlet.

power distribution unit output the electrical power from a device that allocates power to and serves information technology (IT) equipment. Power distribution unit (PDU) output does not include efficiency losses of any transformation that occurs within the PDU, but it can include downstream non-IT ancillary devices installed in IT racks, such as fans. If the PDU system supports non-IT equipment (e.g., computer room air-conditioning units, computer room air handlers, in-row coolers), this equipment must be metered and subtracted from the PDU output reading. The metering approach should be consistent with the metering required for the power usage efficiency (PUE) category (e.g., continuous consumption metering for PUE categories 1, 2, and 3).

power utilization effectiveness (**PUE**) a measure of how efficiently a data center uses its power; specifically, how much power is used by computing equipment rather than for cooling and other overhead

process energy power resources consumed in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort and amenities for building occupants of a building. It may include refrigeration equipment, cooking and food preparation, clothes washing, and other major support appliances. (ASHRAE)

process load or **unregulated load** the load on a building resulting from the consumption or release of process energy (ASHRAE)

regulated load any building end use that has either a mandatory or a prescriptive requirement in ANSI/ASHRAE/IES Standard 90.1–2010

server input the information technology (IT) load as measured at the point of connection (e.g., power receptacle) of the IT device to the electrical power system. Server input captures the actual power load of the IT device exclusive of any power distribution losses and non-IT loads (e.g., rack-mounted fans).

uninterruptible power supply (**UPS**) **output** the electricity provided by a unit that keeps information technology (IT) equipment functioning during a power outage. UPS output does not include efficiency losses from the unit itself but does include losses from downstream electrical distribution components, such as power distribution units, and it may include non-IT ancillary devices installed in IT racks, such as fans. If the UPS system supports non-IT equipment (e.g., computer room air-conditioning units, computer room air handlers, in-row coolers), this usage must be metered and subtracted from the UPS output reading. The metering approach should be consistent with the metering required for the power usage efficiency (PUE) category (e.g., continuous consumption metering for PUE categories 1, 2 and 3).

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE PREREQUISITE

Building-Level Energy Metering

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To support energy management and identify opportunities for additional energy savings by tracking building-level energy use.

REQUIREMENTS

NEW CONSTRUCTION, SCHOOLS, RETAIL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, HEALTHCARE

Install new or use existing building-level energy meters, or submeters that can be aggregated to provide building-level data representing total building energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, biomass, etc). Utility-owned meters capable of aggregating building-level resource use are acceptable.

Commit to sharing with USGBC the resulting energy consumption data and electrical demand data (if metered) for a five-year period beginning on the date the project accepts LEED certification. At a minimum, energy consumption must be tracked at one-month intervals.

This commitment must carry forward for five years or until the building changes ownership or lessee.

CORE AND SHELL

Install new or use existing base building-level energy meters, or submeters that can be aggregated to provide base building-level data representing total building energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, etc.). Utility-owned meters capable of aggregating base building-level resource use are acceptable.

Commit to sharing with USGBC the resulting energy consumption data and electrical demand data (if metered) for a five-year period beginning on the date the project accepts LEED certification or typical occupancy, whichever comes first. At a minimum, energy consumption must be tracked at one-month intervals.

This commitment must carry forward for five years or until the building changes ownership or lessee.

BEHIND THE INTENT

Whole-building metering lets building operators track energy consumption over time, illustrating variations in usage patterns that can be used to develop energy conservation measures over the lifetime of the building. Once such conservation measures are in place, metering then allows staff to track energy savings and justify additional investments with calculable payback periods. Building operators gain detailed feedback, enabling them to precisely calibrate operational parameters, depending on the needs of changing occupancy groups, while continuing to operate building systems efficiently.

Disparities between how buildings are designed to operate and how they actually perform are common. Even green buildings exhibit this gap between projected and actual performance. Numerous factors can explain the incongruity: flaws with energy modeling, inadequate commissioning, inaccurate assumptions regarding occupants' behavior, lack of coordination during the transition from construction to operations, or the everyday operation of the building systems. To reduce such disparities, USGBC collects and analyzes performance data, comparing building performance across the LEED portfolio to identify common traits among high and low performers, then shares the findings to help LEED registrants improve their buildings' performance.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY ALL ENERGY SOURCES THAT SERVE BUILDING

Identify all sources of energy delivered to the building. Sources of energy that must be metered include all energy supplied by a utility company or campus central plant, such as the following:

- Electricity
- Natural gas, synthetic natural gas, propane, fuel oil, diesel fuel, other fossil fuels
- Biofuels
- District chilled water, steam, and hot water

This prerequisite does not require metering of locally generated sources of energy that are dedicated to the project building, such as the following:

- Solar photovoltaic–generated electricity
- Wind-generated electricity
- Solar hot water generation for domestic hot water or heating hot water

STEP 2. DETERMINE SCOPE OF UTILITY COMPANY METERING

If all energy provided to the building is supplied by one or more utility companies and the utility meters provide monthly consumption data, those meters meet the prerequisite requirements. However, the project team may have little influence on the location and function of utility company meters, so the building owner should confirm the following with the utility company:

- Location: where the meter will be located (e.g., inside the building, or under or above ground outside)
- Accessibility: how the building manager will reach the meter
- Reporting: how the meter will be read (e.g., manually or via remote transmission)

If the utility company restricts access to the meter or uses proprietary remote reporting technology, the project team may meet the prerequisite requirements by tracking energy usage through monthly billing. To collect more frequent or accurate data, the team may elect to install a private meter downstream of the utility company meter.

STEP 3. DETERMINE NUMBER, TYPE, AND LOCATION OF ALL METERS

If the project is not served by a utility company, or if the project uses multiple sources of energy, additional meters may be required. Identify the location of primary building-level meters for each energy source. If the project shares utility meters with other buildings or includes energy sources that are not metered by the supplier, install submeters that will provide the required data.

- Projects may use a single meter at the utility entrance or multiple submeters that account for whole building energy use in aggregate (see *Further Explanation, Examples*).

- Areas within the project boundary that are served by separate utility feeds, such as parking garages, must also be metered.
- Some projects may elect to use multiple submeters to gain more insight into energy uses.
- Select locations with easy access for reading and maintenance.
- There are no requirements for the type of meters except that they be permanent (see *Further Explanation, Meter Selection*).
- Additional meters and meter capabilities will be needed if the project team pursues EA Credit Advanced Energy Metering (see *Related Credit Tips*).
- Meters installed by the owner must be maintained and calibrated per the manufacturer's recommendations.

STEP 4. TRACK ENERGY CONSUMPTION DATA

Begin tracking energy use when the project achieves LEED certification or at occupancy, whichever occurs first.

- Measure and record energy consumption on at least a monthly basis (see *Further Explanation, Measurement Intervals*).
- Consider tracking building occupancy, use, and maintenance concurrently to help place energy use data in context and understand anomalies in usage patterns.

STEP 5. SHARE WHOLE-BUILDING ENERGY CONSUMPTION

Commit to sharing with USGBC the whole-project energy usage data acquired from permanent installed meters in accordance with the prerequisite requirements. The project owner must commit to sharing energy use data with USGBC for five years in one of two ways:

- USGBC-approved data template
- Third-party data source

To see the most recent list of data-sharing pathways, visit USGBC's credit library, at usgbc.org/credits.

FURTHER EXPLANATION

EXAMPLES

Example 1. An office building within an office park is directly served by the local electric utility, which has installed a meter. The building receives monthly bills for the electricity consumed. The project meets the requirements for electrical energy.

Example 2. The same office building receives chilled water from a central utility plant, which is owned and operated by the office park management company. The office building pays a flat fee for chilled water, included as part of the lease. The management company does not meter or invoice for actual chilled water consumption. To meet the requirements for chilled water, the building must install a chilled water meter at each service point.

Example 3. A stand-alone data center building on a corporate campus receives electricity from a campus central utility plant, and there are no meters at the electrical service entrances. The data center includes a sophisticated real-time advanced energy monitoring and reporting system, comprising submeters on all end devices downstream of a whole-building uninterruptable power supply (UPS) system backed up by diesel generators. The project meets the requirements for electrical energy.

Example 4. An office building in the central business district of a large city shares a boiler system with another building across the street. The building housing the boiler system sells steam to the other building, which pays for the associated energy on a square-foot-prorated basis. To meet the requirements for steam, the building must install a steam meter at each service point.

METER SELECTION

Utility-provided meters are typically regulated by code or law to establish their accuracy. Utility meters are often called "revenue-grade" because their measurement results directly in a charge to the customer. However, the accuracy of commercial meters and submeters available to building owners varies, and incorrect meter application or installation can further affect measurement accuracy. Meter selection is an important component of this prerequisite for owners to consider because of its implications for data quality.

Standards and regulations vary by location, and there is no single standard for revenue-grade accuracy (see Referenced Standards). For building-level meters located at the fuel source point of entry, projects should aim to provide meters that conform to one of the referenced resources or to a local law or regulation governing revenue-grade metering, or are otherwise defensible as sufficiently accurate. For more information regarding system submeters, see EA Credit Advanced Energy Metering.

METER LOCATION

For projects served by a utility, the utility generally owns the meter, so all energy required to power the building is accounted for. If the meter is owned by the building, the best location for the purposes of determining building-level energy consumption is generally at the point where energy enters the building.

The location of the meter affects whether conversion losses are included. Ideally, building-level measurement will include losses from conversion and distribution of power within the building via transformer or heat exchangers. For example, in a data center, the UPS is a point of power conversion, meaning the energy consumption metered at the UPS output does not include conversion losses; therefore the meter should be located upstream of the UPS.

MEASUREMENT INTERVALS

Projects with utility-owned energy meters may meet the monthly measurement requirement through one of two strategies: either the utility provides monthly energy consumption data in the form of invoices or online reporting tools, or building staff can read monthly cumulative energy usage directly from the meter.

Projects with owner-provided energy meters may meet the monthly measurement requirement through one of two strategies: either data are collected through the building automation system or other energy-reporting software on a monthly basis, or building staff can read monthly cumulative energy usage directly from the meter.

PROJECT TYPE VARIATIONS

District Energy Systems (DES)
This prerequisite is not applicable to upstream equipment. However, it is applicable to the energy source entering the building produced by upstream equipment. Building-level metering does not need to account for inefficiencies of the central plant or energy delivery methods.

Additions
If the original building has building-level meters and the addition's energy use is fully covered by those meters, the requirements of the prerequisite are met. If the original building is not metered, the project needs to install meters to cover only the entirety of the addition's energy use to meet the prerequisite requirements.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
Confirmation of permanently installed meters	X
Letter of commitment	X
Confirmation of data sharing source	X

RELATED CREDIT TIPS

EA Credit Advanced Energy Metering. The advanced metering credit expands on the requirements of this prerequisite by requiring building-level energy meters to have advanced capabilities; the credit also includes additional submetering requirements. An early decision on whether to pursue the credit will help inform prerequisite compliance.

EA Credit Enhanced Commissioning Option 1, Path 2. Data gathered from the metering system will help the commissioning authority during the evaluation of energy and water performance.

CHANGES FROM LEED 2009

- This prerequisite is new.
- Minimum program requirements: The ongoing energy tracking and reporting components were previously required under MPR 6 for all LEED 2009 projects.

REFERENCED STANDARDS

Electricity. American National Standards Institute, ANSI C12.20, Class 0.2 (± 0.2): ansi.org

Natural gas. American National Standards Institute, ANSI B109: ansi.org

Thermal energy (Btu meter or heat meter). EN Standard, EN-1434: cen.eu

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

revenue-grade meter a measurement tool designed to meet strict accuracy standards required by code or law. Utility meters are often called revenue grade because their measurement directly results in a charge to the customer.

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE PREREQUISITE

Fundamental Refrigerant Management

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To reduce stratospheric ozone depletion.

REQUIREMENTS

Do not use chlorofluorocarbon (CFC)-based refrigerants in new heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems. When reusing existing HVAC&R equipment, complete a comprehensive CFC phase-out conversion before project completion. Phase-out plans extending beyond the project completion date will be considered on their merits.

Existing small HVAC&R units (defined as containing less than 0.5 pound [225 grams] of refrigerant) and other equipment, such as standard refrigerators, small water coolers, and any other equipment that contains less than 0.5 pound (225 grams) of refrigerant, are exempt.

BEHIND THE INTENT

Chlorofluorocarbons (CFCs) and other refrigerants contribute to the depletion of the stratospheric ozone layer. The thinning of this ozone layer is linked to many human health problems, such as skin cancer, to ecological effects, such as reduced crop yields, and to damage to the marine food chain.[1] To address these issues, the 1987 Montreal Protocol established an international agreement to phase out use of the most harmful ozone-depleting substances, including CFCs.

Production of CFCs was phased out in industrialized nations that signed the Montreal Protocol before December 1995 and in most other countries by 2010. Accordingly, new construction projects cannot install new CFC-based refrigeration. However, CFCs may still be used in previously installed HVAC equipment.

To further progress, LEED requires that CFCs be phased out of existing building equipment before major renovation projects are complete. Though both hydrochlorofluorocarbons (HCFCs) and CFCs contribute to ozone depletion, only CFCs must be addressed to meet this prerequisite.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT NEW EQUIPMENT THAT CONTAINS NO CFC REFRIGERANTS

Identify all new HVAC&R equipment in the project that contains refrigerant and confirm that CFC refrigerants are not used.

- The mechanical engineer is typically responsible for specifying equipment that meets the prerequisite requirements.
- Older or retrofit equipment with higher efficiency ratings are the most likely to have CFCs, but it is important to check the refrigerant type for all new equipment.

Major Renovations

STEP 1. IDENTIFY CFCS IN EXISTING EQUIPMENT

Inventory all existing HVAC&R equipment in the project and determine whether any items use CFC refrigerants.

STEP 2. PHASE OUT CFCS IN EXISTING EQUIPMENT

Replace or retrofit all existing CFC-based equipment in the base building HVAC&R before the project's completion. Existing small equipment with less than 0.5 pound (225 grams) of refrigerant is exempt from the prerequisite requirements.

- If the CFC phaseout cannot be completed before occupancy, see *Further Explanation, Postoccupancy CFC Phaseout*.
- Projects that retain CFCs past initial occupancy, even if a phase-out plan is in progress, are ineligible for EA Credit Enhanced Refrigerant Management. The credit calculations must account for all refrigerants present at time of occupancy, except those contained in existing small equipment with less than 0.5 pound (225 grams) of refrigerant.
- Projects that retain CFCs after occupancy must reduce refrigerant leakage (see *Further Explanation, Minimizing Refrigerant Leakage*).

1. *Questions and Answers about the Environmental Effects of the Ozone Layer Depletion and Climate Change: 2010 Update. URL: http://ozone.unep.org/Assessment_Panels/EEAP/eeap-report2010-FAQ.pdf*

FURTHER EXPLANATION

POSTOCCUPANCY CFC PHASEOUT

If all CFC-based equipment cannot be replaced or retrofitted before the project's completion, adopt a CFC phase-out plan with a schedule. Develop a narrative that describes the circumstances that prevent CFC phaseout before the project concludes. Consider obtaining preapproval for a postoccupancy phase-out plan before submission for certification.

MINIMIZING REFRIGERANT LEAKAGE

When CFC-containing equipment is retained, project teams must adhere to the U.S. Environmental Protection Agency Clean Air Act, Title VI, Section 608 (or local equivalent for projects outside the U.S.) to minimize leakage in the building. Apply the following best practices in addition to the requirements of Section 608 (or local equivalent):

- Require that the maximum amount of ozone-depleting compounds (including both CFCs and HCFCs) are recycled during the servicing and disposal of air-conditioning and refrigeration equipment.
- Set certification requirements for recycling and recovery equipment and technicians, and prohibit the sale of refrigerants to uncertified technicians.
- Require those who service or dispose of air-conditioning and refrigeration equipment to confirm with EPA (or the authority having jurisdiction for projects outside the U.S.) that they have acquired recycling or recovery equipment and are complying with the requirements of the rule.
- Require the repair of substantial leaks in air-conditioning and refrigeration equipment with a charge of greater than 50 pounds (23 kilograms).
- Establish safe disposal requirements to ensure removal of refrigerants from goods that enter the waste stream with the charge intact (e.g., refrigerators, room air-conditioners).
- Prohibit individuals from knowingly venting ozone-depleting compounds that are used as refrigerants (generally CFCs and HCFCs) into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (including appliances).

PROJECT TYPE VARIATIONS

District Energy Systems (DES)
All applicable downstream equipment must meet the prerequisite requirements. Either all applicable upstream systems must be CFC-free, or a commitment must be in place to phase out CFC-based refrigerants with a firm timeline of five years from substantial completion of the LEED project. Before phaseout, reduce annual leakage of CFC-based refrigerants to 5% or less, following EPA Clean Air Act, Title VI, Rule 608 procedures governing refrigerant management and reporting (or a local equivalent for projects outside the U.S.).

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	All equipment	Phaseout required
Equipment type		X
Refrigerant type		X
CFC conversion or replacement plan		X
Refrigerant leakage rate, quantity		X
Phase-out completion date		X
Confirmation that no new or existing equipment contains CFCs	X	

RELATED CREDIT TIPS

EA Credit Enhanced Refrigerant Management. Selecting equipment that has low ozone depletion potential (ODP) and global warming potential (GWP), as well as no CFCs, will help achieve the related credit.

EA Credit Optimize Energy Performance. Alternatives to CFC and HCFC refrigerants, such as HFC-410A, have lower refrigerant impacts but may require higher levels of energy use. Some energy-efficient systems, like variable refrigerant flow (VRF), may increase the overall refrigerant impact because of the relatively higher amount of refrigerants their operation requires.

CHANGES FROM LEED 2009

The compliance path for economic feasibility of a CFC phase out plan was removed from this credit.

REFERENCED STANDARDS

U.S. EPA Clean Air Act, Title VI, Section 608, Refrigerant Recycling Rule: epa.gov/air/caa/

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

chlorofluorocarbon (CFC)-based refrigerant a fluid, containing hydrocarbons, that absorbs heat from a reservoir at low temperatures and rejects heat at higher temperatures. When emitted into the atmosphere, CFCs cause depletion of the stratospheric ozone layer.

downstream equipment the heating and cooling systems, equipment, and controls located in the project building or on the project site and associated with transporting the thermal energy of the district energy system (DES) into heated and cooled spaces. Downstream equipment includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE CREDIT

Enhanced Commissioning

This credit applies to:

New Construction (2-6 points)
Core and Shell (2-6 points)
Schools (2-6 points)
Retail (2-6 points)
Data Centers (2-6 points)
Warehouses and Distribution Centers (2-6 points)
Hospitality (2-6 points)
Healthcare (2-6 points)

INTENT

To further support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.

REQUIREMENTS

Implement, or have in place a contract to implement, the following commissioning process activities in addition to those required under EA Prerequisite Fundamental Commissioning and Verification.

Commissioning Authority

- The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy;
- The CxA may be a qualified employee of the owner, an independent consultant, or a disinterested subcontractor of the design team.

OPTION 1. ENHANCED SYSTEMS COMMISSIONING (3-4 POINTS)

Path 1: Enhanced Commissioning (**3 points**)
Complete the following commissioning process (CxP) activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies in accordance with ASHRAE Guideline 0–2005 and ASHRAE Guideline 1.1–2007 for HVAC&R systems, as they relate to energy, water, indoor environmental quality, and durability.

The commissioning authority must do the following:

- Review contractor submittals.
- Verify inclusion of systems manual requirements in construction documents.
- Verify inclusion of operator and occupant training requirements in construction documents.
- Verify systems manual updates and delivery.
- Verify operator and occupant training delivery and effectiveness.
- Verify seasonal testing.
- Review building operations 10 months after substantial completion.
- Develop an on-going commissioning plan.

Include all enhanced commissioning tasks in the OPR and BOD.

OR

Path 2: Enhanced and Monitoring-Based Commissioning (**4 points**)

Achieve Path 1.

AND

Develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of energy- and water-consuming systems.

Include the procedures and measurement points in the commissioning plan. Address the following:

- roles and responsibilities;
- measurement requirements (meters, points, metering systems, data access);
- the points to be tracked, with frequency and duration for trend monitoring;
- the limits of acceptable values for tracked points and metered values (where appropriate, predictive algorithms may be used to compare ideal values with actual values);
- the elements used to evaluate performance, including conflict between systems, out-of-sequence operation of systems components, and energy and water usage profiles;
- an action plan for identifying and correcting operational errors and deficiencies;
- training to prevent errors;
- planning for repairs needed to maintain performance; and
- the frequency of analyses in the first year of occupancy (at least quarterly).

Update the systems manual with any modifications or new settings, and give the reason for any modifications from the original design.

AND/OR

OPTION 2. ENVELOPE COMMISSIONING (2 POINTS)

Fulfill the requirements in EA Prerequisite Fundamental Commissioning and Verification as they apply to the building's thermal envelope in addition to mechanical and electrical systems and assemblies.

Complete the following commissioning process (CxP) activities for the building's thermal envelope in accordance with ASHRAE Guideline 0–2005 and the National Institute of Building Sciences (NIBS) Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process, as they relate to energy, water, indoor environmental quality, and durability.

Commissioning authority must complete the following:

- Review contractor submittals.
- Verify inclusion of systems manual requirements in construction documents.
- Verify inclusion of operator and occupant training requirements in construction documents.

- Verify systems manual updates and delivery.
- Verify operator and occupant training delivery and effectiveness.
- Verify seasonal testing.
- Review building operations 10 months after substantial completion.
- Develop an on-going commissioning plan.

DATA CENTERS ONLY

Projects that select Option 1 must complete the following commissioning process.

For small projects with peak cooling loads less than 2,000,000 Btu/h (600 kW), or a total computer room peak cooling load less than 600,000 Btu/h (175 kW), the CxA must perform the following activities:

- conduct at least one commissioning verification review of the owner's project requirements, basis of design, and design documents before mid-construction documents development;
- back-check the review comments in all subsequent design submissions; and
- conduct an additional full verification review at 95% completion of the design documents and basis of design.

For projects with peak cooling loads 2,000,000 Btu/h (600 kW) or more, or a total computer room peak cooling load 600,000 Btu/h (175 kW) or more, the CxA must conduct at least three verification reviews of the basis of design:

- one verification review of design documents before the start of design development;
- one verification review of design documents before midconstruction documents; and
- one final verification review of 100% complete design documents, verifying achievement of the owner's project requirements and adjudication of previous review comments.

BEHIND THE INTENT

Enhanced commissioning is a natural extension of the fundamental commissioning (Cx) process. It provides owners, via the commissioning authority (CxA), further oversight and verification that the building will meet their expectations and requirements beyond the first day of occupancy. Enhanced commissioning gives the CxA the power to act as the owner's advocate by conducting in-depth reviews of the basis of design, design documents, and construction submittals. Training and a postconstruction verification visit are some of the enhancements that contribute to ongoing quality building control and operations.

The CxA may make additions to the Cx plan to verify that the building operators will have the proper tools to manage the building's equipment efficiently and effectively. Monitoring-based commissioning (MBCx) gives the building owner, operators, and the CxA a continual stream of information that helps them identify operational issues as they occur, thereby saving time, money, and energy consumption over the lifetime of the building.

A second option in this credit is building envelope commissioning (BECx) to test and verify the building's thermal envelope, achieving better building performance and less energy expenditure over its lifetime. Adding envelope commissioning ensures not only that active energy-consuming systems are considered but also that passive load-defining envelope systems are understood and verified. Early introduction of BECx helps meet an owner's requirements for envelope performance through the review of design documents and contractor submittals. Such actions can help prevent problems with envelope design and construction that would be costly or impossible to address after construction. Additional benefits of BECx include improving occupants' comfort through glare control, infiltration testing, and reduced solar heat gain.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT ONE OR BOTH OPTIONS

Use input from the CxA and the project team and select one or both options. Review the building type, the assumed occupancy type, and the project goals and scope. The team should be familiar with the credit requirements so that any gaps in scope or skill can be addressed (see *Further Explanation, Planning the Cx Process* and *Choosing an Appropriate CxA*).

- Option 1 has two compliance paths.
  - Path 1, Enhanced Commissioning
  - Path 2, Enhanced and Monitoring-Based Commissioning. This is often appropriate for projects that are energy-intensive and will benefit from real-time data and the ability to track trends. The additional first costs may be offset by maintaining the proper energy usage over time.
- Option 2 is beneficial for most projects but especially for those that are envelope dominated, located in an extreme climate or microclimate, or subject to potential leakage or infiltration of contaminants.

STEP 2. UPDATE DOCUMENTS TO INCLUDE ENHANCED CX ACTIVITIES

Project documents should reflect the enhanced commissioning activities included in the project scope.

- Update the owner's project requirements (OPR), basis of design (BOD), and Cx plan (see *Further Explanation, Enhanced Commissioning Plan*).
- The CxA must ensure that the OPR, the BOD, and the Cx plan include all additional commissioning activities that will be conducted throughout the design and construction phases of the project.

Option 1, Path 1. Enhanced Systems Commissioning

STEP 1. DEVELOP SYSTEMS MANUAL SCOPE AND FORMAT

During the design development phase, outline the scope and format for the project systems manual to include all the information necessary to operate, maintain, and recommission all energy-consuming systems within the building.

- The CxA is responsible for working with the owner to develop and outline the requirements of the systems manual. Include operating staff in preparing the manual if the team is in place during design.
- Information for the systems manual is generally collected during construction and after completion of a project.

The basic scope and format of a systems manual are outlined in ASHRAE Guideline 0–2005, Annex O; the manual usually includes the following:

- Executive summary
- Owner's project requirements
- Basis of design
- System single-line diagrams
- Construction record documents and specifications
- Approved submittals
- As-built drawings
- As-built sequence of operation
- Original setpoints for all systems commissioned
- Recommended schedule for recommissioning
- Recommended schedule for sensor recalibration
- Equipment operations and maintenance manuals
- Equipment preventive maintenance schedules
- Confirmation of completed training for the owner and occupants
- Ongoing system optimization procedures
- Final commissioning report

STEP 2. DEVELOP TRAINING REQUIREMENTS

Create training requirements. Verify that they meet the scope of the owners' requirement for the operator training.

- Training requirements must be completed before the bid documents are final.
- Integrate requirements into the commissioning specifications, to be issued as part of the bid package during the construction document phase.

Training requirements include the following:

- List of those who should receive operational training, by position or name
- List of systems that require operator training
- Level of instruction required for each system
- Determination of whether the training provided by the equipment manufacturer is acceptable
- Tracking method to ensure that all required positions or persons receive training

STEP 3. ENSURE ENHANCED CX SCOPE ITEMS ARE INCLUDED IN CONSTRUCTION DOCUMENTS

Confirm that the following items are included in the construction documents to be issued for bid:

- System manual requirements
- Operator and occupant training requirements

STEP 4. REVIEW CONTRACTOR'S SUBMITTALS

Ensure ongoing compliance with the OPR, BOD, and Cx requirements by reviewing the HVAC&R contractor's submittals.

- Conduct a submittal review by the CxA concurrently with the design team's review or, at the latest, before final acceptance by the engineer or architect of record.
- The CxA must document all issues discovered during the review process in a log, to be distributed to the project's design and construction teams (see *Further Explanation, Examples, Table 4*).
- The CxA must also confirm that all issues recorded in the log are addressed or resolved by the owner, design, or construction teams.
- Establish the submittal review process at the commissioning kickoff meeting included in the fundamental commissioning steps.

STEP 5. VERIFY TRAINING

Confirm that the training program has been completed according to the owner's requirements for all commissioned equipment.

- Training is required to ensure that the building's operating staff is fully knowledgeable about operating the equipment and systems. Typically, it is provided by the equipment manufacturer, general contractor, or subcontractors.
- A good training program covers all new HVAC&R equipment and associated controls as well as monitoring equipment and software (if Option 1, Path 2 is pursued).
- It is recommended that the training cover all operating scenarios to help the building engineering team understand the most effective and efficient way to operate the building.

As outlined in ASHRAE Guideline 0–2005, a robust training program will address the following:

- Emergency instructions and procedures
- Operation instructions and procedures
- Troubleshooting procedures
- Maintenance and inspection procedures
- Repair procedures
- Upkeep of the systems manual and associated maintenance documentation logs

STEP 6. DELIVER POSTCONSTRUCTION DOCUMENTS

Complete and deliver the necessary operating documents and reports to the owner before building occupancy to ensure a smooth transition from construction to operation. The project CxA must confirm delivery, and the final package must include the following:

- Up-to-date systems manual, including operations and maintenance manuals for all commissioned equipment
- Documentation of operator training on all commissioned systems
- Completed functional performance test reports
- Up-to-date issues log detailing closed and open issues
- Updated Cx plan that outlines commissioning completed to date, plan for seasonal testing, plan for 10-month operational review, and plan for addressing open issues identified after the initial round of commissioning.

STEP 7. PERFORM SEASONAL TESTING, IF REQUIRED

Determine whether seasonal testing will be necessary, based on the project schedule.

- Both projects that reach substantial completion during peak heating or cooling months and projects that are occupied and operational before all equipment has been installed must create Cx plans and complete all necessary tests.
- The project CxA must be involved in seasonal testing, even if it occurs after the project is completed.

The results of seasonal testing and the issues log must be included in the final commissioning report (preferred) or issued as an addendum to the owner.

STEP 8. REVIEW BUILDING OPERATIONS 10 MONTHS AFTER SUBSTANTIAL COMPLETION

Perform the 10-month review of building operations after substantial completion to ensure that the building is being operated according to the owners' requirements. The 10-month review may include the following:

- Interviews with the operations and maintenance staff
- Interviews with occupants
- Status of outstanding commissioning-related issues
- Comparison of current operations with the operations and maintenance plan that was documented as part of EA Prerequisite Fundamental Commissioning
- Follow-up functional performance testing, when required
- Trends in building operations, as indicated by the building automation system, system submeters, or whole-building utility meters

STEP 9. DEVELOP ONGOING CX PLAN

Before or as part of the 10-month review of building operations, the CxA must issue an ongoing commissioning plan. The plan should provide the building's operating staff with procedures, blank test scripts, and a schedule for ongoing Cx activities. It may be executed either by the building operators, in addition to their normal preventive maintenance activities, or by an independent CxA (see *Further Explanation, Ongoing Commissioning Basics*).

The plan must include the following:

- Definition of the ongoing commissioning process

- Defined roles and responsibilities
- Recommended schedule for recommissioning as-built systems
- Continuous documentation and updating of building operating plan and current facility requirements throughout the building's lifetime
- Blank testing materials, including functional performance tests for all commissioned as-built systems in the building, as well as an issues log
- Direction for testing new and retrofitted equipment

Option 1, Path 2. Enhanced and Monitoring-Based Commissioning

STEP 1. ACHIEVE OPTION 1, PATH 1

Ensure that the requirements for Path 1 have been met.

STEP 2. UPDATE CX PLAN TO INCLUDE MONITORING-BASED COMMISSIONING (MBCX) REQUIREMENTS

During the design development phase, incorporate the MBCx requirements and activities into the project's Cx plan (see *Further Explanation, Monitoring-Based Commissioning Basics*).

- Define analysis procedures, including frequency during year one.
- Outline the evaluation process and determine the procedure for handling system conflicts, usage profiles, and out-of-sequence operations.
- Include preventive planning and maintenance procedures necessary to meet performance goals.
- Determine measurement requirements and decide whether predictive algorithms can be used in conjunction with metered points.

STEP 3. CONFIRM THAT MBCX IS FULLY INCORPORATED INTO ENHANCED CX

Ensure that requirements for MBCx are included in all commissioning documents. Items to look for may include the following:

- Owner's requirements, such as specific trends to track, reflected accurately in the engineer's BOD
- Metering and monitoring required for MBCx, included in the BOD
- Single-line or riser diagrams for location of building and system meters
- Controls sequences for specification of appropriate monitoring points
- Cx specifications for contractors and building operators
- Submittal reviews of meters, energy analysis software, and drawings of controls for compliance with the owner's MBCx metering and monitoring requirements
- Creation and completion of prefunctional tests for MBCx-related equipment, such as meters and energy analysis software programs, by the CxA and contractors
- MBCx operator education regarding measurement techniques, energy analysis software tools, fault detection and fault resolution, all incorporated into training requirements

STEP 4. IMPLEMENT MBCX PLAN

Execute, concurrently whenever possible, MBCx monitoring and analysis with the functional performance testing completed for EA Prerequisite Fundamental Commissioning.

The equipment and tools required for MBCx must be installed, and the electrical and controls contractor should submit construction checklists for review by the CxA. The benefits of implementing MBCx functional testing after construction but before occupancy include the following:

- More robust documentation of functional performance tests
- Verification that the energy meters and monitoring points have been properly installed and programmed
- CxA oversight of monitoring procedures and energy analysis, to ensure that the owner's requirements for ongoing monitoring are executed correctly
- Verification that energy analysis software tools, if installed, are appropriately identifying faults and producing the correct reports

It is recommended that the CxA confirm execution of the MBCx commissioning plan during the 10-month review. Confirmation of execution includes the following:

- Review of metering and trend logs

- Review of the issues log showing results of the MBCx
- Confirmation of issue resolution
- Confirmation of ongoing operator training
- Updating of the systems manual with any modifications or new settings that differ from design, with explanations for the changes
- See *Further Explanation, Bridging the Gap between LEED BD+C and LEED O+M.*

Option 2. Envelope Commissioning

Incorporate envelope commissioning into the Cx plan by extending the requirements of EA Prerequisite Fundamental Commissioning and Verification to cover the building's thermal envelope and completing EA Credit Enhanced Commissioning (Option 1, Path 1) as it relates to the building envelope. It is not necessary to complete the enhanced commissioning for building systems to meet the requirements of this option. However, doing so will help to ensure a better-performing building.

Ensure that the building envelope is fully accounted for in all commissioning documents and testing procedures (see *Further Explanation, Building Envelope Commissioning Basics*).

FURTHER EXPLANATION

PLANNING THE COMMISSIONING PROCESS

Table 1 outlines the tasks required to meet the intent of EA Prerequisite Fundamental Commissioning and Verification, EA Credit Enhanced Commissioning, Option 1 Path 1, Option 1 Path 2, and Option 2, as well as suggested timing.

TABLE 1. Commissioning activities

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx	BECx
Predesign	Develop OPR	Owner	X	X	X	X
Schematic design	Develop BOD, including envelope requirements	Design team	X	X	X	X
	Include general monitoring, metering, and trending requirements	Design team			X	
Design	Engage CxA	Owner	X	X	X	X
Documents	Develop initial commissioning plan	CxA	X	X	X	X
	Include monitoring requirements, equipment	CxA			X	
	Include envelope requirements	CxA				X
	Conduct OPR, BOD, and design document review	CxA, owner, design team	X	X	X	X

TABLE 1. (CONTINUED) Commissioning activities

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx	BECx
Documents	Prepare systems manual outline	CxA, owner		X	X	X
	Include monitoring requirements, equipment	CxA, owner			X	
	Include envelope requirements	CxA, owner				X
	Document training requirements	CxA, owner		X	X	X
	Update OPR and BOD as necessary	CxA, owner, design team	X	X	X	X
Construction Documents	Issue Cx specifications for inclusion in bid/permit documents	CxA	X	X	X	X
	Include enhanced Cx requirements	CxA		X	X	X
	Include monitoring-based Cx requirements	CxA			X	
	Include envelope based Cx requirements	CxA				X
	Update OPR and BOD as necessary	CxA, owner, design team	X	X	X	X
	Conduct design review (recommended)	CxA, design team	X	X	X	X
Construction	Update OPR and BOD as necessary	CxA, owner, design team	X	X	X	X
	Perform prefunctional inspections	CxA	X	X	X	X
	Complete submittal reviews concurrently with or before acceptance by design team	CxA		X	X	X
	Update OPR, BOD, Cx plan and systems manual as necessary	CxA	X	X	X	X
	Issue owner's training requirements	CxA to contractor		X	X	X
	Issue construction checklists	CxA	X	X	X	X
	Issue functional performance test scripts for contractor review	CxA, contractor	X	X	X	X
	Issue/review verified TAB report	Contractor, CxA	X	X	X	X
	Issue/review completed construction checklists	Contractor, CxA	X	X	X	X
	Execute functional performance tests	CxA, contractor	X	X	X	X
	Document issues in issues log	CxA	X	X	X	X
	Compile final systems manual	CxA		X	X	X

TABLE 1. (CONTINUED) Commissioning activities

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx	BECx
Construction	Complete final commissioning report	CxA	X	X	X	X
	Verify training plan has been implemented	CxA, contractor, building operators		X	X	X
Occupancy and operations	Complete Cx report	CxA	X	X	X	X
	Compile operations and maintenance plan	CxA	X	X	X	X
	Compile final systems manual	CxA		X	X	X
	Perform seasonal testing	CxA, contractor, building operators		X	X	X
	Perform 10-month review	CxA, contractor, building operators		X	X	X
	Develop ongoing Cx plan	CxA, building operators		X	X	X

BECx = building envelope commissioning process

BOD = basis of design

Cx = commissioning process

CxA = commissioning authority

MBCx = monitoring-based commissioning process

OPR = owner's project requirements

CHOOSING AN APPROPRIATE CXA

Review the guidance on qualifications for commissioning authorities in EA Prerequisite Fundamental Commissioning, including Table 1, Who can be the CxA? The following points also apply:

- Multiple team members from different companies may collaborate to complete the commissioning scope of work. However, one CxA must lead, review, oversee, and coordinate all activities and deliverables provided by the commissioning team.
- The members of the commissioning team can be employees of the same company or employees of separate firms, provided they all meet the basic requirements for the task to which they are assigned.
- Not all CxAs are qualified to perform all aspects and types of commissioning activities. For example, HVAC&R commissioning specialists may not have the experience or equipment to commission building envelopes in accordance with the NIBS guideline. The owner and the design team must carefully review the qualifications of all potential CxAs.
- For projects pursuing Option 2, envelope commissioning, the building envelope commissioning agent (BeCxA) may be completely independent of the lead CxA, and oversight of envelope commissioning activities by the lead CxA is not required. However, in this case, the BeCxA must meet all credit requirements for the Commissioning authority. Specifically:
  - The BeCxA must have documented envelope commissioning process experience on at least two building projects with a similar scope of work.
  - The BeCxA may be a qualified employee of the owner, an independent consultant, or a disinterested subcontractor of the design team.

- For projects pursuing Option 2, envelope commissioning, the building envelope commissioning agent (BeCxA) may be completely independent of the lead CxA, and oversight of envelope commissioning activities by the lead CxA is not required. However, in this case, the BeCxA must meet all credit requirements for the Commissioning authority. Specifically:
  - The BeCxA must have documented envelope commissioning process experience on at least two building projects with a similar scope of work.
  - The BeCxA may be a qualified employee of the owner, an independent consultant, or a disinterested subcontractor of the design team.

ENHANCED COMMISSIONING PLAN

The CxA develops the commissioning plan with input from the project team. Updates during the design and construction process are the primary responsibility of the CxA. A sample table of contents for the enhanced commissioning plan is provided in ASHRAE Guideline 0–2005, Informative Annex G, Commissioning Plan. The recommended components of the commissioning plan are the following:

- Commissioning program overview
  - Goals and objectives
  - General project information
  - Scope of commissioning
    - Systems (Option 1, Path 1)
    - Monitoring, which may include points, meters, and trending logs (Option 1, Path 2)
    - Envelope (Option 2)
    - Commissioning team
  - Team members, roles, and responsibilities
  - Communication protocol, coordination, meetings, and management
- Commissioning process activities
  - Reviewing the OPR
  - Reviewing the BOD
  - Documenting the systems commissioning review process (Option 1, Path 1)
  - Documenting the monitoring-based commissioning review process (Option 1, Path 2)
  - Documenting the envelope commissioning review process (Option 2)
  - Developing the systems manual
  - Developing systems functional test procedures documentation
  - Verifying system performance via functional performance testing
  - Reporting deficiencies and the resolution process: monitoring system analysis (Option 1, Path 2) must be conducted at least quarterly on an ongoing basis during occupancy.
  - Verifying the training of operations personnel: monitoring system training (Option 1, Path 2) must be conducted on an ongoing during building occupancy.
  - Reviewing building operation after 10 months of operations

ONGOING COMMISSIONING BASICS

Ongoing Cx, an extension of enhanced Cx process, is essentially a repetition of the functional performance testing and reporting procedures that occurred immediately after construction, during the initial occupancy and operations phase. Ongoing testing is required to ensure that the building continues to perform according to the OPR, BOD, and approved design and construction documents. The commissioning activities should occur approximately twice a year, to correspond with the summer and winter seasons. Those who conduct the Cx activities should use the functional performance tests and issues log templates provided as part of the original Cx report.

Ongoing Cx activities can be conducted either by in-house operating staff (in addition to their normal preventive maintenance activities) or by a third-party CxA who is responsible for all testing and issues reporting. Using the operating staff to perform the functional performance tests may be beneficial to their understanding of the building operations. However, as the facility requirements change or as systems are retrofitted over the lifetime of the building, a CxA may need to be retained to ensure all test scripts and procedures are up to date and properly documented.

MONITORING-BASED COMMISSIONING BASICS

Monitoring-based commissioning is the integration of three components: permanent energy monitoring systems, real-time energy analysis, and ongoing commissioning. Ongoing Cx is a component of MBCx but should not be confused with it. When executed independently or without MBCx capabilities, ongoing Cx is a process of discrete functional performance testing and reporting over the lifetime of a building. In comparison, MBCx is an ongoing performance analysis of an operational building that provides real-time equipment performance information to the building operators. In other words, MBCx allows the user to track energy consumption, detect faulty equipment operations, and identify unusual energy or power consumption patterns as they occur.

MBCx can be accomplished via systems submetering, operational points trending, and real-time analyses, such as fault detection and sequence verification. The real-time analyses can be performed by either a service provider or an on-site energy manager who uses software to monitor data from building meters and the building automation system.

Additions to the commissioning plan may include the following:

- Roles and responsibilities for maintaining an MBCx plan throughout the first year of occupancy
- Monitoring requirements
  - Meters and meter locations
  - Points to be tracked
  - Frequency and duration of trend monitoring
  - Software
  - Hardware
  - Data access
- Limits of acceptable values for tracked points and metered values
- Specification of fault diagnostics or predictive algorithms for tracked points and metered values, if appropriate
- Elements used to evaluate performance, including the following:
  - Conflict between systems, such as simultaneous heating and cooling
  - Out-of-sequence operation of systems components
  - Unexpected energy and water usage profiles
- Action plan for identifying and correcting operational errors and deficiencies, including the ongoing documentation of an issues log
- Ongoing operator and occupant training to prevent errors
- Planning ongoing monitoring device calibration to maintain performance
- Frequency of analyses in the first year of occupancy (at least quarterly)

MBCx is most cost-effective when the metering and energy analysis software are integrated into the initial design of a building.

BRIDGING THE GAP BETWEEN LEED BD+C AND LEED O+M

Much of the documentation created for EA Prerequisite Fundamental Commissioning, EA Credit Enhanced Commissioning, and the LEED certification process in general can be the basis for documenting compliance for LEED O+M, particularly EA Prerequisite Existing Building Best Management Practices, EA Credit Existing Building Commissioning, Analysis, EA Credit Existing Building Commissioning, Implementation, and EA Credit Ongoing Commissioning.

Table 2 identifies which documents created during a building's design and construction phases can be adapted and integrated into an ongoing building management plan.

TABLE 2. Comparison of LEED BD+C and LEED O+M documentation

LEED BD+C document	LEED O+M document	Example components
Owner's project requirements	Current facility requirements	• Building occupancy schedule • Lighting level requirements • Space use requirements
Systems manual	Operations and maintenance plan	• Sequence of operation • Preventive maintenance plan • HVAC equipment setpoints • Equipment run-times • Operations and maintenance manuals
Basis of design	Systems narrative	Descriptions of the mechanical, electrical, plumbing and envelope systems and equipment

If MBCx is implemented during initial operations and occupancy, project teams that apply for LEED O+M certification will find it easier to achieve the energy conservation tracking and measurement requirements of EA Credit Existing Building Commissioning, Implementation, and EA Credit Ongoing Commissioning.

BUILDING ENVELOPE COMMISSIONING BASICS

Building envelope commissioning (BECx) is used to validate that the design and performance of materials, components, assemblies and systems achieve the objectives and requirements of the owner. The process comprises modeling, observing, testing, documenting, and verifying materials, components, assemblies, and systems to validate that both their use and installation meet the owner's requirements. It uses performance-oriented practices and procedures to verify that the project is achieving the owner's project requirements.

To complete BECx, the CxA should have access to the equipment required for completing all envelope-testing activities, including the following:

- Infrared camera
- Tracer smoke
- Water bottle
- Calibrated water hose
- Moisture meter
- Field mock-up
- Blower door assembly

Examples of envelope systems tests include the following:

- Air infiltration
- Water infiltration
- Exhaust reentrainment
- Thermal performance
- Building envelope pressure
- Building envelope air leakage
- Daylighting glare control

Ideally, the CxA should have experience working with different envelope types and buildings of various sizes. The type of envelope and size of building will determine what tests are conducted and the equipment required.

For example, performing a blower door test to determine the air-tightness of an envelope may be appropriate for a 20,000-square-foot (1 860-square-meter) facility with brick façade and recessed windows. However, this type of test would be impractical for a 500,000-square-foot (46 450-square meter) commercial building with a curtain wall façade. For large structures, field mock-up or thermal imaging of the installed façade may better prevent or detect envelope leaks.

See NIBS Guideline 3–2006 2012 Building Enclosure Commissioning Process BECx, Annex U for additional guidance regarding envelope systems testing equipment and procedures.

EXAMPLES

TABLE 3. Example training plan

System, subsystem	Spec Section	Hours per class	Training date(s)	Theory of operation	Hands-on demo	Remarks
Rooftop unit	01783 - O&M	2	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain rooftop units
Makeup air unit	01783 - O&M	1	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain the makeup air unit
Kitchen exhaust fans	01783 - O&M	0.5	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain kitchen exhaust fans
General exhaust fans	01783 - O&M	0.5	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain general in-line exhaust fans
Packaged booster pumps	01783 - O&M	0.5	4/26/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain controls and pumps

TABLE 4. Example submittal review log

Comment	Sheet	Comment	Design team comments, response	Final review comment, status
1	M2-1	FF 1C and 2C call for 30 kBtu/h at 3 gpm with 180°F entering and 160°F leaving and 300 cfm. Transmittal 312037-0031 states 34.8 kBtu/h at 3 gpm with 180°F and 156.82°F leaving, and 320 cfm. Designer to comment if slight deviation in parameters is acceptable.	Acceptable to engineer	Item closed
2	M2-1	FC 1F and CU 1F specified as 12 mbh at 95°F entering air temperature to the condenser. Transmittal 312037-0026 shows 11.9 kBtu/h at AHRI standard conditions. Design to comment if rating is acceptable.	Acceptable to engineer	Item closed
3	M1-1C	AV 1 minimum cfm specified as 600, heating as 4,000. Transmittal 312037-0022 lists each as 800 cfm. Designer to check cfm discrepancy.	Noted by engineer on submittal	Final approved submittal needed
4	M1-1C	AV 2 minimum cfm specified as 360, heating as 2,400. Transmittal 312037-0022 lists each as 800 cfm. Designer to check cfm discrepancy.	Noted by engineer on submittal	Final approved submittal needed
5	M1-1C	TB-CO3 minimum cooling cfm specified as 100 on M1-1c. Transmittal 312037-0022 states as 250 cfm. Designer to confirm fm discrepancy.	Noted by engineer on submittal	Final approved submittal needed

RATING SYSTEM VARIATIONS

Core and Shell

Systems to be commissioned include only those that are included in the design team's scope of work.

Data Centers

For small projects with computer room peak cooling loads of less than 2,000,000 Btu/h (600 kW), or a total computer room peak cooling load of less than 600,000 Btu/h (175 kW), the CxA must perform the following activities:

- During the design development or early construction documents phase, review the OPR, BOD, and design documents.
- Review the design documents and the BOD at 95% completion of the design documents.
- From construction documents through construction, back-check the review comments to ensure that they were addressed.

For projects with peak cooling loads of 2,000,000 Btu/h (600 kW) or more, or a total computer room peak cooling load of 600,000 Btu/h (175 kW) or more, the CxA must conduct at least three verification reviews of the BOD:

- During schematic design, conduct one verification review of design documents.
- During the design documents or early construction documents phase, complete one verification review of design documents.
- At the end of the construction documents phase, conduct one final verification review of 100% complete design documents, verifying achievement of the OPR and adjudication of previous review comments.

Functional testing for data centers often includes rigorous failure mode testing, including prime power backup, also known as mission-critical functional testing. The requirements of this type of commissioning often exceed the requirements of this credit.

The CxA should work with the owner to ensure that the requirements of the mission critical testing are appropriately addressed in the OPR. Additionally, the CxA should be aware of the mission-critical component of commissioning a data center and account for those differences in the contract with the owner.

Mission-critical testing for a data center can be completed by a CxA other than the CxA who completes the fundamental and enhanced commissioning.

Healthcare

Health care facilities may have additional testing requirements for life safety equipment, including prime power backup that would not be addressed under the LEED fundamental and enhanced commissioning scope of work.

The CxA should work with the owner to ensure that the requirements of the life safety testing are appropriately addressed in the OPR. Additionally, the CxA should be aware of the life safety component of commissioning a health care facility and account for those differences in the contract with the owner.

Life safety testing for a health care facility can be completed by a CxA other than the CxA who completes the fundamental and enhanced commissioning.

PROJECT TYPE VARIATIONS

District Energy Systems (DES)

All downstream equipment is included in the scope of this credit. Such equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls.

All upstream equipment associated with serving the building is included in the scope if the project is taking credit for the efficiency of the DES under EA Credit Optimize Energy Performance using Option 1 (Path 2 or 3); if not, upstream equipment is excluded from the scope of this credit.

Commissioning applies only to the DES services used by the project building. For example, if the building is using only the heating services of a district heating and cooling plant, only the heating systems of the DES must be included in the scope. However, commissioning of upstream equipment applies to that entire portion of the DES, including both the central plant and the transmission and distribution systems.

All upstream DES equipment associated with serving the project building subject to EA Credit Enhanced Commissioning requirements may show compliance using either of the following approaches, depending on whether the DES is “new” or “preexisting.”

New DES. If the DES is new, being substantially upgraded, or has new additions, show that commissioning or recommissioning of all relevant DES equipment has taken place within three years of the date of the project building’s substantial completion.

A DES that is three years old or less at the date of the project building's substantial completion is considered "new" construction and should be commissioned in accordance with the requirements of EA Credit Enhanced Commissioning. Similarly, any new equipment additions to an existing plant along with any controls or plant distribution equipment that have changed as a result of the additions must be commissioned in accordance with the requirements of EA Credit Enhanced Commissioning.

Preexisting DES. If the DES is in operation, show that preventive maintenance, corrective maintenance, and efficiency monitoring programs have been in place for all relevant DES equipment, ensuring that its energy efficiency meets or exceeds the DES design intent. Show that DES performance has been tested, recorded, and improved as needed under those programs within the past three years. Any reasonable efficiency metric may be used for this purpose, such as overall system coefficient of performance or kW/ton.

A DES more than three years old with no substantial new equipment additions is considered "preexisting." Show proof that it was commissioned in accordance with the requirements of LEED O+M EA Credit Existing Building Commissioning—Implementation within the past three years or that the requirements of LEED O+M EA Credit Existing Building Commissioning—Ongoing Commissioning have been applied.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1, Path 1	Option 1, Path 2	Option 2
List of all tasks completed as part of Cx activities	X	X	X
Training outline and participation list	X	X	X
Confirmation of systems manual delivery	X	X	X
Ongoing Cx plan	X	X	X
Inclusion of monitoring and tracking in Cx plan		X	
Inclusion of envelope in Cx plan			X
Verification of additional reviews per Data Center requirements (data centers only)	X	X	

RELATED CREDIT TIPS

EA Prerequisite Fundamental Commissioning and Verification. Enhanced commissioning is an extension of fundamental commissioning and cannot be completed if the scope of fundamental commissioning is not fulfilled.

EA Credit Renewable Energy Production. Renewable energy systems installed on site must be commissioned under this credit.

EA Credit Demand Response. Meeting the requirements for demand response will help project teams achieve the ongoing commissioning portions of this credit.

EA Credit Advanced Energy Metering. Although not a requirement of this credit, achievement of the related credit will ease the execution of the MBCx plan. Conversely, if a project is pursuing the related credit, MBCx is a powerful tool for extracting additional value from the existing advanced metering system.

CHANGES FROM LEED 2009

This credit now includes monitoring-based commissioning and building envelope commissioning options.

REFERENCED STANDARDS

ASHRAE Guideline 0–2005, The Commissioning Process: ashrae.org

ASHRAE Guideline 1.1–2007, HVAC&R Technical Requirements for the Commissioning Process: ashrae.org

NIBS Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process: nibs.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

basis of design (**BOD**) the information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines

commissioning (**Cx**) the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements

commissioning authority (**CxA**) the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

downstream equipment the heating and cooling systems, equipment, and controls located in the project building or on the project site and associated with transporting the thermal energy of the district energy system (DES) into heated and cooled spaces. Downstream equipment includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

operations and maintenance (**O&M**) **plan** a plan that specifies major system operating parameters and limits, maintenance procedures and schedules, and documentation methods necessary to demonstrate proper operation and maintenance of an approved emissions control device or system

owner's project requirements (**OPR**) a written document that details the ideas, concepts, and criteria determined by the owner to be important to the success of the project

systems manual provides the information needed to understand, operate, and maintain the systems and assemblies within a building. It expands the scope of the traditional operating and maintenance documentation and is compiled of multiple documents developed during the commissioning process, such as the owner's project requirements, operation and maintenance manuals, and sequences of operation.

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE CREDIT

Optimize Energy Performance

This credit applies to:

New Construction (1–18 points)
Core and Shell (1–18 points)
Schools (1–16 points)
Retail (1–18 points)
Data Centers (1–18 points)
Warehouses and Distribution Centers (1–18 points)
Hospitality (1–18 points)
Healthcare (1–20 points)

INTENT

To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, HEALTHCARE

Establish an energy performance target no later than the schematic design phase. The target must be established as kBtu per square foot-year (kWh per square meter-year) of source energy use.

Choose one of the options below.

OPTION 1. WHOLE-BUILDING ENERGY SIMULATION (1–18 POINTS EXCEPT SCHOOLS AND HEALTHCARE, 1–16 POINTS SCHOOLS, 1–20 POINTS HEALTHCARE)

Analyze efficiency measures during the design process and account for the results in design decision making. Use energy simulation of efficiency opportunities, past energy simulation analyses for similar buildings, or published data (e.g., Advanced Energy Design Guides) from analyses for similar buildings.

Analyze efficiency measures, focusing on load reduction and HVAC-related strategies (passive measures are acceptable) appropriate for the facility. Project potential energy savings and holistic project cost implications related to all affected systems.

Project teams pursuing the Integrative Process credit must complete the basic energy analysis for that credit before conducting the energy simulation.

Follow the criteria in EA Prerequisite Minimum Energy Performance to demonstrate a percentage improvement in the proposed building performance rating compared with the baseline. Points are awarded according to Table 1.

TABLE 1. Points for percentage improvement in energy performance

New Construction	Major Renovation	Core and Shell	Points (except Schools, Healthcare)	Points (Healthcare)	Points (Schools)
6%	4%	3%	1	3	1
8%	6%	5%	2	4	2
10%	8%	7%	3	5	3
12%	10%	9%	4	6	4
14%	12%	11%	5	7	5
16%	14%	13%	6	8	6
18%	16%	15%	7	9	7
20%	18%	17%	8	10	8
22%	20%	19%	9	11	9
24%	22%	21%	10	12	10
26%	24%	23%	11	13	11
29%	27%	26%	12	14	12
32%	30%	29%	13	15	13
35%	33%	32%	14	16	14
38%	36%	35%	15	17	15
42%	40%	39%	16	18	16
46%	44%	43%	17	19	-
50%	48%	47%	18	20	-

RETAIL ONLY

For all process loads, define a clear baseline for comparison with the proposed improvements. The baselines in Appendix 3, Tables 1–4, represent industry standards and may be used without additional documentation. Calculate the baseline and design as follows:

- *Appliances and equipment.* For appliances and equipment not covered in Tables 1–4, indicate hourly energy use for proposed and budget equipment, along with estimated daily use hours. Use the total estimated appliance/equipment energy use in the energy simulation model as a plug load. Reduced use time (schedule change) is not a category of energy improvement in this credit. ENERGY STAR ratings and evaluations are a valid basis for performing this calculation.
- *Display lighting.* For display lighting, use the space-by-space method of determining allowed lighting power under ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), to determine the appropriate baseline for both the general building space and the display lighting.
- *Refrigeration.* For hard-wired refrigeration loads, model the effect of energy performance improvements with a simulation program designed to account for refrigeration equipment.

OPTION 2. PRESCRIPTIVE COMPLIANCE: ASHRAE ADVANCED ENERGY DESIGN GUIDE (1–6 POINTS)

To be eligible for Option 2, projects must use Option 2 in EA Prerequisite Minimum Energy Performance.

Implement and document compliance with the applicable recommendations and standards in Chapter 4, Design Strategies and Recommendations by Climate Zone, for the appropriate ASHRAE 50% Advanced Energy Design Guide and climate zone. For projects outside the U.S., consult ASHRAE/ASHRAE/IESNA Standard 90.1–2010, Appendixes B and D, to determine the appropriate climate zone.

ASHRAE 50% Advanced Energy Design Guide for Small to Medium Office Buildings

- *Building envelope, opaque:* roofs, walls, floors, slabs, doors, and continuous air barriers (1 point)
- *Building envelope, glazing:* vertical fenestration (1 point)
- *Interior lighting,* including daylighting and interior finishes (1 point)
- *Exterior lighting* (1 point)
- **Plug loads,** including equipment and controls (1 point)

ASHRAE 50% Advanced Energy Design Guide for Medium to Large Box Retail Buildings

- *Building envelope, opaque:* roofs, walls, floors, slabs, doors, and vestibules (1 point)
- *Building envelope, glazing:* fenestration - all orientations (1 point)
- *Interior lighting,* excluding lighting power density for sales floor (1 point)
- *Additional interior lighting* for sales floor (1 point)
- *Exterior lighting* (1 point)
- **Plug loads,** including equipment choices and controls (1 point)

ASHRAE 50% Advanced Energy Design Guide for K–12 School Buildings

- *Building envelope, opaque:* roofs, walls, floors, slabs, and doors (1 point)
- *Building envelope, glazing:* vertical fenestration (1 point)
- *Interior lighting,* including daylighting and interior finishes (1 point)
- *Exterior lighting* (1 point)
- **Plug loads,** including equipment choices, controls, and kitchen equipment (1 point)

ASHRAE 50% Advanced Energy Design Guide for Large Hospitals

- *Building envelope, opaque:* roofs, walls, floors, slabs, doors, vestibules, and continuous air barriers (1 point)
- *Building envelope, glazing:* vertical fenestration (1 point)
- *Interior lighting,* including daylighting (form or nonform driven) and interior finishes (1 point)
- *Exterior lighting* (1 point)
- **Plug loads,** including equipment choices, controls, and kitchen equipment (1 point)

RETAIL ONLY

Meet the requirements of Option 2 and comply with the prescriptive measures in Appendix 3, Tables 1–4, for 90% of total energy consumption for all process equipment.

DATA CENTERS

Whole-Building Energy Simulation

Analyze efficiency measures focused on IT load reduction and HVAC-related strategies (air-side economizers, hot aisle–cold aisle, etc.). Project the potential energy savings and cost implications for all affected systems.

Follow the criteria in EA Prerequisite Minimum Energy Performance to demonstrate a percentage improvement in the proposed performance rating compared with the baseline.

Use energy cost savings from both the building and IT to determine the total percentage reduction.

BEHIND THE INTENT

See EA Prerequisite Minimum Energy Performance, *Behind the Intent*.

STEP-BY-STEP GUIDANCE

STEP 1. REVIEW REQUIREMENTS FOR EA PREREQUISITE MINIMUM ENERGY PERFORMANCE

- Ensure that the related prerequisite will be achieved before pursuing the credit.
- Follow the initials steps of the prerequisite.
- The option pursued in the prerequisite must also be pursued in the credit.
- Projects that achieved the prerequisite under Option 3 (Prescriptive Compliance: Advanced Buildings™ Core Performance™ Guide) are not eligible to pursue this credit.

Option 1. Whole-Building Energy Simulation

STEP 1. REVIEW PREREQUISITE AND CREDIT REQUIREMENTS

Read the requirements and referenced standards for both the related prerequisite and this credit before beginning the simulation. If pursuing the Integrative Process Credit, identify the requirements for concept-level energy modeling to determine how to coordinate the overall model development.

STEP 2. CONFIRM ENERGY USE TARGET FOR BUILDING

Ensure that an energy use intensity (EUI) target has been developed, as outlined in the prerequisite. For credit compliance, the target must be established as EUI in kBtu per square foot-year (kWh per square meter-year) of source energy use.

STEP 3. DEVELOP PRELIMINARY ENERGY MODEL

Determine whether preliminary energy models will be prepared, as outlined in the prerequisite. A preliminary model may satisfy the credit requirement for analysis of energy efficiency measures and can assist with estimating the energy implications of early design alternatives.

- A concept model prepared for compliance with the Integrative Process Credit can form the basis for the preliminary energy model.
- Project teams must perform an analysis of efficiency measures. Past analyses of similar buildings or published data, such as the ASHRAE Advanced Energy Design Guides (AEDGs), may also be used to guide decision making in lieu of a preliminary energy model, though the results will be less project-specific.
- The AEDGs were designed around specific building types and sizes by climate zone, making the recommendations most appropriate for projects with attributes similar to those specified types, sizes, and locations.

STEP 4. MODEL POTENTIAL HVAC SYSTEM TYPES

Create an energy model of the proposed design, or expand the scope of the preliminary model, to analyze HVAC system alternatives early in the design process (see EA Prerequisite Minimum Energy Performance, *Further Explanation, Modeling Potential HVAC Systems*).

STEP 5. UPDATE PROPOSED MODEL

Throughout the design process, add details to the proposed building model to reflect changes that may affect the energy efficiency of other systems (see EA Prerequisite Minimum Energy Performance, *Further Explanation*, *Building the Proposed Energy Model*).

STEP 6. UPDATE BASELINE AND PROPOSED ENERGY MODELS BASED ON FINAL DESIGN DOCUMENTS

Update the proposed and baseline energy models to reflect final construction details and specifications (see *Further Explanation, Finalizing the Energy Models for Credit Compliance*) and review the table of common mistakes to avoid (see EA Prerequisite Minimum Energy Performance*, Further Explanation, Common Issues with Energy Modeling*).

STEP 7. DETERMINE ENERGY COST SAVINGS

Compare the proposed model with the baseline model to determine the anticipated energy cost savings (see EA Prerequisite Minimum Energy Performance*, Further Explanation, Energy Cost Savings*). Apply any savings from on-site renewable energy systems after minimum compliance has been demonstrated (see *Further Explanation, Applying Renewable Energy Savings*).

Option 2. ASHRAE 50% Advanced Energy Design Guides (AEDGs)

STEP 1. CONFIRM PREREQUISITE REQUIREMENTS

Ensure that all HVAC and service water-heating equipment meets the requirements of the appropriate AEDG, determined in EA Prerequisite Minimum Energy Performance.

STEP 2. DETERMINE WHICH POINTS TO PURSUE UNDER AEDGS

Consider the AEDG requirements for additional points.

- Points can be achieved for building glazing and envelope, including opaque elements such as roofs and walls, interior and exterior lighting, and plug loads.
- Retail projects are subject to the prescriptive retail criteria listed in Appendix 3, Tables 1–4, but have an additional point opportunity addressing sales floor lighting.

FURTHER EXPLANATION

FINALIZING THE ENERGY MODELS FOR CREDIT COMPLIANCE

Update the proposed model based on the information and specifications for systems, assemblies, and equipment in the final construction documents (see EA Prerequisite Minimum Energy Performance, *Further Explanation, Finalizing the Energy Models*). Ensure that all changes made to the design have been captured in the model. If changes occur during construction that could affect efficiency measures, the model information will have to be updated accordingly. Value engineering exercises may affect building efficiency as well as credit achievement.

Document the energy modeling input assumptions for receptacle and process loads. These loads should be modeled accurately to reflect the actual expected energy consumption of the building (see EA Prerequisite Minimum Energy Performance, *Further Explanation, Exceptional Calculation Method*).

Verify the final energy cost savings. Evaluate the energy savings by end use for reasonableness based on the differences in the modeling inputs between the baseline and proposed models. Ensure that renewable energy savings have been properly credited (see *Further Explanation, Applying Renewable Energy Savings*).

APPLYING RENEWABLE ENERGY SAVINGS

Only projects pursuing Option 1 of this credit may count savings from renewable energy systems.

Calculate the total amount of energy generated by the system and convert this value into the equivalent cost using either utility rates or virtual energy rates (see EA Credit Renewable Energy Production). Apply the equivalent cost directly to the energy model through the simulation software, or subtract it from the final energy cost savings calculation.

RATING SYSTEM VARIATIONS

Retail
Option 2 Prescriptive Compliance: ASHRAE 50% AEDG. Comply with the prescriptive measures in Appendix 3, Tables 1–4, for 90% of total energy consumption for all process equipment.

Data Centers
See EA Prerequisite Minimum Energy Performance, *Further Explanation, Rating System Variations.*

PROJECT TYPE VARIATIONS

District Energy Systems
See EA Prerequisite Minimum Energy Performance, *Further Explanation, Project Type Variations.*

INTERNATIONAL TIPS

Option 1, Whole-Building Energy Simulation. If ASHRAE 90.1 is not applicable, Option 1 requirements can be met with a USGBC-approved equivalent standard.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Appendix G energy modeling inputs	X	
Input and output reports from modeling software	X	
Renewable energy (if applicable)	X	
Exceptional calculations (if applicable)	X	
Target Finder results and summary	X	X
Energy consumption and demand for each building end use and fuel type	X	
Fuels rates	X	
AEDG compliance tables		X
List of process equipment efficiencies (retail only)		X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. See *Related Credit Tips* under the prerequisite.

EA Credit Renewable Energy Production. To receive credit for renewable energy systems savings, calculate the equivalent cost of the energy generated using the methodology outlined in the related credit.

CHANGES FROM LEED 2009

See EA Prerequisite Minimum Energy Performance, *Changes from LEED 2009*.

REFERENCED STANDARDS

ASHRAE 90.1–2010 and ASHRAE 90.1–2010 User's Manual: ashrae.org

ASHRAE 50% Advanced Energy Design Guides: ashrae.org

COMNET Commercial Buildings Energy Modeling Guidelines: comnet.org/mgp-manual

EXEMPLARY PERFORMANCE

Option 1. New construction, major renovation, and core and shell projects: Achieve at least 54% energy savings.

DEFINITIONS

See EA Prerequisite Minimum Energy Performance.

ENERGY AND ATMOSPHERE CREDIT

Advanced Energy Metering

This credit applies to:

New Construction (1 point)
Core and Shell
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use.

REQUIREMENTS

NEW CONSTRUCTION, SCHOOLS, RETAIL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, HEALTHCARE

Install advanced energy metering for the following:

- all whole-building energy sources used by the building; and
- any individual energy end uses that represent 10% or more of the total annual consumption of the building.

The advanced energy metering must have the following characteristics.

- Meters must be permanently installed, record at intervals of one hour or less, and transmit data to a remote location.
- Electricity meters must record both consumption and demand. Whole-building electricity meters should record the power factor, if appropriate.
- The data collection system must use a local area network, building automation system, wireless network, or comparable communication infrastructure.
- The system must be capable of storing all meter data for at least 36 months.
- The data must be remotely accessible.
- All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.

CORE AND SHELL

Install meters for future tenant spaces so that tenants will be capable of independently metering energy consumption (electricity, chilled water, etc.) for all systems dedicated to their space. Provide a sufficient number of meters to capture total tenant energy use with a minimum of one meter per energy source per floor.

Install advanced energy metering for all base building energy sources used by the building.

The advanced energy metering must have the following characteristics.

- Meters must be permanently installed, record at intervals of one hour or less, and transmit data to a remote location.
- Electricity meters must record both consumption and demand. Whole-building electricity meters should record the power factor, if appropriate.
- The data collection system must use a local area network, building automation system, wireless network, or comparable communication infrastructure.
- The system must be capable of storing all meter data for at least 36 months.
- The data must be remotely accessible.
- All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.

BEHIND THE INTENT

See EA Prerequisite Building-Level Energy Metering, *Behind the Intent*.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY ENERGY SOURCES THAT SERVE PROJECT BUILDING

Determine all energy sources that serve the project.

- Whole-building energy sources delivered to the building by an external provider, such as a utility company or campus central plant, include sources owned by the building owner that cross an exterior wall between the point of generation and point of use (see EA Prerequisite Building-Level Metering).
- Count both renewable and nonrenewable sources of on-site energy generation.
- Renewable sources include wind turbines, photovoltaic panels, solar thermal panels, and geothermal.
- Nonrenewable sources include fossil fuel–burning generators and microturbines. Both inputs and outputs of nonrenewable sources, including fuel input, electricity output, and recovered heat (if applicable), must be metered.

STEP 2. IDENTIFY ENERGY END USES THAT REQUIRE ADVANCED ENERGY METERING

Determine the type and quantity of advanced meters necessary to capture all individual end uses that represent 10% or more of the building's total annual energy consumption (see *Further Explanation, Determining Major End Uses*).

- Projects that used modeling to achieve EA Prerequisite Minimum Energy Performance (Option 1) must use the whole-building simulation results to determine which end uses must be metered.
- Projects that followed a prescriptive pathway for EA Prerequisite Minimum Energy Performance (Option 2 or 3) should use historical end-use data from buildings with similar design and operational characteristics.

Note: Step 2 is not applicable to Core and Shell Projects.

STEP 3. IMPLEMENT ADVANCED METERING SYSTEM

Design and install an advanced metering system.

- Refer to the credit requirements for types of equipment, measurement frequency, communication protocols, and data storage requirements (see *Further Explanation, Meter Selection*).
- Locate the meters to capture the usage of major end users (see *Further Explanation, Electricity Metering Strategies*).
- Install and calibrate the meters according to the manufacturers' recommendations.

FURTHER EXPLANATION

DETERMINING MAJOR ENERGY END USES

Defining appropriate energy end uses is crucial to the success of an advanced energy metering program and energy management plan. Low data granularity, such as with whole-building energy data, will not help a building operator understand or identify sources of anomalies in energy consumption and does not meet the intent of this credit.

Extreme granularity, achieved by metering every piece of equipment in a building, may be cost prohibitive because of the quantity of equipment and the data storage capacity required. In addition, too much information may overwhelm an energy manager and may hamper the effectiveness of an energy management program.

Identifying major energy end uses is the first step in choosing what to meter. Often, in large commercial or industrial buildings, end uses are classified as systems composed of discrete pieces of equipment that can be metered together. For example,

- Chilled water system: chillers, chilled water pumps

- Condenser water system: cooling tower, condenser water pumps
- Hot water system (natural gas): boilers
- Hot water system (electricity): hot water pumps
- Air-handling system: supply fan, return fan, damper motors

Smaller buildings may not have large systems that are easily segregated by function. A common example is a rooftop unit (RTU), a single packaged piece of equipment that can provide the cooling, heating, and air handling but is cost and space prohibitive to submeter. Therefore, metering the entire RTU (or metering each fuel supplying the RTU, if there is more than one) is an acceptable way to achieve this credit. Even though metering the energy usage of each system component of a packaged system is not practical, the performance of each system component should be monitored by the building automation system.

The metering strategy for systems that serve the same basic function, such as multiple built-up air-handling units serving a 1,000,000-square-foot (92 900-square-meter) multitenant office building, or multiple RTUs serving a 25,000-square-foot (2 325-square-meter) physician's office, is left to the discretion of the project team. Examples of options for submetering these systems include the following:

- Meter all similar systems together. This strategy is appropriate for multiple systems that serve the same type of occupant and operate according to the same schedule.
- Meter all similar systems separately. This strategy is appropriate if each system serves a different type of occupancy group or has a different operating schedule.
- Meter similar systems by grouped occupancy type or operating schedule. This strategy is a combination of the above.

It is acceptable to exclude a small portion of the total loads from each end-use category. Not more than 10% of the total connected load of any of the required end-uses is permitted to be excluded from that end-use advanced metering data collection. Not more than 10% of the total connected load of any of the end-uses where metering is required is permitted to consist of loads not part of that end-use.

Choosing what equipment and components to group requires a balance between keeping the project costs on budget while ensuring that robust data are available for future decision making.

Examples of typical end uses for a commercial office building that may require advanced metering include the following:

- Receptacle equipment
- Interior lighting
- Space heating
- Space cooling
- Fans
- Pumps
- Heat rejection
- Exterior lighting
- Service water heating

Energy modeling software that is acceptable for EA Credit Minimum Energy Performance produces a report of energy consumption for a standard set of end uses. Some programs also allow the user to virtually meter additional end uses. An energy model completed in the design phase of the project will enable the metering system to be integrated into design drawings and project specifications. The engineer of record may enlist the energy modeling professional to help identify and specify the number and location of meters.

If the project team does not conduct energy modeling to comply with EA Prerequisite Minimum Energy Performance, the end uses to meter can be estimated by referencing the Commercial Building Energy Consumption Survey (2003) End-Use Consumption Tables for Non-Mall Buildings or End-Use Consumption Tables for All Buildings.

End uses can be grouped by occupancy type, building section, or building level. This type of consolidation can be useful for buildings with different usage types, such as a commercial office with an industrial test kitchen, since it allows building operators and energy managers to separately monitor different space types and account for different energy usage patterns.

METER SELECTION

The accuracy of available commercial meters and submeters varies widely. Select meters based on the level of accuracy required for energy management purposes. It is recommended that submeters that may be used for revenue purposes conform to the applicable revenue-grade accuracy (see EA Prerequisite Building-Level Metering, *Further Explanation, Meter Selection*).

When locating meters, consider any physical installation requirements (e.g., straight lengths of piping). Incorrect application or installation of a meter can reduce measurement accuracy.

Ensure that staff responsible for installing and maintaining equipment and using the data have input into the meter selection.

The owner is responsible for maintaining and calibrating meters according to the manufacturers' recommendations.

ELECTRICITY-METERING STRATEGIES

The number and location of electricity meters depend on the layout of a project's electrical panels.

If major energy-using systems are segregated by panel, energy consumption can be measured at the panel level and fewer submeters will be required (Figure 1). Individual branch circuit meters can be avoided if more than 90% of the panel's power is directed to a single end use. For example, if a panel is shared by the air-handling system and mechanical room but the lighting accounts for less than 10% of the power load of the panel, then the individual lighting branch circuits do not need to be metered.

If multiple diverse end uses are connected to the same panel, individual branch circuits must be metered to extract the individual energy consumption of each (Figure 2). Submetering individual branch circuits will be an additional cost.

If the majority of a panel serves one system type, subtraction metering may be used. This strategy requires metering of the entire panel as well the individual branch circuits for minority end uses. The energy consumption of the majority end use is then determined by subtracting the minority end uses from the total panel consumption (Equation 1, Figure 3).

EQUATION 1. Example subtraction metering

Lighting energy consumption (Major panel end use) = Total panel energy (Panel meter) - Water heater energy (Branch circuit meter 1) - Conference room fan powered box (Branch circuit meter 2)

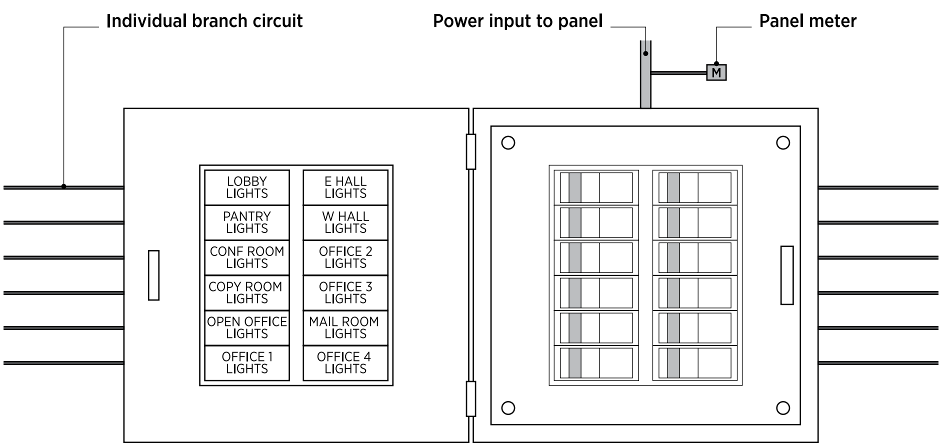


Figure 1. Power panel that serves single end use: single submeter

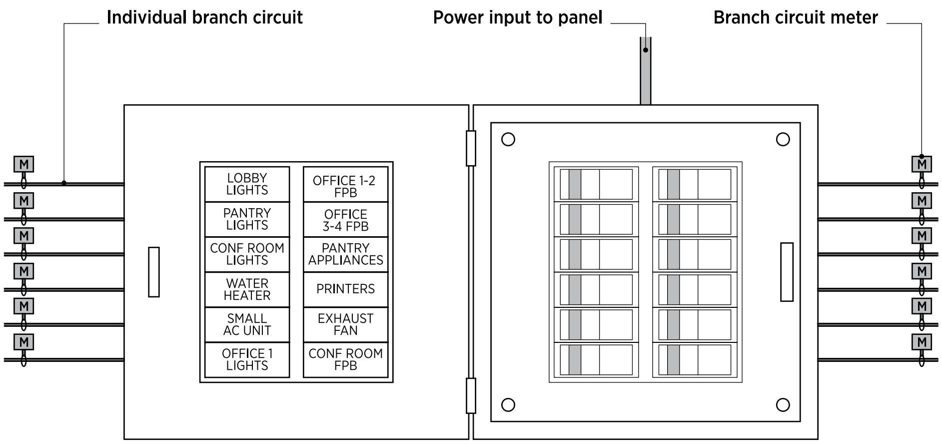


Figure 2. Panel that serves diverse end uses: one submeter for each branch circuit

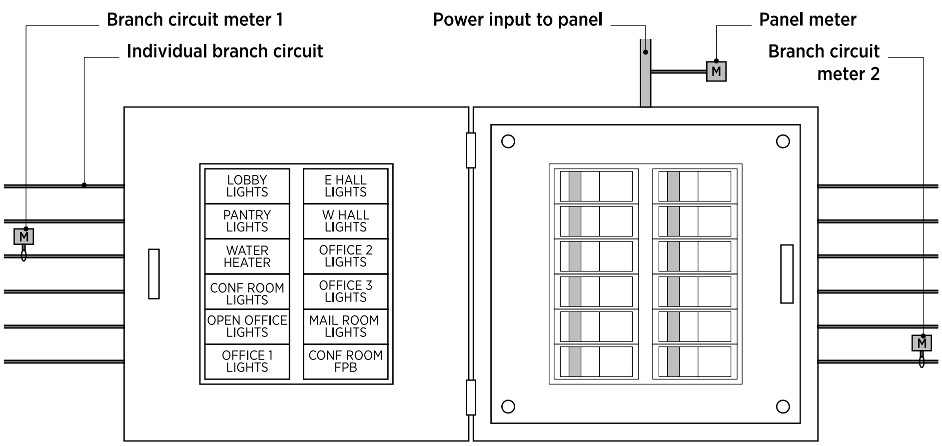


Figure 3. Panel that serves one majority use: one meter for panel and one meter for branch circuits for minority uses

RATING SYSTEM VARIATIONS

Core and Shell

Advanced energy metering must be installed for all energy sources used by the base building. Additionally, the devices must enable independent metering of future tenants' energy consumption.

Base building energy consumption includes all building systems and equipment in the core and shell scope of work. Examples include central plants, elevators and escalators, interior and exterior lighting, receptacle equipment, and HVAC equipment that serves core space, such as parking garages, lobbies, corridors, and restrooms.

The number of meters required for tenant spaces depends on building configuration; a minimum of one meter per energy source per floor is required. All energy sources utilized by a tenant must have advanced metering, including electricity, natural gas, chilled water, and heating hot water (service hot water may be excluded). Advanced metering is not required to measure end-use consumption of systems and equipment installed by tenants.

Examples for Core and Shell projects:

Example 1: Base building includes condenser water system (electric cooling towers and pumping system) and heating hot water systems (boilers). Energy sources required to be metered with advanced metering characteristics: electricity and natural gas (boilers). Tenant spaces served by water source heat pump systems using base building condenser water with radiant baseboard heating (hot water supplied by base building). Energy sources required to be metered with advanced metering characteristics: electricity, and heating hot water (at least one per floor).

Example 2: Base Building includes chilled water system (electric chillers, cooling towers, and pumping system) and heating hot water systems (boilers). Energy sources required to be metered with advanced metering characteristics: electricity and natural gas (boilers). Tenant spaces served by four-pipe fan coil units. Energy sources required to be metered with advanced metering characteristics: electricity, chilled water, and heating hot water (at least one per floor).

Data Centers
IT energy consumption, as measured from an uninterruptible power supply (UPS) output meter, should be metered separately from non-IT equipment, such as HVAC, plug loads, and lighting. If the UPS system supports non-IT loads that amount to more than 10% of its load, such as lighting or cooling, this non-IT load should also be submetered. This guidance is derived from ENERGY STAR and applies to data center buildings as well as commercial buildings that contain large data centers.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
List of all advanced meters to be installed, including type, energy source metered	X
Manufacturers' cutsheets	X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. Project teams following Option 1, Whole-Building Energy Simulation, must use the results of the simulation to determine which end uses represent 10% or more of the total annual consumption of the building. Project teams following the prescriptive options (Option 2, ASHRAE 50% Advanced Energy Design Guide or Option 3 Advanced Buildings Core Performance Guide) can estimate energy consumption by referencing the Commercial Building Energy Consumption Survey (2003), End-Use Consumption Tables for Non-Mall Buildings or End-Use Consumption Tables for All Buildings.

EA Prerequisite Building-Level Metering. If an advanced metering system is installed, additional whole-building metering is not required for the related prerequisite.

EA Credit Demand Response. An advanced metering system facilitates participation in demand response programs and provides an additional means to track building energy reduction levels.

EA Credit Renewable Energy Production. Renewable energy systems and net metering will affect the kind of energy meters that are installed for this credit.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

ENERGY AND ATMOSPHERE CREDIT

Demand Response

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To increase participation in demand response technologies and programs that make energy generation and distribution systems more efficient, increase grid reliability, and reduce greenhouse gas emissions.

REQUIREMENTS

Design building and equipment for participation in demand response programs through load shedding or shifting. On-site electricity generation does not meet the intent of this credit.

Case 1. Demand Response Program Available (2 points)

- Participate in an existing demand response (DR) program and complete the following activities. Design a system with the capability for real-time, fully-automated DR based on external initiation by a DR Program Provider. Semi-automated DR may be utilized in practice.
- Enroll in a minimum one-year DR participation amount contractual commitment with a qualified DR program provider, with the intention of multiyear renewal, for at least 10% of the estimated peak electricity demand. Peak demand is determined under EA Prerequisite Minimum Energy Performance.
- Develop a comprehensive plan for meeting the contractual commitment during a Demand Response event.
- Include the DR processes in the scope of work for the commissioning authority, including participation in at least one full test of the DR plan.

Case 2. Demand Response Program Not Available (1 point)

Provide infrastructure to take advantage of future demand response programs or dynamic, real-time pricing programs and complete the following activities.

- Install interval recording meters with communications and ability for the building automation system to accept an external price or control signal.
- Develop a comprehensive plan for shedding at least 10% of building estimated peak electricity demand. Peak demand is determined under EA Prerequisite Minimum Energy Performance.
- Include the DR processes in the scope of work for the commissioning authority, including participation in at least one full test of the DR plan.
- Contact local utility representatives to discuss participation in future DR programs.

BEHIND THE INTENT

When temperatures rise or fall dramatically, use of air-conditioning or heating increases. The electricity grid must respond quickly, especially in urban areas and places where commercial buildings or industrial operations are clustered. Utilities work to keep the system operating in balance, reliably, and at reasonable cost.

Demand response (DR) strategies encourage electricity customers to reduce their usage during peak demand times, helping utilities optimize their supply-side energy generation and delivery systems. One strategy is tiered demand electricity pricing. Another is incentive programs that reward commercial consumers who agree to change their usage patterns when the utility company sends an alert (to the building's operator or the building automation system) announcing a DR event (also known as a curtailment event). DR programs set a maximum number of events that can be announced and specify the time frames in which they may occur.

By reducing overall demand for electricity, DR helps utilities avoid building additional power generation facilities, transmission lines, and distribution stations, thereby avoiding some of the environmental effects of energy infrastructure and consumption. DR also helps balance the contribution of renewable energy sources. For example, on calm days or at night, when renewable sources such as wind and solar are less available, grid operators must either find additional generation sources or persuade energy users to lower demand. DR achieves the latter, balancing systemwide usage and reducing the need for nonrenewable backup generation.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE APPLICABLE CASE

Contact the utilities serving the project site to see whether demand response programs are available and determine the appropriate case (see *Further Explanation, Demand Response Program Availability*).

- Case 1 Demand Response Program Available is for projects in locations that have DR programs. Participation is required to achieve the credit.
- Case 2 Demand Response Program Not Available requires the project team to design a system to accommodate future DR programs.

STEP 2. DESIGN SYSTEM TO ACCEPT EXTERNAL SIGNALS

Incorporate the capability for a demand response program into the design process as indicated in the credit requirements and by the utility (if applicable). Systems must be capable of acting on an external signal, but their actual operation may be either fully or semi-automated (see *Further Explanation, Demand Response Event Management*).

STEP 3. DETERMINE PEAK DEMAND REDUCTION REQUIREMENT

Establish the peak demand estimate. Projects that used modeling to achieve EA Prerequisite Minimum Energy Performance should take the estimated peak from the model. Projects that followed a prescriptive path may use space peak load calculations to estimate overall building peak demand, or other methods or calculations based on information available. Use Equation 1 to determine the minimum peak demand reduction required.

EQUATION 1. Minimum reduction in peak electricity demand

$$\text{Minimum reduction} = 10\% \times \text{Peak demand}$$

STEP 4. DEVELOP STRATEGIES FOR PEAK DEMAND REDUCTION

Identify strategies that will allow the project to meet or exceed the minimum demand reduction target (see *Further Explanation, Strategies to Reduce Demand*).

- Project teams may wish to incorporate these strategies into the energy model to confirm that they will meet or exceed the reduction target.
- Many utilities and third-party energy providers can work with project teams to review local demand response options and make design suggestions.

STEP 5. PREPARE PLAN FOR PEAK DEMAND REDUCTION

Generate a plan that provides clear direction for implementing the identified demand reduction strategies. Include activities, responsible parties, and anticipated reduction for each measure (see *Further Explanation, Developing the Action Plan*). The training plan and objectives for those employees directly responsible for executing the demand response action plan should address the following activities:

- Individual assignments
- Event signals
- Communication protocols
- Recovery
- Reporting
- Clear status

Ensure that the DR operations team members, which may include the DR coordinator, facilities manager, and DR action plan manager, agree with the content of the plan, since they will be implementing it (see *Further Explanation, Demand Response Operations Team*). The building's DR coordinator and team members should be well trained in mitigating any potential problems.

STEP 6. INCLUDE DEMAND RESPONSE IN COMMISSIONING

Coordinate with the CxA to include a review of the DR plan in the commissioning of the building's system test procedures, to verify the ability to handle an externally initiated demand response event. The Cx plan must include at least one performance test of the full DR plan to verify that all equipment responds as planned and that all responsible parties understand their roles.

CASE 1. DEMAND RESPONSE PROGRAM AVAILABLE

STEP 1. ENROLL IN DEMAND RESPONSE PROGRAM

Select a DR program and enroll in a minimum one-year contract (see *Further Explanation, Demand Response Program Types*).

- Participation in a DR program requires engaging a DR provider and entering into an agreement to provide curtailment of building energy demand upon notification of a DR event, or to participate in other DR strategies, such as ancillary services.
- Retain a copy of the DR program enrollment contract or verification issued by the independent system operator, regional transmission organization, or energy provider.
- Typical contracts specify the physical address of the building(s), authorized agents for event notification, utility account numbers, terms for earning revenue, terms for revenue sharing, number and duration of events, notification processes, monitoring requirements, enrollment periods, minimum size, performance and consequences for nonperformance, penalties, and renewal options. Not all elements listed will be applicable to all project types.

CASE 2. DEMAND RESPONSE PROGRAM NOT AVAILABLE

STEP 1. CONTACT LOCAL UTILITY

Contact the local utility or service provider to express interest in a future program. Utilities and service providers may want to start a demand response program but not know about facilities that can and would participate. Indicating the project's capability and willingness to take part in a program may encourage them to proceed.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

DEMAND RESPONSE PROGRAM AVAILABILITY

Energy supply and demand vary widely on a regional and national basis and are determined in part by local market conditions and regulatory frameworks. Participation in demand response is often encouraged by state regulatory agencies or state legislatures. Information on state demand response programs can often be found on the public utility commission's website.

In the U.S., the Federal Energy Regulatory Commission has developed the National Action Plan on Demand Response, with the goal of achieving greater demand response, consistent with the requirements of the Energy Independence and Security Act of 2007.

DEMAND RESPONSE EVENT MANAGEMENT

When a DR event is called, the DR program provider sends a signal as specified in the program enrollment contract. The signal may be based on price, reliability, or supply and demand.

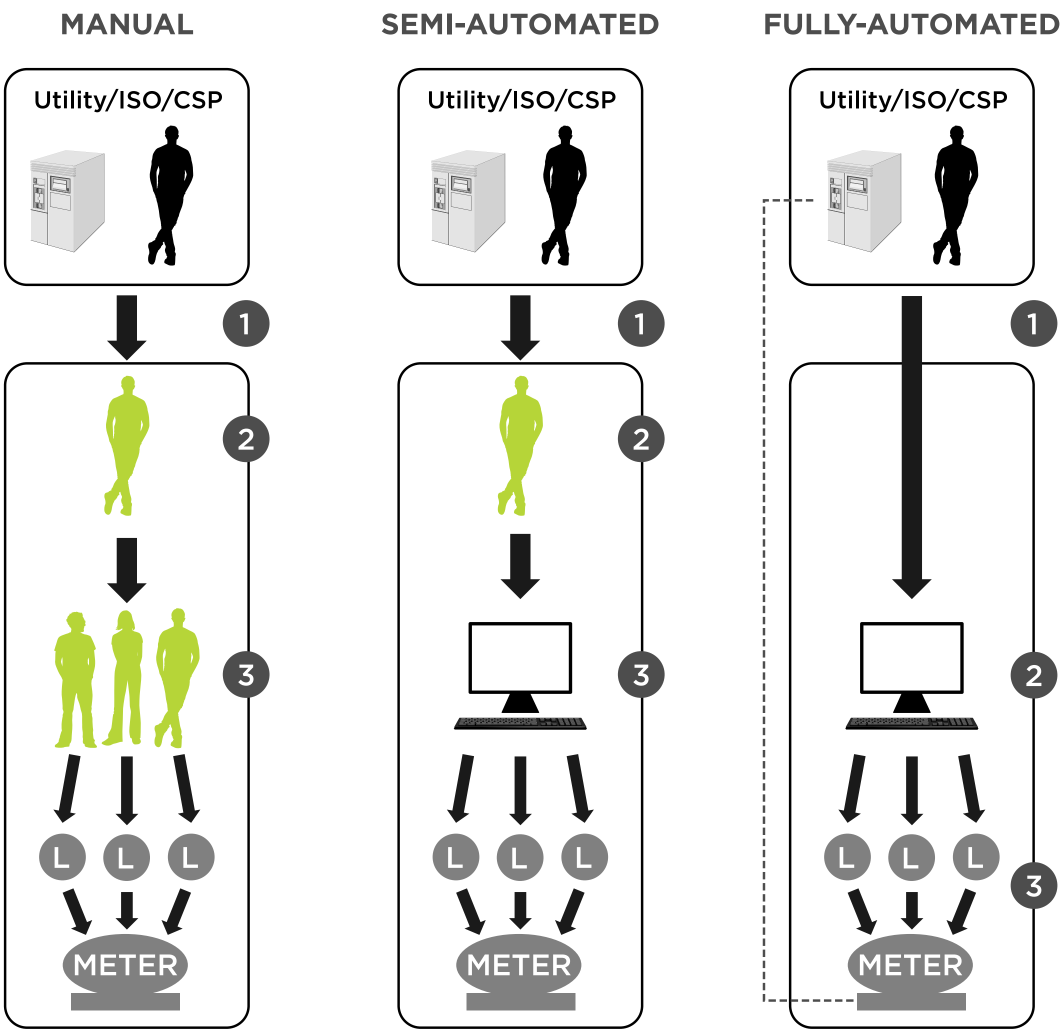
Demand response signals are received and acted on manually or through an energy management control system, which may include a building automation system (BAS), a building management system, and a programmable load control.

TABLE 1. Demand response management

Level	Energy management control system	Response to DR event	Eligible for credit
Manual demand response	No	Building operator or occupants manually turn off end-use systems (e.g., lights, HVAC, other equipment)	No
Semiautomated demand response	Yes	DR coordinator or other person initiates control strategy programmed into BAS	Yes
Fully automated demand response	Yes	BAS control sequence initiates strategy, without human intervention	Yes

Source: Used with permission from Lawrence Berkeley National Laboratory.

Figure 1. Demand response progression. Used with permission from Lawrence Berkeley National Laboratory.



1. DR Event notice sent via text, e-mail or phone call
2. Decision to participate is made by a person
3. DR measures are initiated by people on-site and limited to manually adjustable components such as light switches, thermostats, etc.

1. DR Event notice sent via text, e-mail or phone call
2. Decision to participate is made by a person
3. Pre-programmed DR measures are initiated by a person at a workstation

1. DR Event notice sent over the Internet or private network
2. Pre-programmed DR measures are initiiated automatically
3. In some cases the meter feed-back is provided

ISO = Independent System Operator   CSP = Curtainment Service Provider   L = Load

STRATEGIES TO REDUCE DEMAND

Project teams may reduce peak demand by modifying consumption from various end-use systems, such as HVAC and lighting.

- Global temperature adjustments increase cooling setpoints (or decrease heating setpoints) for an entire facility for a given period. Facilities managers may find that some occupants prefer the temperatures under DR events, indicating the possibility of making permanent changes to the setpoints.
- Turning off decorative features, like fountains and video displays, reduces energy consumption without affecting worker productivity.
- Hospitality and health care facilities may be able to reschedule housekeeping activities, such as dishwashing and laundry.

DEMAND RESPONSE OPERATIONS TEAM

Participating in DR requires careful evaluation, planning, and execution of curtailment strategies. A project team member may fill one or more of the following roles:

- DR project coordinator
- Facilities manager
- DR action plan (curtailment) manager
- DR credit project manager
- DR integration service provider, or energy services company
- DR provider account manager (e.g., utility, independent system operator, curtailment service provider employee)

The demand response provider or curtailment service provider can recommend qualified outside contractors for help with system analysis and demand response planning.

DEVELOPING THE ACTION PLAN

Projects must develop a comprehensive action plan to address roles, responsibilities, and expectations for a demand response event. The plan should address at least the following:

- Potential for demand response participation, such as curtailment of peak demand, and the elected demand response value, or schedule of values, in kWs, to be registered with the DR provider
- Event notification process for demand response events, such as a phone call, an alarm with countdown clock, or a signal to a BAS console, depending on the degree of program automation (i.e., semi-automated or automated).
- Detailed procedures and responses to execute the program measures consistent with the demand response contract
- Contract and the registered demand response participation amount, including the notification method, specific actions, order of execution, load-monitoring process, and postevent recovery process
- Energy management team responsible for coordinating with the program provider, the facilities department, and internal risk management, including event notification and response, revenue settlements, contract administration, assessments, action fulfillment, employee awareness training, readiness drills, and energy management reporting
- Description of end-use systems that will be affected, such as HVAC or lighting, on a stand-alone or integrated basis, during participation in demand response events.

DEMAND RESPONSE PROGRAM TYPES

DR programs vary regionally in the number and timing of events called. One factor that affects the type and number of DR programs is weather: regions with hot weather may have more summer-peaking programs, and regions with cool weather may have more winter-peaking programs. Congestion (transmission constraints) is another: regions that have congestion may have more interruptible load and emergency DR programs. Some program types may be better suited to certain building use categories.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Case 1	Case 2
Proof of enrollment in DR program	X	
Evidence of ability to shed 10% of peak demand	X	X
Confirmation that system is capable of receiving and acting on external signal	X	X
Action plan for meeting reduction requirement during event	X	X
Inclusion of DR in CxA systems testing plan	X	X

RELATED CREDIT TIPS

EA Prerequisite Fundamental Commissioning and Verification. Include DR in the Cx plan to ensure that the building systems respond as anticipated during an event. Test the sequence before an event occurs to work out any problems ahead of time.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

demand response (**DR**) a change in electricity use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized

demand response (**DR**) **event** a specific period of time when the utility or independent service operator calls for a change in the pattern or level of use in grid-based electricity from its program participants. Also known as a curtailment event.

load shedding an intentional action by a utility to reduce the load on the system. Load shedding is usually conducted during emergency periods, such as capacity shortages, system instability, or voltage control.

peak demand the maximum electricity load at a specific point in time or over a period of time

permanent peak load shifting the transfer of energy consumption to off-peak hours, when demand for power is lower and energy is therefore less expensive

ENERGY AND ATMOSPHERE CREDIT

Renewable Energy Production

This credit applies to:

New Construction (1–3 points)
Core and Shell (1–3 points)
Schools (1–3 points)
Retail (1–3 points)
Data Centers (1–3 points)
Warehouses and Distribution Centers (1–3 points)
Hospitality (1–3 points)
Healthcare (1–3 points)

INTENT

To reduce the environmental and economic harms associated with fossil fuel energy by increasing self-supply of renewable energy.

REQUIREMENTS

Use renewable energy systems to offset building energy costs. Calculate the percentage of renewable energy with the following equation:

$$\%\ \text{renewable energy} = \frac{\text{Equivalent cost of usable energy produced by the renewable energy system}}{\text{Total building annual energy cost}}$$

Use the building's annual energy cost, calculated in EA Prerequisite Minimum Energy Performance, if Option 1 was pursued; otherwise use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) database to estimate energy use and cost.

The use of solar gardens or community renewable energy systems is allowed if both of the following requirements are met.

- The project owns the system or has signed a lease agreement for a period of at least 10 years.
- The system is located with the same utility service area as the facility claiming the use.

Credit is based on the percentage of ownership or percentage of use assigned in the lease agreement. Points are awarded according to Table 1.

TABLE 1. Points for renewable energy

Percentage renewable energy	Points (All, except Core and Shell))	Points (Core and Shell)
1%	1	1
3%	—	2
5%	2	3
10%	3	—

BEHIND THE INTENT

Renewable energy generation can reduce carbon emissions and offer local environmental benefits by reducing air pollution. Some renewable energy systems capture wind or sunlight; others usefully employ materials that might otherwise be wasted. Renewable energy produced on-site protects projects from energy price volatility and reliance on the grid while reducing wasted energy lost in transmission. Ultimately, renewable energy production contributes to reducing a country's demand for imported energy.

STEP-BY-STEP GUIDANCE

STEP 1. EXPLORE OPPORTUNITIES FOR RENEWABLES

Determine the most abundant renewable resources on site, such as sunlight, wind, or water, and explore opportunities for using renewable fuels, such as waste wood or biomass (see *Further Explanation, Renewable Resource Considerations*).

STEP 2. COMPARE REQUIREMENTS FOR RENEWABLE ENERGY SYSTEMS

Carefully evaluate the space requirements, costs, financial incentives, and efficiencies for each potential technology.

- Local funding, financing, and incentives for renewable generation projects may be available for certain technologies and may be a significant factor.
- Excess energy, beyond the building's energy demand at a given point, can be sold to the utility company (net metering). The building owner receives the market rate, however, and cannot charge a premium for the renewable energy. In effect, the grid serves as a storage system and frees the project from hosting a storage system on site.
- Tying into an existing community system or creating a community system may lower cost barriers through economies of scale, because unit costs may decrease as system sizes increase. Community systems can also take advantage of time-shifted demand: one building that is occupied during the day and another building that is occupied at night could both take advantage of the same biofuel-fired heating system.
- Renewable energy may be available from a third-party system, or the project team may enter an arrangement in which a third party owns a system that serves the project. In such cases, project teams must take additional steps to ensure that the arrangement continues for a set period of time and that the renewable energy credits (RECs) are retained (see *Further Explanation, Renewable Energy Systems and Third Parties*).
- Some systems that are commonly considered renewable do not qualify for this credit (see *Further Explanation, Eligible Renewable Energy Systems*).

STEP 3. SET RENEWABLE ENERGY TARGET

To establish the target renewable energy system size for the project, estimate the annual energy cost for the project.

- Projects that used modeling to achieve EA Prerequisite Minimum Energy Performance (Option 1) must base annual energy cost on the whole-building simulation results (see *Further Explanation, Example 1*).
- Projects that used a prescriptive path to achieve EA Prerequisite Minimum Energy Performance (Option 2 or 3) must use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) data to estimate annual energy use and cost (see *Further Explanation, Example 2*).
- Use either the maximum building system size that can be accommodated in the project or the available budget as the starting point to estimate the maximum number of points for this credit.
- To qualify toward credit points, the environmental benefits associated with generated renewable energy must be retained or, if sold, purchased in an equivalent amount (see *Further Explanation, Renewable Energy Certificates [RECs]* and *Carbon Offsets*).

STEP 4. DESIGN AND SPECIFY SYSTEM CRITERIA

Many resources are available, some for no or little cost, for planning and designing a renewable energy system. Given basic information for the project, many manufacturers can complete the necessary calculations for the project team. Teams will also find software tools that help in sizing. If pursuing EA Credit Enhanced Commissioning, address commissioning of the system at this step.

STEP 5. CALCULATE RENEWABLE ENERGY COST CONTRIBUTION

Use Equation 1 to estimate the annual energy cost of the usable energy produced by the renewable energy system and calculate the points available. Teams that used whole-building simulations to comply with EA Prerequisite Minimum Energy Performance must use the results of the model in this calculation.

EQUATION 1. Percentage renewable energy cost contribution

$$\text{\% renewable energy cost} = \frac{\text{Equivalent cost usable energy produced by renewable energy system}}{\text{Total estimated building annual energy cost}}$$

- Usable energy is defined as the output energy from the system less any transmission and conversion losses, such as standby heat loss or losses when converting electricity from DC to AC.
- The project may use the virtual energy rate or the actual utility rates (see *Further Explanation, Equivalent Cost for Renewable Energy*).

Projects served by a district energy system (DES) using renewable energy are eligible to receive credit for the percentage of its contribution. Use Equation 2 to determine this amount (see *Further Explanation, Example 3*).

EQUATION 2. Equivalent cost of renewable energy with district energy system

$$\text{Equivalent cost of DES renewable energy} = (\text{\$ value of renewable energy used at DES} \times \text{\% of DES energy delivered to building})$$

Projects generating renewable energy through a community or off-site facility have additional documentation requirements for the criteria noted in the credit requirements.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*.

RENEWABLE RESOURCE CONSIDERATIONS

A project team should use web resources and other tools available to determine the feasibility of renewable systems, given the project site’s climate, context, and infrastructure. Consider the features of the site, such as solar availability, wind patterns, and other renewable energy sources, and any seasonal or daily variations in its supply. Certain project types may have special opportunities: office or university campuses typically have available land, for example, and warehouse projects may have large roof areas.

Match the project’s energy needs with renewable energy output when selecting a renewable system. For example, a sunny site is a good candidate for solar thermal hot water, but this type of renewable resource is most cost-effective if the building has a constant demand for hot water. Accordingly, a hotel or a multifamily project may be a better match for a solar thermal hot water system than an office complex.

Daily and seasonal variations in loads also factor into the investigation of renewable energy. For example, a residential project with low daytime electricity demand may require battery storage to benefit from a photovoltaic (PV) array; an office building with high daytime demand may not.

RENEWABLE ENERGY SYSTEMS AND THIRD PARTIES

Renewable Fuels Purchased Off-Site

Some renewable energy power generation systems that use fuels produced off site (e.g., landfill gas) can still be eligible to receive points under this credit if these fuels are harvested and produced within the same utility service area.

- The project has a minimum 10-year contract with the fuel provider.
- The contract with the fuel provider includes both the fuel and all associated RECs.

On-Site Third Party Systems

In some cases, on-site renewable energy may be available from equipment, such as a PV array or wind turbine owned by a third party. Project teams wishing to receive credit for such an arrangement must submit documentation, including the agreement between the project owner and the power producer. The contract must last for at least 10 years, and the project owner must retain all environmental benefits from the renewable energy.

ELIGIBLE RENEWABLE ENERGY SYSTEMS

Allowable sources for renewable energy include the following:

- Photovoltaic
- Solar thermal
- Wind
- Biofuel (in some cases)
- Low-impact hydroelectricity
- Wave and tidal energy
- Geothermal energy (in some cases)

Some renewable energy systems do not meet the intent of the credit and are not eligible. Strategies like architectural features, passive solar, and daylighting, for example, reduce energy consumption but are not eligible renewable energy systems.

Geothermal energy, such as electricity generated from subterranean steam or heat generated from subterranean steam or hot water, is eligible. However, geothermal energy used in conjunction with vapor compression cycles, as in a ground-source heat pump, is not.

If a biofuel is used in a cogeneration plant that produces both electricity and heat, both of these energy uses count as renewable energy. A biofuel used in a boiler to produce heat also qualifies. However, not all biofuels meet the intent of this credit. The following biofuels are ineligible:

- Combustion of municipal solid waste
- Forest biomass waste other than mill residue
- Wood coated with paints, plastics, or laminate
- Wood treated for preservation with materials containing halogens, chlorine compounds, halide compounds, chromated copper arsenate, or arsenic; if more than 1% of the wood fuel has been treated with these compounds, the energy system is ineligible

RENEWABLE ENERGY CERTIFICATES AND CARBON OFFSETS

The environmental benefits from renewable energy generation are certified and tracked through renewable energy certificates (RECs). A third party ensures that a specific amount of power was generated by a renewable source. By purchasing RECs, a project that is using nonrenewable energy can still stimulate demand for green power.

Carbon offsets allow buildings or companies to fund activities that decrease carbon emissions or remove carbon from the atmosphere. Carbon offset projects include reforestation, carbon sequestration, energy efficiency projects, and land-use changes.

Generating renewable energy has both environmental and financial benefits, and projects must retain both benefits to be eligible for this credit. Projects with ownership of renewable energy generation have the option to sell the RECs associated with their renewable energy generation. Some utilities may grant a rebate to projects that generate their own renewable energy and also require that they give up the rights to the RECs associated with the generation. An on-site renewable generation project can still claim this credit by purchasing enough RECs or offsets to make up for the RECs that were sold. In such cases, projects that are generating electricity are required to purchase Green-e–certified RECs; projects that are generating heat or other nonelectric energy are required to purchase Green-e Climate–certified carbon offsets.

Both RECs and carbon offsets are addressed in EA Credit Green Power and Carbon Offsets.

EQUIVALENT COST OF RENEWABLE ENERGY

The equivalent cost of the usable energy system can be calculated in two ways, virtual rate or actual utility tariff plus demand rates.

Virtual rate. The project team may use the virtual energy rate determined by the proposed building energy model used for EA Credit Optimize Energy Performance. The virtual rate accounts for both consumption and demand charges. Project teams that use the Energy Information Administration's average energy prices must use the virtual rates to determine the renewable energy system cost.

Actual rate plus demand. Calculate the expected savings in both consumption and demand charges, based on the rates charged by the utility that serves the project. If a project is served by a utility that uses time-dependent valuation to set rates, the team may use those rates but must provide hourly calculations for the value of generated energy. Some energy modeling software may calculate the savings from renewable energy systems if the utility rates include consumption, demand, time-dependent valuation, time-of-use, ratchets, and other factors.

For renewable energy sources priced on a basis other than per unit of energy, the project team must account for all the costs associated with the source, such as delivery costs and annual fees. For example, a project that uses heat generated from geothermal steam needs to account for all the equipment, maintenance, and labor costs associated with the geothermal system throughout the year.

In addition to calculating the equivalent cost of the energy generated, project teams must also provide calculations that show how much energy the renewable energy system will produce. With some technologies, like a biofuel-fired boiler, energy modeling software can determine the amount of energy generated. In other cases, such as PV or wind systems, the amount of energy generated may be determined by using an external calculation program. In either case, provide all assumptions and outputs associated with the renewable energy calculations.

EXAMPLES

Example 1. Project with complete energy modeling data

A proposed multifamily residential project has completed its energy model for EA Credit Optimize Energy Performance and is sizing a PV array. The project anticipates using 562,457 kWh of electricity, with a virtual energy rate of $0.082 per kWh. Gas consumption is calculated as 29,650 therms, at a utility rate of $0.675 per therm of natural gas. The total building annual energy cost is as follows:

Total cost = (Gas consumption x Gas rate) + (Electricity consumption x Electricity rate)

Total cost = (29,650 therms x $0.675/therm) + (562,457 kWh x $0.082/kWh)

Total cost = $20,013 + $46,121 = $66,134

The project has space on site for a 150-kW PV array. Based on calculations provided by the solar array installer, the system will produce 218,789 kWh of electricity per year, after transmission and conversion losses. The project team calculates the equivalent cost of the renewable energy generated:

Equivalent cost = (Units of renewable energy generated x Project utility or virtual rate for type of energy generated)

Equivalent cost = (218,789 kWh x $0.082/kWh) = $17,941

The project can now calculate its percentage of renewable energy:

$$\% \text{ renewable energy} = \frac{\text{Equivalent cost usable energy produced by renewable energy system}}{\text{Total building annual energy cost}}$$

$$\% \text{ renewable energy} = \frac{\$17{,}941}{\$66{,}134}$$

$$\% \text{ renewable energy} = 27\%$$

Example 2. Project without energy modeling data

A proposed 75,000-square-foot office project is complying with EA Prerequisite Minimum Energy Performance through a prescriptive path but is also installing an on-site renewable energy system. To achieve this credit, the team must determine its total building annual energy cost. The project will have gas and electricity service. Local utility rates are $1.10 per therm of natural gas and $0.09 per kWh of electricity. Using data from CBECS (Table 1), the project can estimate its annual energy consumption by fuel type.

Projects with multiple space types should calculate energy consumptions for each space type separately based on Table 2.

TABLE 2. CBECS building energy intensity data

Building type	Total energy consumption (CBECS Table C3)		Total electric energy consumption (CBECS Table C14)		Total nonelectric energy consumption	
	kBtu/ft²	kWh/m²	kWh/ft²	kWh/m²	kBtu/ ft²	kWh/m²
Education	83.1	262.2	11	118.4	45.5	143.6
Food sales	199.7	630.1	49.4	531.8	194.6	614
Food service	258.3	814.9	38.4	413.3	127.4	401.9
Health care inpatient	249.2	786.2	27.5	296.0	155.5	490.6
Health care outpatient	94.6	298.5	16.1	173.3	39.6	124.9
Lodging	100	315.5	13.5	145.3	53.9	170.1
Retail (nonmall)	73.9	233.2	14.3	153.9	25.1	79.2
Enclosed and strip malls	102.2	322.4	22.3	240.0	26.2	82.7
Office	92.9	293.1	17.3	186.2	34	107.3
Public Assembly	93.9	296.3	12.5	134.6	51.3	161.9
Public order and safety	115.8	365.3	15.3	164.7	63.5	200.3
Religious worship	43.5	137.2	4.9	52.7	26.9	84.9
Service	77	242.9	11	118.4	39.5	124.6
Warehouse and storage	45.2	142.6	7.6	81.8	19.3	60.9
Other	164.4	518.7	22.5	242.2	87.6	276.4

Source: This table is from the Energy Information Administration (EIA) website.

Electricity cost is estimated as follows:

$$\text{Electricity cost} = (\text{Electricity kWh/ft}^2 \text{ for space type} \times \text{Project area} \times \text{Project electricity rate})$$

$$\text{Electricity cost} = (17.3 \text{ kWh/ft}^2 \times 75{,}000 \text{ ft}^2 \times \$0.09/\text{kWh})$$

$$\text{Electricity cost} = \$116{,}775$$

The project's gas cost can be estimated in the same manner:

$$\text{Gas cost} = (\text{Nonelectric kBtu/ft}^2 \text{ for space type} \times \text{Project area} \times (1 \text{ Therm} / 100 \text{ kBtu}) \times \text{Project gas rate})$$

$$\text{Gas cost} = (34 \text{ kBtu/ft}^2 \times 75{,}000 \text{ ft}^2 \times (1 \text{ Therm} / 100 \text{ kBtu}) \times \$1.10 / \text{Therm})$$

$$\text{Gas cost} = \$28{,}050$$

The project's total annual building energy cost is the sum of the electricity and gas costs, or $144,573. The building site has space for a 70-kW solar array, which is estimated to produce 92,254 kWh of electricity per year, after transmission and conversion losses. The project's equivalent cost of usable energy is calculated as follows:

$$\text{Equivalent cost} = (\text{Units of renewable energy generated} \times \text{Project utility rate for type of energy generated})$$

$$\text{Equivalent cost} = (92{,}254 \text{ kWh} \times \$0.09/\text{kWh}) = \$8{,}303$$

The project can now calculate its percentage of renewable energy:

$$\%\text{ renewable energy} = \frac{\text{Equivalent cost usable energy produced by renewable energy system}}{\text{Total building annual energy cost}}$$

$$\%\text{ renewable energy} = \frac{\$8{,}303}{\$144{,}825}$$

$$\%\text{ renewable energy} = 5.7\%$$

Example 3. Project connected to a DES
A university classroom building is connected to a central chilled-water plant that serves multiple campus buildings. The central plant has a dedicated photovoltaic array that provides a portion of the energy to the chilled water plant. The DES uses the equivalent of $100,000 of electricity generated from PV, and the project receives 25% of the chilled water output of the DES. The project calculates its equivalent cost of renewable energy as follows:

$$\text{Equivalent cost} = (\$ \text{ value of renewable energy used at DES} \times \% \text{ of DES energy delivered to building})$$

$$\text{Equivalent cost} = (\$100{,}000 \times 25\%)$$

$$\text{Equivalent cost} = \$25{,}000$$

PROJECT TYPE VARIATIONS

District Energy Systems (DES)
For projects documenting EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance using Path 2 or 3 (full DES performance accounting or streamlined DES modeling), qualifying renewable energy sources used in a DES may earn points in EA Credit Renewable Energy Production for a connected

building. That is, they count as "on-site" renewable energy for the connected building. Projects using energy model Path 1 for renewable DES sources do not earn points in the energy performance prerequisite and credit for a connected building.

The fraction of project costs offset by the renewable energy that the DES contributes depends on the total cost of renewable energy used at the DES to generate each thermal energy source, and the percent of each DES thermal energy source delivered to the project. For each thermal energy source provided to the building by the district plant, calculate the renewable contribution as follows.

1. Use equation 1 in Further Explanation > Step by Step Guidance to estimate the annual energy cost for each district thermal energy source provided by qualifying renewables.
2. Sum the annual cost of the renewable energy contribution from each district thermal energy source serving the building to identify the total renewable energy contribution from the district plant.

If renewable energy contributions from the DES are applied to a connected building, submit a letter from the DES owner or operator verifying all of the following:

- That the quantity of renewable energy reported above is allocated to the DES itself (i.e., the upstream generation or distribution equipment) and not directly to any building
- That within the overall DES renewable energy allocation, no renewable energy assigned specifically to the DES central plant building, if any (in a separate LEED application), is also being counted toward the renewable energy contribution of the connected project building
- That no renewable energy is being double-counted among any connected project buildings (in separate LEED applications)
- That either the DES owner or its operator maintains rights to the environmental benefits of the site-generated renewable energy, or that RECs or offsets are being purchased in an amount equal to the benefits being claimed

Projects that do not use energy modeling may not take credit for renewable energy sources used for the DES upstream of the project.

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	On-site system	On-site third party system ownership	Community system
Renewable system rated capacity	X	X	X
Calculations to determine energy generated	X	X	X
Equivalent cost of renewable energy produced	X	X	X
Documentation of annual energy costs	X	X	X
Contract indicating duration		X	X
Documentation indicating percentage owned or leased of community system			X
If selling RECs for on-site system, Contract and Green-e certification for REC or carbon offset purchase	X		

RELATED CREDIT TIPS

EA Credit Advanced Energy Metering. All whole-building energy sources, including renewable energy sources, must be submetered to comply with the related credit.

EA Credit Green Power and Carbon Offsets. Renewable energy certificates, green power, and carbon offsets purchased from outside vendors are addressed in the related credit; additional points are available for projects that purchase them.

CHANGES FROM LEED 2009

The credit now allows solar gardens and community systems.

REFERENCED STANDARDS

Center for Resource Solutions Green-e Program: green-e.org

Commercial Building Energy Consumption Survey (CBECS): eia.gov/consumption/commercial

EXEMPLARY PERFORMANCE

Renewable energy must account for 15% of total energy. For Core and Shell projects, the threshold is 10%.

DEFINITIONS

district energy system (DES) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

solar garden a shared solar array or other renewable energy system with grid-connected subscribers who receive credit for the use of renewables using virtual net metering. Also known as a community renewable energy system. (Adapted from solargardens.org)

ENERGY AND ATMOSPHERE CREDIT

Enhanced Refrigerant Management

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, HEALTHCARE

OPTION 1. NO REFRIGERANTS OR LOW-IMPACT REFRIGERANTS (1 POINT)

Do not use refrigerants, or use only refrigerants (naturally occurring or synthetic) that have an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of less than 50.

OR

OPTION 2. CALCULATION OF REFRIGERANT IMPACT (1 POINT)

Select refrigerants that are used in heating, ventilating, air-conditioning, and refrigeration (HVAC&R) equipment to minimize or eliminate the emission of compounds that contribute to ozone depletion and climate change. The combination of all new and existing base building and tenant HVAC&R equipment that serve the project must comply with the following formula:

IP Units	SI Units
$LCGWP + LCODP \times 10^5 \leq 100$	$LCGWP + LCODP \times 10^5 \leq 13$
Calculation definitions for LCGWP + LCODP × $10^5 \leq 100$ (IP units)	**Calculation definitions for LCGWP + kg CFC 11/(kW/year) x $10^5 \leq 13$ (SI units)**
LCODP = [ODPr × (Lr × Life + Mr) × Rc] / Life	kg CFC 11/(kW/year) = [ODPr × (Lr × Life + Mr) × Rc] / Life
LCGWP = [GWPr × (Lr × Life + Mr) × Rc] / Life	LCGWP = [GWPr × (Lr × Life + Mr) × Rc] / Life
LCODP: Lifecycle Ozone Depletion Potential (lb CFC 11/Ton-Year)	kg CFC 11/(kW/year): Lifecycle Ozone Depletion Potential (lb CFC 11/Ton-Year)
LCGWP: Lifecycle Direct Global Warming Potential (lb CO_2/Ton-Year)	LCGWP: Lifecycle Direct Global Warming Potential (kg CO_2/kW-year)
GWPr: Global Warming Potential of Refrigerant (0 to 12,000 lb CO_2/lbr)	GWPr: Global Warming Potential of Refrigerant (0 to 12,000 kg CO_2/kg r)
ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 lb CFC 11/lbr)	ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 kg CFC 11/kg r)
Lr: Refrigerant Leakage Rate (2.0%)	Lr: Refrigerant Leakage Rate (2.0%)
Mr: End-of-life Refrigerant Loss (10%)	Mr: End-of-life Refrigerant Loss (10%)
Rc: Refrigerant Charge (0.5 to 5.0 lbs of refrigerant per ton of gross AHRI rated cooling capacity)	Rc: Refrigerant Charge (0.065 to 0.65 kg of refrigerant per kW of AHRI rated or Eurovent Certified cooling capacity)
Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)	Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)

For multiple types of equipment, calculate a weighted average of all base building HVAC&R equipment, using the following formula:

IP UNITS

$$\frac{\sum \left[\left(LCGWP + LCODP \times 10^5 \right) \times Qunit \right]}{Qtotal} \leq 100$$

SI UNITS

$$\frac{\sum \left[\left(LCGWP + LCODP \times 10^5 \right) \times Qunit \right]}{Qtotal} \leq 13$$

CALCULATION DEFINITIONS FOR (IP UNITS)

$$\frac{\sum \left[\left(LCGWP + LCODP \times 10^5 \right) \times Qunit \right]}{Qtotal} \leq 100$$

Qunit = Gross AHRI rated cooling capacity of an individual HVAC or refrigeration unit (Tons)

Qtotal = Total gross AHRI rated cooling capacity of all HVAC or refrigeration

CALCULATION DEFINITIONS FOR (SI UNITS)

$$\frac{\sum \left[\left(LCGWP + LCODP \times 10^5 \right) \times Qunit \right]}{Qtotal} \leq 13$$

Qunit = Eurovent Certified cooling capacity of an individual HVAC or refrigeration unit (kW)

Qtotal = Total Eurovent Certified cooling capacity of all HVAC or refrigeration (kW)

RETAIL

Meet Option 1 or 2 for all HVAC systems.

Stores with commercial refrigeration systems must comply with the following.

- Use only non-ozone-depleting refrigerants.
- Select equipment with an average HFC refrigerant charge of no more than 1.75 pounds of refrigerant per 1,000 Btu/h (2.72 kg of refrigerant per kW) total evaporator cooling load.
- Demonstrate a predicted store-wide annual refrigerant emissions rate of no more than 15%. Conduct leak testing using the procedures in GreenChill's best practices guideline for leak tightness at installation.

Alternatively, stores with commercial refrigeration systems may provide proof of attainment of EPA GreenChill's silver-level store certification for newly constructed stores.

BEHIND THE INTENT

This credit addresses the two main threats to the environment posed by refrigerants: their ozone depletion potential (ODP) and global warming potential (GWP).

As is well known, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and other ozone-depleting substances commonly used in refrigerants contribute to the depletion of the stratospheric ozone layer. Yet refrigerants released into the atmosphere also contribute to global climate change, having a disproportionately large effect compared with other greenhouse gases. For example, HCFC-22 contributes to warming at 1,780 times the potency of an equal amount of carbon dioxide.

However, trade-offs also exist between the above concerns and energy use. Alternatives to CFC and HCFC refrigerants, such as HFC-410A, have a lower GWP when directly released, but their use may require more energy—which also affects climate. Conversely, variable refrigerant flow (VRF) systems may improve energy efficiency but have a higher refrigerant charge.

Careful consideration of the refrigerant requirements of energy systems and appliances can improve performance and reduce operating cost. Refrigerants vary in operating pressure, material compatibility, flammability, and toxicity. Operating pressure and material compatibility are particularly critical factors to take into account when refrigerants in existing equipment are replaced.

The refrigerant impact calculation addresses the overall effect of each refrigerant's ODP and GWP combined by accounting for these interrelated factors.

STEP-BY-STEP GUIDANCE

STEP 1. GATHER INFORMATION ON SYSTEMS AND REFRIGERANTS IN PROJECT

Identify all HVAC&R equipment that contains refrigerants and record the refrigerant charge and type for existing and new units. Project teams may incorporate the credit requirements and equations into project specifications if needed. Projects that retain CFCs past initial occupancy, even if using a phase-out plan to meet the requirements of EA Prerequisite Fundamental Refrigerant Management, are ineligible for this credit.

- Small systems with less than 0.5 pound (225 grams) of refrigerants, such as individual water fountains or stand-alone refrigerators, do not need to be included in credit calculations.
- Unit charge information is often not available for new equipment until contractor submittals are provided (particularly for split systems) because the charge depends on the length of refrigerant piping runs.
- If a district energy system (DES) serves the project, data for the refrigerant-using equipment in the DES must be collected.

STEP 2. SELECT ONE OPTION

Choose the appropriate option for the project.

- Option 1 is for projects that have no refrigerants and projects with refrigerants that have an ODP of zero and a GWP of less than 50 (see *Further Explanation, Designing for No Refrigerants or Low-Impact Refrigerant Use*). These projects achieve the credit; no additional steps are required.
- Option 2 is for projects whose refrigerants exceed the Option 1 limit.

Option 2. Refrigerant Impact Calculation

STEP 1. CALCULATE REFRIGERANT IMPACT OF PROPOSED SYSTEMS

To determine the environmental effects of HVAC&R systems containing refrigerants, apply the following assumptions. Assume the ODP and GWP values listed in Table 1.

TABLE 1. Ozone depletion and global warming potentials of common refrigerants			
Refrigerant	**ODPr**	**GWPr**	**Common building application**
Chlorofluorocarbons			
CFC-11	1.0	4,680	Centrifugal chiller
CFC-12	1.0	10,720	Refrigerators, chiller
CFC-114	0.94	9,800	Centrifugal chiller
CFC-500	0.605	7,900	Centrifugal chiller, humidifier
CFC-502	0.221	4,600	Low-temperature refrigeration
Hydrochlorofluorocarbons			
HCFC-22	0.04	1,780	Air-conditioning, chiller
HCFC-123	0.02	76	CFC-11 replacement
Hydrofluorocarbons			
HFC-23	~0	12,240	Ultra-low-temperature refrigeration
HFC-134a	~0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	~0	1,020	Insulation agent, centrifugal chiller
HFC-404A	~0	3,900	Low-temperature refrigeration
HFC-407C	~0	1,700	HCFC-22 replacement
HFC-410A	~0	1,890	Air-conditioning
HFC-507A	~0	3,900	Low-temperature refrigeration
Natural refrigerants			
Carbon dioxide (CO_2)	0	1.0	
Ammonia (NH3)	0	0	
Propane	0	3	

Assume equipment life according to Table 2. For any HVAC&R equipment not listed, assume an equipment life of 10 years. Different values for equipment life may be substituted, with manufacturers' documentation.

For existing equipment, apply the default equipment life according to Table 2. The equation is based on refrigerant impact spread over the life of the equipment; estimated remaining equipment life should not be substituted because it would provide inaccurate results.

TABLE 2. Default equipment life	
Equipment	**Default equipment life**
Window air-conditioner, heat pump	10 years
Unitary, split, packaged air-conditioner, package heat pump	15 years
Reciprocating and scroll compressor, reciprocating chiller	20 years
Absorption chiller	23 years
Water-cooled packaged air-conditioner	24 years
Centrifugal chiller	25 years

Assume that refrigerant leakage rate (Lr) is 2% per year and end-of-life refrigerant loss (Mr) is 10%, for all equipment types. No alternative values may be substituted for these percentages (see *Further Explanation, Examples*).

Refrigerant charge (Rc) is the ratio of the total refrigerant used in a piece of equipment to the total cooling capacity of that equipment, expressed in pounds per ton or kilograms per kW. For example, if a packaged air-conditioning unit uses 7 pounds of refrigerant and its cooling capacity is 5 tons, the refrigerant charge is 1.4.

STEP 2. INCORPORATE DESIGN CRITERIA INTO PROJECT PLANS AND SPECIFICATIONS

If calculations were performed during design, use the results to specify the maximum refrigerant charge for the HVAC equipment. When the project is under construction, review equipment submittals from the mechanical contractor to verify that the equipment and refrigerant charge meet the design specifications.

FURTHER EXPLANATION

CALCULATIONS

Weighted Average Refrigerant Impact for the Project Building

The project team must develop a weighted average calculation based on both downstream and upstream equipment. The weighted average is based on the entire downstream equipment capacity, but only the designed capacity of the equipment being served by the district cooling plant, not the entire capacity of the district cooling plant.

$$\left\{ \frac{\left(\text{Project building design chilled water cooling load} \times \text{Chilled water central plant refrigerant impact value}\right) + \left(\text{Project building refrigerant systems' total capacity} \times \text{Project building refrigerant impact value}\right)}{\text{Project building refrigerant systems' total capacity} + \text{Project building design chilled water cooling load}} \right\}$$

For example, a building has 50 tons of packaged equipment with a refrigerant impact value of 150 per ton. The district energy plant has a refrigerant impact value of 70 per ton and a total capacity of 1,000 tons. The building also has a designed 500 tons of equipment served by the district cooling plant. The weighted average impact is calculated as follows:

$$\left\{ \frac{\left(500 \text{ tons} \times 70\right) + \left(50 \text{ tons} \times 150\right)}{\left(500 \text{ tons} + 50 \text{ tons}\right)} \right\} = \text{77.3 weighted average refrigerant impact}$$

OPTIMIZING HVAC SYSTEMS TO MINIMIZE REFRIGERANT IMPACT

Avoiding equipment with a high refrigerant charge, such as multiple small packaged units or split systems, can make this credit easier to achieve. Systems that use chillers or a central plant are more likely to meet the credit requirements. If possible, incorporate indirect or direct evaporative cooling.

For renovations, consider retrofitting or replacing existing HVAC systems to minimize ODP and GWP contributions. Assess whether equipment replacement or refrigerant conversion is economical. Equipment that is easily accessible and has a high run time may be a candidate for refrigerant swap with a reasonable return on investment.

EXAMPLES

Example calculation 1. The cooling equipment for a school consists of the following systems:

- Twelve 5-ton packaged HVAC units with HFC-410A for classrooms
- One 2-ton split system HVAC unit with HCFC-22 for a data room
- One 1-ton window HVAC unit with HCFC-22 for an office

TABLE 3. Example calculations for school

Inputs								
Units	Qunit (tons)	Refrigerant	GWPr	ODPr	Rc (lb/ton)	Life (yrs.)	Lr (%)	Mr (%)
12	5	R-410A	1,890	0	1.8	15	2	10
1	2	R-22	1,780	0.04	3.3	15	2	10
1	1	R-22	1,780	0.04	2.1	10	2	10
Qtotal	63							
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 105) × Qunit) / Qtotal 108.33								
Result: Average refrigerant impact has a value greater than 100, therefore this project does not earn this credit								

TABLE 3 (CONTINUED). Example calculations for school

Calculations				
Tr Total Leakage (Lr × Life +Mr)	LCGWP (GWPr × Tr × Rc) / Life	LCODP^10^5 100,000 × (ODPr × Tr × Rc) / Life	Refrigerant atmospheric impact = LCGWP + LCODP × 10^5	(LCGWP + LCODP × 10^5 × N × Qunit
40%	90.72	0	90.7	5,443
40%	156.6	352	508.6	1,017
30%	112.1	252	364.1	364
			Subtotal	6,825
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 10^5) × Qunit) / Qtotal 108.33				
Result: Average refrigerant impact has a value greater than 100, therefore this project does not earn this credit				

Example calculation 2. The cooling equipment in an office building consists of the following systems:

- One 500-ton centrifugal chiller with HFC-134a
- One 50-ton reciprocating "pony" chiller with HCFC-22
- Five 10-ton computer room air-conditioning units with HCFC-22

TABLE 4. Example calculations for office building								
Inputs								
Units	Qunit (tons)	Refrigerant	GWPr	ODPr	Rc (lb/ton)	Life (yrs.)	Lr (%)	Mr (%)
1	500	R-134a	1,320	0	2	25	2	10
1	50	R-22	1,780	0.04	2.1	20	2	10
5	10	R-22	1,780	0.04	2.4	15	2	10
Qtotal	600							
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 10^5) × Qunit) / Qtotal 108.92								
Result: Average refrigerant impact has a value greater than 100, therefore this project does not earn this credit.								

TABLE 4 (CONTINUED). Example calculations for office building				
Calculations				
Tr Total Leakage (Lr × Life +Mr)	LCGWP (GWPr × Tr × Rc) / Life	LCODP^10^5 × 100,000 (ODPr × Tr × Rc) / Life	Refrigerant atmospheric impact = LCGWP + LCODP × 10^5	(LCGWP + LCODP × 10^5 × N × Qunit
60%	63.36	0	63.36	31,680
50%	93.5	210	303	15,173
40%	113.9	256	369.9	18,496
			Subtotal	65,349
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 10^5) × Qunit) / Qtotal 108.92				
Result: Average refrigerant impact has a value greater than 100, therefore this project does not earn this credit.				

Example calculation 3. A hotel's cooling system includes the following equipment:

- Three 1400-kW centrifugal chillers with HCFC-123
- One 140-kW commercial refrigeration compressor rack with HCFC-22
- Twelve 7-kW telephone and data room split-system cooling units with HCFC-22

TABLE 5. Example calculations for hotel								
Inputs								
Units	Qunit (kW)	Refrigerant	GWPr	ODPr	Rc (kg/kW)	Life (yrs.)	Lr (%)	Mr (%)
3	1 400	R-123	76	0.02	0.21	25	2	10
1	140	R-22	1,780	0.04	0.27	20	2	10
12	7	R-22	1,780	0.04	0.4	15	2	10
Qtotal	4 424							
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 10^5) × Qunit) / Qtotal 12.34								
Result: Average refrigerant impact has a value less than or equal to 13, therefore this project earns this credit.								

TABLE 5 (CONTINUED). Example calculations for hotel				
Calculations				
Tr Total Leakage (Lr × Life +Mr)	LCGWP (GWPr × Tr × Rc) / Life	LCODP × 100,000	Refrigerant atmospheric impact = LCGWP + LCODP × 10^5	(LCGWP + LCODP × 10^5 x N x Qunit
60%	.38	10.08	10.46	43 932
50%	12.02	27	39.02	5 462.8
40%	18.99	42.67	61.66	5 179.44
			Subtotal	54 574.24
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 10^5) × Qunit) / Qtotal 12.34				
Result: Average refrigerant impact has a value less than or equal to 13, therefore this project earns this credit.				

Example calculation 4. The cooling equipment in an apartment building consists of four 8-ton outdoor VRF units. Each unit has a base refrigerant amount of 16.5 pounds and an additional refrigerant amount of 2.7 pounds for distribution, which must be included. The Rc for each unit is (16.5 pounds + 2.7 pounds) / 8 tons = 2.4 pounds / ton.

TABLE 6. Example calculations for apartment building								
Inputs								
Units	Qunit (tons)	Refrigerant	GWPr	ODPr	Rc (lb/ton)	Life (yrs.)	Lr (%)	Mr (%)
4	8	R-410A	1,890	0	2.4	15	2	10
Qtotal	32							
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 10^5) × Qunit) / Qtotal 120.96								
Result: Average refrigerant impact has a value greater than 100, therefore this project does not earn this credit								

TABLE 6 (CONTINUED). Example calculations for apartment building				
Calculations				
Tr Total Leakage (Lr × Life + Mr)	LCGWP (GWPr × Tr × Rc) / Life	LCODP × 10^5 × 100,000 (ODPr × Tr × Rc) / Life	Refrigerant atmospheric impact = LCGWP + LCODP × 10^5	(LCGWP + LCODP × 10^5 × N × Qunit
40%	120.96	0	120.96	3,871
			Subtotal	3,871
Average refrigerant atmospheric impact = ∑ (LCGWP + LCODP × 10^5) × Qunit) / Qtotal 120.96				
Result: Average refrigerant impact has a value greater than 100, therefore this project does not earn this credit				

DESIGNING FOR NO REFRIGERANTS OR LOW-IMPACT REFRIGERANT USE

In some cases, cooling needs can be met without vapor compression HVAC equipment. This can be possible in buildings that are designed for natural ventilation and have very low cooling loads. Optimizing the following non-HVAC design elements can help reduce the project building's cooling load:

- Massing
- Building orientation
- Window-to-wall ratio

- Glazing properties
- Shading
- Insulation
- Lighting and equipment power density

Determine whether natural refrigerants like carbon dioxide, ammonia, or water can be used to meet cooling needs or other building goals. Absorption chillers, for example, are compatible with refrigerants like ammonia, and carbon dioxide is popular for low-temperature cooling applications.

Heat from the refrigeration process can be recovered for other uses, like service hot water heating. To reduce peak cooling requirements for ventilation air, use air-side energy recovery.

EVAPORATIVE COOLING

Another strategy for minimizing refrigerant charge is to incorporate direct or indirect evaporative cooling. Table 7 outlines the most favorable circumstances for this approach to refrigerant impact reduction.

TABLE 7. Evaporative cooling scenarios

Direct evaporative cooling	Indirect evaporative cooling
Hot and dry climates with design wet-bulb temperatures 68°F (20°C) or lower	Hot and dry climates with design wet-bulb temperatures 68°F (20°C) or lower
Residential, light commercial, industrial or other spaces with low latent heat gain	Pretreatment of outside air for systems with higher latent loads, such as densely occupied office spaces, and need to control humidity

Indirect and direct evaporative cooling can be combined for greater efficiency. An indirect cooler lowers the temperature of air and reduces the air's moisture content; a direct cooler then cools the air further and restores humidity to the air.

RATING SYSTEM VARIATIONS

Core and Shell
If the core and shell project does not include all HVAC associated with anticipated work by the tenant but the project team would like to include those systems to achieve the credit, documentation must be supported by the tenant sales or lease agreement.

Retail
For Retail HVAC systems, use the calculation methodology and assumptions listed for all projects.

Retail projects with commercial refrigeration systems may either follow the prescriptive criteria or pursue certification through U.S. EPA GreenChill's certification program for newly constructed stores. If pursuing EPA certification, follow the certification steps outlined on the program website.

If following prescriptive requirements, have the commercial refrigeration equipment tested for leaks according to the procedures outlined in GreenChill's Best Practices Guideline for Leak Tightness at Installation. The leak testing is required for GreenChill certification but the guidelines are applicable to any retail project, including international projects, regardless of whether the building is pursuing GreenChill certification. The installer is typically responsible for conducting leak testing after installation. Include requirements in the contract with the commercial refrigerant installer. The commissioning scope may also include verification of proper leak testing, but this is not required.

Non-Retail projects that have commercial refrigeration systems may follow the prescriptive criteria available to retail projects for commercial refrigeration systems. Both these prescriptive criteria for the commercial refrigeration systems and the credit requirements for the HVAC refrigerant-using systems must be met to achieve credit compliance in this case.

PROJECT TYPE VARIATIONS

District Energy Systems
If a project has only downstream refrigeration equipment, only that equipment must be included in the refrigerant impact calculation. If a project has only upstream refrigeration equipment, only that equipment must be included in the refrigerant impact calculation. If a project has both downstream and upstream refrigeration equipment, use the following procedure to show credit compliance.

Complete two separate refrigerant impact calculations: one to calculate the refrigerant impact using only the downstream equipment and another using only the upstream equipment.

If both calculations meet the credit requirements, the project team has demonstrated credit compliance. If neither calculation meets the credit requirements, the project cannot achieve this credit. If one calculation fails but the other passes, the project team may demonstrate compliance using the weighted average refrigerant impact for the project building (see *Further Explanation, Calculations*).

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Option 1. Eligible.

Option 2. Ineligible. Each LEED project may pursue the credit individually.

Documentation	Option 1	Option 2
Confirmation that only no or low-impact refrigerants are used	X	
Equipment type		X
Refrigerant charge calculations (for VRF systems only)		X
Equipment cooling capacity		X
Provide refrigerant equipment schedule or GreenChill certification (commercial refrigeration systems)		X
Equipment quantity		X
Refrigerant type		X
Refrigerant charge (plus supporting documentation, if applicable)		X
Equipment life (plus supporting documentation, if applicable)		X
Leak test results (commercial refrigeration systems only)		X

RELATED CREDIT TIPS

EA Credit Optimize Energy Performance. Alternatives to CFCs and HCFCs, such as HFC-410A, have lower refrigerant impacts but may require higher levels of energy use. Variable refrigerant flow and some split systems rarely meet the requirements of this credit because of the long refrigerant piping runs and the high quantity of refrigerant needed.

CHANGES FROM LEED 2009

Sector-specific requirements have been added for commercial refrigeration equipment.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

downstream equipment the heating and cooling systems, equipment, and controls located in the project building or on the project site and associated with transporting the thermal energy of the district energy system (DES) into heated and cooled spaces. Downstream equipment includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

natural refrigerant a compound that is not manmade and is used for cooling. Such substances generally have much lower potential for atmospheric damage than manufactured chemical refrigerants. Examples include water, carbon dioxide, and ammonia.

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE CREDIT

Green Power and Carbon Offsets

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To encourage the reduction of greenhouse gas emissions through the use of grid-source, renewable energy technologies and carbon mitigation projects.

REQUIREMENTS

Engage in a contract for qualified resources that have come online since January 1, 2005, for a minimum of five years, to be delivered at least annually. The contract must specify the provision of at least 50% or 100% of the project's energy from green power, carbon offsets, or renewable energy certificates (RECs).

Green power and RECs must be Green-e Energy certified or the equivalent. RECs can only be used to mitigate the effects of Scope 2, electricity use.

Carbon offsets may be used to mitigate Scope 1 or Scope 2 emissions on a metric ton of carbon dioxide–equivalent basis and must be Green-e Climate certified, or the equivalent.

For U.S. projects, the offsets must be from greenhouse gas emissions reduction projects within the U.S.

Determine the percentage of green power or offsets based on the quantity of energy consumed, not the cost. Points are awarded according to Table 1.

TABLE 1. Points for energy from green power or carbon offsets

Percentage of total energy addressed by green power, RECs and/or offsets	Points
50%	1
100%	2

Use the project's annual energy consumption, calculated in EA Prerequisite Minimum Energy Performance, if Option 1 was pursued; otherwise use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) database to estimate energy use.

CORE AND SHELL ONLY

A core and shell building's energy is defined as the energy usage of the core and shell floor area as defined by the Building Owners and Managers Association (BOMA) standards, but not less than 15% of the project's floor area.

BEHIND THE INTENT

The voluntary market can be an effective catalyst for encouraging energy generators and utility companies to develop clean energy sources and help address climate change. Purchasing renewable energy certificates (RECs) allows buildings that use nonrenewable power to create market demand for renewable energy. Carbon offsets allow buildings or companies to fund activities that seek to decrease carbon emissions or remove carbon from the atmosphere, such as methane abatement, energy efficiency projects, and reforestation or land-use changes.

STEP-BY-STEP GUIDANCE

STEP 1. INVESTIGATE AVAILABLE OPTIONS

The possibilities for purchasing green power, RECs, and offsets will vary with the project's location and energy types. Consider the costs of various options (see *Further Explanation, Green Power Purchasing*).

- Green power and RECs must be Green-e Energy certified or the equivalent. Direct or local green power may be available through local utility providers; review their websites for green power cost premiums.
- Green power and RECs can be used only toward the electric energy use portion of the project's annual energy use (Scope 2, electricity). They cannot be applied toward nonelectric energy uses.
- Carbon offsets must be Green-e Climate certified or the equivalent. Unlike RECs and purchased green power, carbon offsets can be used toward both electric and nonelectric energy use.

STEP 2. CONDUCT COST-BENEFIT ANALYSIS

Undertake a cost-benefit analysis to understand the financial and environmental benefits for the available options. All carbon offsets are not the same. Some are associated with land-use development, others with energy efficiency projects. Teams are encouraged to purchase carbon offsets that align with their environmental interests and values.

STEP 3. SET PROJECT GOAL FOR GREEN POWER OR CARBON OFFSETS

Review the credit point thresholds and establish the green power or carbon offset purchase goal for the project. The offset goal is not a one-time purchase—it must be met for multiple consecutive years, as indicated in the credit requirements.

STEP 4. CALCULATE ENERGY USE ASSOCIATED WITH SCOPE 1 AND SCOPE 2 EMISSIONS CATEGORIES

Determine the total grid-generated annual energy use, based on the option selected in EA Prerequisite Minimum Energy Performance.

- Projects that used modeling to comply with EA Prerequisite Minimum Energy Performance (Option 1) must use the whole-building simulation results to determine the total annual electricity and nonelectricity energy use.
  - Exclude any site-generated electricity (e.g., wind turbines, photovotaics) and fuel (e.g., biogas) from the total consumption amount, provided the project does not sell the on-site energy generated as RECs.
  - Include as nonelectric energy any steam and chilled water purchased from the utility provider or a third party and any fuel purchased for on-site electricity generation in the building (e.g., diesel for gensets).
- Projects that used a prescriptive pathway to achieve EA Prerequisite Minimum Energy Performance (Option 2 or 3) must use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) database to estimate annual energy use.
  - Exclude any site-generated electricity from the total annual electric energy use.
  - Use the total building area and appropriate energy use intensity (EUI) from the CBECS database to calculate the projected electric and nonelectric annual energy use.

- ◦ If a project contains multiple space types (e.g., an office building with ground-floor retail), use the EUIs associated with each space type to generate the projected annual energy use (see *Further Explanation, Calculating Annual Energy Use Using CBECS Data for Projects with Multiple Space Types*).
- Net-zero buildings—those anticipated to consume zero net energy on an annual basis—are eligible to achieve 2 points under this credit without purchasing any additional renewable energy, RECs, or carbon offsets, provided the project does not sell any RECs associated with the on-site renewable energy production.

STEP 5. CALCULATE REQUIRED GREEN POWER AND CARBON OFFSETS

Use the project's electricity and nonelectricity energy use totals to determine the required amount of green power and/or carbon offsets to be purchased.

- Projects that use green power or RECs must convert their annual grid-generated electricity use to MWh.
- Projects that use carbon offsets must convert their annual grid-generated electricity use to metric tons of CO_2e. For conversion factors and GHG emissions factors, see *Further Explanation, Calculating Greenhouse Gas Emissions*.
- All projects must convert their annual nonelectricity energy use to metric tons of CO_2e.
- Any combination of the above can be used to achieve either the 50% or the 100% threshold. If the project goal is less than the 100% threshold, prorate the required amount accordingly.

STEP 6. OBTAIN PROPOSALS FOR GREEN-E CERTIFIED PRODUCTS OR EQUIVALENT AND MAKE PURCHASE

Solicit proposals for green power, RECs, and/or carbon offsets from providers of Green-e certified products, as specified in the credit requirements and select a vendor.

- The provider must provide confirmation of the date on which the qualified resources came online.
- The contract must specify the purchasing goals and is valid for the duration indicated in the credit requirements.
- For U.S. projects, the offsets must come from greenhouse gas (GHG) emissions reduction projects within the U.S.
- If Green-e certified products are not available, equivalency of other products must be demonstrated (see *Further Explanation, Establishing Green-e Equivalency*). Projects outside the U.S. that cannot find local products that meet the Green-e standard or equivalent can still achieve this credit by purchasing Green-e certified products from the U.S.

FURTHER EXPLANATION

CALCULATIONS

EQUATION 1. Total qualifying energy use

$$\text{Total qualifying annual energy use} = \left\{ \left(\text{Total annual grid-based electricity use} - \text{Total annual site-generated electricity} \right) + \left(\text{Total annual fossil fuel use} - \text{Total annual renewable fuels use} \right) \right\}$$

EQUATION 2. Percentage of energy purchased or offset

$$\text{\% Energy purchased or offset} = \left\{ \frac{\left(\text{Quantity of RECs in kWh}\right)}{\left(\text{Annual building energy use in kWh}\right)} + \frac{\left(\text{Purchased green power}\right)}{\left(\text{Annual building energy use in kWh}\right)} + \frac{\left(\text{Purchased carbon offsets}\right)}{\left(\text{GHG emissions associated with project's annual energy use}\right)} \right\}$$

EQUATION 3. Metric tons of CO_2 equivalent, Fuel A

$$\text{Metric tons of } CO_2 \text{ equivalent, Fuel A} = \text{Annual use, Fuel A (kBtu)} \times \text{Direct GHG emissions factor, Fuel A (mt } CO_2e/\text{kBtu)}$$

EQUATION 4. Metric tons of CO_2 equivalent, electricity

$$\text{Metric tons of } CO_2 \text{ equivalent, electricity} = \text{Annual electricity use (kWh)} \times 3.412 \text{ (kBtu/kWh)} \times \text{Indirect GHG emissions factor, electricity (mt } CO_2e/\text{kBtu)}$$

CALCULATING ANNUAL ENERGY USE USING CBECS DATA FOR PROJECTS WITH MULTIPLE SPACE TYPES

A proposed 75,000-square-foot office project with 15,000 square feet of retail space has achieved EA Prerequisite Minimum Energy Performance through a prescriptive path. The team wants to earn points under EA Credit Green Power and Carbon Offsets, which requires determining the building's total annual energy usage. The project will have natural gas and electric service. Using data from CBECS (Table 2), the team can estimate annual energy consumption by fuel type. For projects with multiple space types, calculate energy consumption for each space type separately, based on Table 2.

TABLE 2. CBECS building energy intensity data

Building type	Total energy consumption (CBECS Table C3)		Total electric energy consumption (CBECS Table C14)		Total nonelectric energy consumption	
	kBtu/ft²	kWh/m²	kWh/ft²	kWh/m²	kBtu/ft²	kWh/m²
Education	83.1	262.2	11	118.4	45.5	143.6
Food sales	199.7	630.1	49.4	531.8	194.6	614
Food service	258.3	814.9	38.4	413.3	127.4	401.9
Health care inpatient	249.2	786.2	27.5	296.0	155.5	490.6
Health care outpatient	94.6	298.5	16.1	173.3	39.6	124.9
Lodging	100	315.5	13.5	145.3	53.9	170.1
Retail (nonmall)	73.9	233.2	14.3	153.9	25.1	79.2
Enclosed and strip malls	102.2	322.4	22.3	240.0	26.2	82.7
Office	92.9	293.1	17.3	186.2	34	107.3

TABLE 2 (CONTINUED). CBECS building energy intensity data						
Building type	**Total energy consumption (CBECS Table C3)**		**Total electric energy consumption (CBECS Table C14)**		**Total nonelectric energy consumption**	
	kBtu/ft²	**kWh/m²**	**kWh/ft²**	**kWh/m²**	**kBtu/ft²**	**kWh/m²**
Public assembly	93.9	296.3	12.5	134.6	51.3	161.9
Public order and safety	115.8	365.3	15.3	164.7	63.5	200.3
Religious worship	43.5	137.2	4.9	52.7	26.9	84.9
Service	77	242.9	11	118.4	39.5	124.6
Warehouse and storage	45.2	142.6	7.6	81.8	19.3	60.9
Other	164.4	518.7	22.5	242.2	87.6	276.4

See the U.S. Energy Information Administration website for building type definitions.

Electricity usage is estimated as follows:

$$\begin{aligned} \text{Electricity usage} &= (\text{Electric kWh/ft}^2 \text{ for space type } \times \text{ Project area}) \\ &= (17.3 \text{ kWh/ft}^2 \times 75{,}000 \text{ ft}^2) + (14.3 \text{ kWh/ft}^2 \times 15{,}000 \text{ ft}^2) \\ &= 1{,}512{,}000 \text{ kWh} \\ &= 5{,}159{,}158 \text{ kBtu} \end{aligned}$$

The project natural gas usage can be estimated in the same manner:

$$\begin{aligned} \text{Natural gas usage} &= (\text{Non-Electric kBtu/ft}^2 \text{ for space type } \times \text{ Project area}) \\ &= (34 \text{ kBtu/ft}^2 \times 75{,}000 \text{ ft}^2) + (25.1 \text{ kBtu/ft}^2 \times 15{,}000 \text{ ft}^2) \\ &= 2{,}926{,}000 \text{ kBtu} \end{aligned}$$

The project's total annual building energy use is the sum of the electric and natural gas usage: 8,085,658 kBtu.

ESTABLISHING GREEN-E EQUIVALENCY

Projects not using Green-e certified products must demonstrate the alternative's equivalency to the quality standards established for Green-e Energy and Green-e Climate products:

- Green-e Energy National Standard v2.3, Sections II, III (excluding G), IV (excluding A), and V
- Green-e Energy Code of Conduct and Customer Disclosure Requirements – Sections III-VII
- Green-e Climate National Standard v2.1, Sections 4, 5, 6.1, 6.3, 6.4, and 7
- Green-e Climate Code of Conduct – Sections II-VII

The accounting process and standards must be equivalent to Green-e products and address the following:

- Verifiable chain of custody
- Verifiable age of renewable energy
- Tracking of GHG reductions from eligible projects
- Mechanism to prevent double-counting
- Third party–verified retail transaction

For carbon offsets, retirement of an eligible credit alone is not equivalent to Green-e Climate certification.

CALCULATING GREENHOUSE GAS EMISSIONS

When calculating offsets, project teams must use the default emissions factors established by ENERGY STAR Portfolio Manager for the appropriate fuel types (Tables 3 and 4). Using Equation 5, apply the default emissions factor to the project's annual fuel consumption to determine the building's greenhouse gas footprint is determined, expressed in metric tons of CO_2 equivalent (CO_2e).

EQUATION 5. Project greenhouse gas emissions

$$\text{GHG emissions } (CO_2e) = \text{Consumption} \times CO_2 \text{ emissions factor}$$

where emissions factor = mass CO_2 per mass or volume unit of fuel

EXAMPLES

Example 1. Determining compliance based on modeled energy use

A project team has used modeling to comply with EA Prerequisite Minimum Energy Performance (Option 1). According to the whole-building simulation results, the project building's annual electricity use is 5,077,667 kWh plus 5,750,000 kBtu of natural gas use. To earn 1 point under this credit, the project team has two choices.

1. The project can purchase RECs for electricity consumption and carbon offsets for natural gas consumption. For RECs, the team uses the following calculation:

   5,077,667 kWh/yr x 50% = 2,538,834 kWh/yr

   For carbon offsets, the team uses this calculation:

   5,775,000 kBtu/yr x (5.32×10^{-5} $mtCO_2e$/kBtu) x 50% = 153.6 $mtCO_2e$/yr

   Projects are not required to cover 50% of its electricity use and 50% of its natural gas use, only 50% of total energy use.

2. Alternatively, the project can purchase carbon offsets for all consumption (Scope 1 and Scope 2 emissions). For the carbon offsets to cover electricity use (Scope 2), the team performs the following calculation:

   5,077,667 kWh/yr x (5.90×10^{-4} $mtCO_2e$/kWh) = 2995.8 $mtCO_2e$/yr

   For carbon offsets to cover natural gas use (Scope 1), the team uses this calculation:

   5,775,000 kBtu/yr x (5.32×10^{-5} $mtCO_2e$/kBtu) = 307.2 $mtCO_2e$/yr

   2995.8 + 307.2 = 3303 metric tons of CO_2 equivalent. Thus, the project's total carbon offsets are as follows:

   3303 $mtCO_2e$/yr x 50% = 1651.5 $mtCO_2e$/yr

Example 2. Determining compliance using CBECS data

A project team has achieved EA Prerequisite Minimum Energy Performance through one of the prescriptive pathways (Option 2 or 3) and will therefore use CBECS data to estimate electricity and gas consumption. The project is a 100,000-square-foot office building with 10,000 square feet of ground-floor retail space that uses both electricity (for cooling and equipment) and natural gas (for heating and domestic hot water). The team is attempting to earn 2 points by covering 100% of the building's energy use through RECs and offsets.

The team must estimate total electricity and natural gas use based on CBECS data for both space types, as follows:

Office electricity: 100,000 ft^2 x 17.3 kWh/ft^2 = 1,730,000 kWh

Retail electricity: 10,000 ft^2 x 14.3 kWh/ft^2 = 143,000 kWh

143,000 + 1,730,000 = 1,873,000 kWh

Office natural gas: 100,000 ft^2 x 34 kBtu/ft^2 = 3,400,000 kBtu

The emissions factors are applied as follows:

3,400,000 kBtu x (5.32×10^{-5}) = 180.88 mtCO_2e office natural gas

Retail natural gas: 10,000 ft^2 x 25.1 kBtu/ft^2 = 251,000 kBtu

251,000 kBtu x (5.32×10^{-5}) = 13.35 mtCO_2e retail natural gas

180.88 + 13.35 = 194.23 mtCO_2e total retail and office

To earn 2 points, the project must purchase Green-e certified green power equal to 1,873,000 kWh and must also purchase carbon offsets for 194.23 metric tons of CO_2 equivalent.

RATING SYSTEM VARIATIONS

Core and Shell

If the core and shell floor area is less than 15% of the gross floor area, use 15% of the total building area for the calculations. If not, use the actual percentage of core and shell floor area to determine the amount of energy consumption.

PROJECT TYPE VARIATIONS

District Energy Systems (DES)

For projects using energy model Path 2 or 3 (aggregate building or DES scenario), green power and offsets used in a DES may contribute toward this credit for a connected building. For any projects using energy model Path 1, green power and offsets used in a DES do not contribute toward the credit for a connected building.

Performance is based on the fraction of the project building's annual energy consumption that is supplied by green power or made up for by carbon offsets. In the DES setting, this fraction depends in turn on the fraction of district plant electricity that is supplied by the green power or offset, and the fraction of the model's annual energy consumption associated with the DES. For each thermal energy source provided to the building by the district plant, calculate the green power or offset contribution by using Equations 6, 7, and 8.

EQUATION 6. Annual DES energy supplied by green power sources or covered by offsets

$$\text{Fraction of thermal energy source i from green power or covered by recs/offsets (gs)} = \left\{ \frac{\left(\dfrac{\text{Quantity recs or green power purchased}}{\text{Electricity use to generate source, i}}\right) + \left(\dfrac{\text{Quantity carbon offsets purchased}}{\text{Carbon equivalent of fuel used to generate source, i}}\right)}{\text{Total energy used to generate source, i}} \right\}$$

EQUATION 7. Annual energy supplied by DES thermal energy source.

$$\text{Fraction of building annual energy consumption supplied by source (bs), i} = \left\{ \frac{\text{Building energy supplied by source, i}}{\text{Total building energy consumed}} \right\}$$

EQUATION 8. Total qualifying contribution from DES

$$\text{Total Green Power or offset contribution from DES} = \sum_{i} GS_i \times BS_i$$

Derive the project building's total annual energy consumption reported for EA Credit Green Power and Carbon Offsets credit compliance from the proposed case modeling run of EA Prerequisite Minimum Energy Performance.

If green energy contributions from the DES are applied to the project, submit a letter from the DES owner or operator verifying that the renewable energy is allocated specifically to the DES generation or distribution equipment, and confirming that no renewable energy allocated specifically to the DES central plant building, if any (in a separate LEED application), is being counted toward the renewable energy contribution of the satellite project building. The letter must also confirm that no renewable energy is being double-counted among any satellite project buildings (in separate LEED applications).

Projects without a Path 2 or 3 energy model may not take credit for renewable energy sources used for the DES upstream of the project. However, credit may be taken for green power associated with the project itself. In this case, project teams should follow the standard guidance.

INTERNATIONAL TIPS

Projects must use Green-e qualified products or demonstrate Green-e equivalency to achieve this credit.

Projects that wish to use a local benchmark based on source energy from their country's national or regional energy agency must submit proof that the local benchmark contains a statistically significant sample of the building type being referenced and that the benchmarking process is repeatable. The benchmark should include at least 30 buildings of the project building type, and the data should be weather normalized and account for internal and external loads.

Additional information on the regressions and models used in CBECS can be found at eia.gov/emeu/cbecs/tech_end_use.html to help determine whether a local baseline is equivalent to CBECS.

Projects outside the U.S. are not required to purchase products from the country in which the building is located. Projects in Canada can either buy Green-e certified products or use RECs from Canadian facilities that meet the eligible renewable definition and are generated at facilities certified by the EcoLogo Program (ecologo.org).

Projects can use the WRI-WBCSD Greenhouse Gas Protocol Standards to calculate GHG emissions based on GHG inventories for the project location.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
Annual electricity and nonelectricity energy use calculations	X
Calculations showing required REC, green power, or carbon offsets for targeted point threshold	X
Purchase contract or letter of commitment showing REC, green power, or carbon offsets for targeted point threshold	X
Green-e equivalency documentation, if not Green-e certified	X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. The amount of the project's proposed energy use, as determined in Option 1 of the related prerequisite, can be used to calculate the green power, RECs, or offsets that will be contracted.

EA Credit Optimize Energy Performance. Implementing energy efficiency measures that reduce total annual energy use will reduce the amount of RECs and carbon offset purchases required to meet this credit's requirements.

EA Credit Renewable Energy Production. Renewable energy production will reduce the project's total energy use and therefore the amount of green power, RECs, or carbon offsets required.

CHANGES FROM LEED 2009

- In addition to including electricity, the credit now requires nonelectric energy use to be offset using carbon offsets.
- The credit now requires a five-year contract and specifies that resources must have come online after January 1, 2005, and be delivered at least annually.
- The percentage thresholds have been increased to 50% for 1 point and 100% for 2 points.

REFERENCED STANDARDS

Green-e Energy and Green-e Climate: green-e.org

U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS): eia.gov/consumption/commercial/index.cfm

Building Owners and Managers Association (BOMA): boma.org

ENERGY STAR Portfolio Manager: Methodology for Greenhouse Gas Inventory and Tracking Calculations: https://portfoliomanager.energystar.gov/pdf/reference/Emissions.pdf

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010. Annex 2 Methodology and Data for Estimating CO_2 Emissions from Fossil Fuel Combustion: epa.gov/climatechange/ghgemissions/usinventoryreport/archive.html

2006 IPCC Guidelines for National Greenhouse Gas Inventories: ipcc-nggip.iges.or.jp/public/2006gl/index.html

eGRID2012 Version 1.0—U.S. Environmental Protection Agency: epa.gov/cleanenergy/energy-resources/egrid/index.html

WRI-WBCSD Greenhouse Gas Protocol: ghgprotocol.org/standards

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

carbon offset a unit of carbon dioxide equivalent that is reduced, avoided, or sequestered to compensate for emissions occurring elsewhere (World Resources Institute)

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

green power a subset of renewable energy composed of grid-based electricity produced from renewable energy sources

Scope 1 emissions direct greenhouse gas emissions from sources owned or controlled by the entity, such as emissions from fossil fuels burned on site. Electricity produced on site through the burning of fossil fuels is measured by the Scope 1 emissions associated with that fossil fuel.

Scope 2 emissions indirect greenhouse gas emissions associated with the generation of purchased electricity, heating/cooling, or steam off site, through a utility provider for the entity's consumption. Transmission and distribution losses related to hot water, chilled water, and steam are included in Scope 2 emissions, but transmission and distribution losses associated with electricity are not included.

Materials and Resources (MR)

OVERVIEW

The Materials and Resources (MR) credit category focuses on minimizing the embodied energy and other impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials. The requirements are designed to support a life-cycle approach that improves performance and promotes resource efficiency. Each requirement identifies a specific action that fits into the larger context of a life-cycle approach to embodied impact reduction.

THE WASTE HIERARCHY

Construction and demolition waste constitutes about 40 percent of the total solid waste stream in the United States[1] and about 25% of the total waste stream in the European Union.[2] In its solid waste management hierarchy, the U.S. Environmental Protection Agency (EPA) ranks source reduction, reuse, recycling, and waste to energy as the four preferred strategies for reducing waste. The MR section directly addresses each of these recommended strategies.

Source reduction appears at the top of the hierarchy because it avoids environmental harms throughout a material's life cycle, from supply chain and use to recycling and waste disposal. Source reduction encourages the use of innovative construction strategies, such as prefabrication and designing to dimensional construction materials, thereby minimizing material cutoffs and inefficiencies.

Building and material reuse is the next most effective strategy because reusing existing materials avoids the environmental burden of the manufacturing process. Replacing existing materials with new ones would entail production and transportation of new materials, and it would take many years to offset the associated greenhouse gases through increased efficiency of the building. LEED has consistently rewarded the reuse of materials. LEED v4 now offers more flexibility and rewards all material reuse achieved by a project—both in situ, as part of a building reuse strategy, and from off site, as part of a salvaging strategy.

Recycling is the most common way to divert waste from landfills. In conventional practice, most waste is landfilled—an increasingly unsustainable solution. In urban areas landfill space is reaching capacity, requiring

1. *U.S. Environmental Protection Agency, epa.gov/osw/conserve/rrr/imr/cdm/pubs/cd-meas.pdf.*
2. *European Commission Service Contract on Management of Construction and Demolition Waste, Final Report, http://www.eu-smr.eu/cdw/docs/BIO_Construction%20and%20Demolition%20Waste_Final%20report_09022011.pdf (accessed April 9, 2013).*

the conversion of more land elsewhere and raising the transportation costs of waste. Innovations in recycling technology improve sorting and processing to supply raw material to secondary markets, keeping those materials in the production stream longer.

Because secondary markets do not exist for every material, however, the next most beneficial use of waste materials is conversion to energy. Many countries are lessening the burden on landfills through a waste-to-energy solution. In countries such as Sweden and Saudi Arabia, waste-to-energy facilities are far more common than landfills. When strict air quality control measures are enforced, waste-to-energy can be a viable alternative to extracting fossil fuels to produce energy.

In aggregate, LEED projects are responsible for diverting more than 80 million tons (72.6 million tonnes) of waste from landfills, and this volume is expected to grow to 540 million tons (489.9 million tonnes) by 2030.[3] From 2000 to 2011, LEED projects in Seattle diverted an average of 90 percent of their construction waste from the landfill, resulting in 175,000 tons (158,757.3 tonnes) of waste diverted.[4] If all newly constructed buildings achieved the 90 percent diversion rate demonstrated by Seattle's 102 LEED projects, the result would be staggering. Construction debris is no longer waste, it is a resource.

LIFE-CYCLE ASSESSMENT IN LEED

Through credits in the MR category, LEED has instigated market transformation of building products by creating a cycle of consumer demand and industry delivery of environmentally preferable products. LEED project teams have created demand for increasingly sustainable products, and suppliers, designers, and manufacturers are responding. From responsibly harvested wood to increased recycled content to bio-based materials, the increased supply of sustainable materials has been measurable over the history of LEED. Several MR credits reward use of products that perform well on specific criteria. It is difficult, however, to compare two products that have different sustainable attributes—for example, cabinets made of wheat husks sourced from all over the country and bound together in resin versus solid wood cabinets made from local timber. Life-cycle assessment (LCA) provides a more comprehensive picture of materials and products, enabling project teams to make more informed decisions that will have greater overall benefit for the environmental, human health, and communities, while encouraging manufacturers to improve their products through innovation.

LCA is a "compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle."[5] The entire life cycle of a product (or building) is examined, the processes and constituents identified, and their environmental effects assessed—both upstream, from the point of manufacture or raw materials extraction, and downstream, including transportation, use, maintenance, and end of life. This approach is sometimes called "cradle to grave." Going even further, "cradle to cradle" emphasizes recycling and reuse at the end of life rather than disposal.

Life-cycle approaches to materials assessment began in the 1960s with carbon accounting models. Since then, LCA standards and practices have been developed and refined. In Europe and a few other parts of the world, manufacturers, regulators, specifiers, and consumers in many fields have been using life-cycle information to improve their product selections and product environmental profiles. Until relatively recently, however, the data and tools that support LCA were lacking in the U.S. Now a growing number of manufacturers are ready to document and publicly disclose the environmental profiles of their products, and programs that assist this effort and help users understand the results are available.

LEED aims to accelerate the use of LCA tools and LCA-based decision making, thereby spurring market transformation and improving the quality of databases. Recognizing the limitations of the life-cycle approach for addressing human health and the ecosystem consequences of raw material extraction, LEED uses alternative, complementary approaches to LCA in the credits that address those topics.

CROSS-CUTTING ISSUES

Required Products and Materials

The scope of the MR credit category includes the building or portions of the building that are being constructed or renovated. Portions of an existing building that are not part of the construction contract are excluded from MR

3. *USGBC, Green Building Facts, usgbc.org/ShowFile.aspx?DocumentID=18693 (accessed September 13, 2012).*
4. *City of Seattle, LEED Projects Analysis, seattle.gov/dpd/greenbuilding/docs/dpdp022009.pdf (accessed March 26, 2013).*
5. *ISO 14040 International Standard, Environmental management, Life cycle assessment, principles and framework (Geneva, Switzerland: International Organization for Standardization, 2006).*

documentation unless otherwise noted. For guidance on the treatment of additions, see the minimum program requirements.

Qualifying Products and Exclusions

The MR section addresses “permanently installed building products,” which as defined by LEED refers to products and materials that create the building or are attached to it. Examples include structure and enclosure elements, installed finishes, framing, interior walls, cabinets and casework, doors, and roofs. Most of these materials fall into Construction Specifications Institute (CSI) 2012 MasterFormat Divisions 3-10, 31, and 32. Some products addressed by MR credits fall outside these divisions.

Furniture is not required to be included in credit calculations. However, if furniture is included in MR credit calculations, all furniture must be included consistently in all cost-based credits.

In past versions of LEED, all mechanical, plumbing, and electrical equipment (MEP), categorized as CSI MasterFormat divisions 11, 21-28, and other specialty divisions, was excluded from MR credits. In this version of LEED some specific products that are part of these systems but are “passive” (meaning not part of the active portions of the system) may be included in credit calculations. This allows flexibility for the optional assessment of piping, pipe insulation, ducts, duct insulation, conduit, plumbing fixtures, faucets, showerheads, and lamp housings. If optional products or materials are included in cost-based credit calculations, such as Option 2 under each Building Product Disclosure and Optimization credits, they must be included consistently across all cost-based credit calculations. Additionally, if optional products and materials are included in product based calculations, such as Option 1 under each Building Product Disclosure and Optimization credits, they are not required to be included in cost-based credit calculations. However, unlike furniture, if some of these products are included in credit calculations, not all products of that type must be included.

Special equipment, such as elevators, escalators, process equipment, and fire suppression systems, is excluded from the credit calculations. Also excluded are products purchased for temporary use on the project, like formwork for concrete.

For Healthcare projects, the scope of MR Credit Medical Furniture and Furnishings includes all freestanding furniture and medical furnishings. Freestanding furniture items included in this credit cannot be counted in any Building Product Disclosure and Optimization credits, to avoid double-counting. Permanently installed items such as casework and built-in millwork should be included in the Building Product Disclosure and Optimization credits, not MR Credit Medical Furniture and Furnishings.

Defining a Product

Several credits in this category calculate achievement on the basis of number of products instead of product cost. For these credits, a “product” or a “permanently installed building product” is defined by its function in the project. A product includes the physical components and services needed to serve the intended function. If there are similar products within a specification, each contributes as a separate product. Here are a few scenarios.

Products that arrive at the project site ready for installation:

- Metal studs, wallboard, and concrete masonry units are all separate products.
- For wallboard, the gypsum, binder, and backing are all required for the product to function, so each ingredient does not count as a separate product.

Products that arrive at the project site ready for installation:

- Metal studs, wallboard, and concrete masonry units are all separate products.
- For wallboard, the gypsum, binder, and backing are all required for the product to function, so each ingredient does not count as a separate product.
- Concrete is a single product as it typically arrives at the site as a mixed product ready to pour.

Products that arrive as an ingredient or component used in a site-assembled product:

- Lumber for custom millwork.
- Concrete mix components (admixture, aggregate, and cement) may be considered separate products if they arrive to site as separate products.

Similar products from the same manufacturer with distinct formulations versus similar products from the same manufacturer with aesthetic variations or reconfigurations:

- Paints of different gloss levels are separate products because each paint type is specified to serve a different function, such as water resistance. Different colors of the same paint are not separate products because they serve the same function.
- Carpets of different pile heights are separate products because they are used for different kinds of foot traffic. The same carpet in a different color is not a separate product.
- Desk chairs and side chairs in the same product line are different products because they serve different functions. Two side chairs differing only in aesthetic aspects, such as the presence of arms, are not different products.

Determining Product Cost

Product and materials cost includes all taxes and expenses to deliver the material to the project site incurred by the contractor but excludes any cost for labor and equipment required for installation after the material is delivered to the site.

To calculate the total materials cost of a project, use either the actual materials cost or the default materials cost.

Actual materials cost. This is the cost of all materials being used on the project site, excluding labor but including delivery and taxes.

Default materials cost. The alternative way to determine the total materials cost is to calculate 45% of total construction costs. This default materials cost can replace the actual cost for most materials and products, as specified above. If the project team is including optional products and materials, such as furniture and MEP items, add the actual value of those items to the default value for all other products and materials.

Location Valuation Factor

Several credits in the MR section include a location valuation factor, which adds value to locally produced products and materials. The intent is to incentivize the purchase of products that support the local economy. Products and materials that are extracted, manufactured, and purchased within 100 miles (160 kilometers) of the project are valued at 200% of their cost (i.e., the valuation factor is 2).

For a product to qualify for the location valuation factor, it must meet two conditions: all extraction, manufacture, and purchase (including distribution) of the product and its materials must occur within that radius (Figure 1), and the product (or portion of an assembled product) must meet at least one of the sustainable criteria

Figure 1. Example material radius

(e.g., FSC certification, recycled content) specified in the credit. Products and materials that do not meet the location criteria but do meet at least one of the sustainability criteria are valued 100% of their cost (i.e., the valuation factor is 1).

The distance must be measured as the crow flies, not by actual travel distance. The point of purchase is considered the location of the purchase transaction. For online or other transactions that do not occur in person, the point of purchase is considered the location of product distribution.

For the location valuation factor of salvaged and reused materials, see MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, *Further Explanation, Material Reuse Considerations.*

Determining Material Contributions of an Assembly

Many sustainability criteria in the MR category apply to the entire product, as is the case for product certifications and programs. However, some criteria apply to only a portion of the product. The portion of the product that contributes to the credit could be either a percentage of a homogeneous material or the percentage of qualifying components that are mechanically or permanently fastened together. In either case, the contributing value is based on weight. Examples of homogeneous materials include composite flooring, ceiling tiles, and rubber wall base. Examples of assemblies (parts mechanically or permanently fastened together) include office chairs, demountable partition walls, premade window assemblies, and doors.

Calculate the value that contributes toward credit compliance as the percentage, by weight, of the material or component that meets the criteria, multiplied by the total product cost.

Product value (\$) = Total product cost (\$) × (%) product component by weight × (%) meeting sustainable criteria

Figure 2. Sustainably produced components of \$500 office chair

TABLE 1. Example calculation for $500 office chair

Chair component	Percentage of product, by weight	Value of component	Percentage of component meeting sustainability criteria	Value of sustainability criteria
Fastening hardware	2%	$10	25% preconsumer recycled content	$2.50
Cotton fabric	5%	$25	100% certified by Rainforest Alliance	$25.00
Plastic component	25%	$125	10% postconsumer recycled content	$12.50
Armrest	5%	$25	10% postconsumer recycled content	$2.50
Metal base	20%	$100	25% preconsumer recycled content	$25.00
Steel post	8%	$40	40% preconsumer recycled content	$16.00
Wheels	5%	$25	10% postconsumer recycled content	$1.25
Total value contributing to credit				**$84.75**

MATERIALS AND RESOURCES PREREQUISITE

Storage and Collection of Recyclables

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To reduce the waste that is generated by building occupants and hauled to and disposed of in landfills.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, HEALTHCARE

Provide dedicated areas accessible to waste haulers and building occupants for the collection and storage of recyclable materials for the entire building. Collection and storage areas may be separate locations. Recyclable materials must include mixed paper, corrugated cardboard, glass, plastics, and metals. Take appropriate measures for the safe collection, storage, and disposal of two of the following: batteries, mercury-containing lamps, and electronic waste.

RETAIL

Conduct a waste stream study to identify the retail project's top five recyclable waste streams, by either weight or volume, using consistent metrics. Based on the waste stream study, list the top four waste streams for which collection and storage space will be provided. If no information is available on waste streams for the project, use data from similar operations to make projections. Retailers with existing stores of similar size and function can use historical information from their other locations.

Provide dedicated areas accessible to waste haulers and building occupants for the separation, collection, and storage of recyclable materials for at least the top four recyclable waste streams identified by the waste study. Locate the collection and storage bins close the source of recyclable waste. If any of the top four waste streams are batteries, mercury-containing lamps, or electronic waste, take appropriate measures for safe collection, storage, and disposal.

BEHIND THE INTENT

Waste disposal continues to be a significant environmental burden on communities and ecosystems. In the U.S., paper, food, glass, metals, and plastics—all recyclable—make up approximately 69% of total municipal solid waste[1] (Figure 1). By diverting such recyclable waste from landfills, building owners can not only reduce hauling costs but also help convert recyclables into new products, reducing demand for virgin materials.

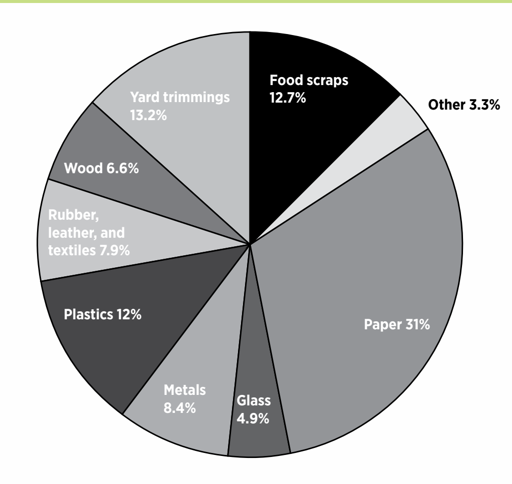


Figure 1. Total municipal solid waste generation. Adapted from the US Environmental Protection Agency.

A factor that commonly thwarts recycling efforts within buildings is a lack of convenient, physical spaces for doing so. Incorporating recycling infrastructure early in the design process encourages successful recycling once operations begin. Well-designed and accessible waste management infrastructure that anticipates how and where waste will be discarded helps occupants make recycling their default behavior.

The increasing volume of electronic waste (e-waste)—computers, cameras, printers, keyboards—has become a growing environmental concern. Therefore, identifying storage areas, recycling facilities, and haulers that can process e-waste is important. The disposal procedure for batteries, fluorescent lamps, and other e-waste is more hazardous than for cardboard, glass, plastic, metals, and paper. Because safety in handling and diversion of these materials is often overlooked by many recycling programs, this prerequisite requires developing waste management infrastructure for at least two hazardous waste streams.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY WASTE DISPOSAL NEEDS FOR PROJECT

Identify the possible waste types and quantities that may be generated by different occupants and spaces. For example, an office may need a large area devoted to paper recycling, whereas a café may require more space for plastics, glass, and metals.

- Core and Shell projects may need to estimate requirements (see *Further Explanation, Rating System Variations*).
- Even if a recycling service is not available, all required recyclable waste streams must have dedicated storage in anticipation of future service (see *Further Explanation, Projects without Available Recycling Infrastructure*).
- Retail projects only: Conduct a waste stream audit for the project in an existing location, or make projections based on historical data for similar establishments. Identify the top-five recyclable waste streams. List the top-four waste streams for which collection and storage space will be provided. See *Further Explanation, Rating System Variations*.

1. *epa.gov/osw/nonhaz/municipal/pubs/msw2009rpt.pdf (accessed July 3, 2013).*

STEP 2. DESIGN APPROPRIATELY SIZED STORAGE AREAS

Provide sufficient collection and storage space for all required recyclables. Indicate recycling storage and collection areas on a floor plan, and be prepared to describe the dedicated recycling storage areas, their accessibility, and how these spaces will serve their functional needs (see *Further Explanation, Infrastructure Considerations*).

- Storage areas should be easily accessible to building occupants, including visitors, full-time occupants, operations staff, and waste haulers.
- For hazardous waste streams (batteries, mercury-containing lamps, e-waste), take appropriate measures for safe collection, storage, and disposal.
- Locate and highlight central collection and storage areas for recyclables, including paper, cardboard, glass, plastic, metal, and e-waste, on submitted floor plans.

FURTHER EXPLANATION

PROJECTS WITHOUT AVAILABLE RECYCLING INFRASTRUCTURE

Projects where there is no access to haulers or external facilities must still comply with this prerequisite by establishing accessible recycling areas. As an interim measure, until a recycling service becomes available, consider alternative means of recycling, such as reuse or donation.

The requirements of this prerequisite help establish recycling infrastructure in the building and encourage waste separation behavior by occupants.

INFRASTRUCTURE CONSIDERATIONS

Consider the following factors for the setup, size, and accessibility of storage and collection of recyclables.

Recycling approach. Research local recycling programs. Some project teams may need to coordinate multiple services. Determine which materials will be stored separately on site and which may be commingled into a single stream and separated off site. The number and size of bins will affect storage requirements. Consider any special equipment that might be needed (e.g., tanks for fryer oil, compactors, and bailers).

Frequency of collection. Occupants may generate more of one type of waste than another, necessitating different schedules for collection or different space requirements. Haulers may operate on a calendar schedule, use sensing technology to retrieve waste only when the compactor is full, or negotiate pick-up patterns for specialized waste, such as e-waste.

Specialized waste streams. Some waste streams may require particular handling or disposal requirements. For example, health care, retail, and some office projects may require secure areas for shredding sensitive or proprietary documents. Electronic waste and mercury-containing lamps may require extra precautions to prevent breakage or exposure to toxins. To set up safe storage and recycling programs, refer to the U.S. Environmental Protection Agency's universal wastes page, at epa.gov/wastes/hazard/wastetypes/universal/index.htm.

Access for waste haulers. Ensuring that waste haulers have access to the recyclable materials is particularly important when planning and building loading docks and roads or when special equipment is required. It may be necessary to demonstrate hauler accessibility by highlighting central storage locations and equipment pull-in on a site plan. Project teams may wish to consult local waste haulers to ensure adequate space for collection vehicles, with appropriate clearances and turning radii.

RATING SYSTEM VARIATIONS

Core and Shell

Because tenant spaces are likely to be unfinished, Core and Shell projects may estimate tenants' recycling needs, based on case study or historical data of similar buildings in the same area, or past project experience.

To reinforce recycling behaviors amongst future occupants, consider incorporating recycling program requirements into tenant guidelines, including information regarding the building's recycling policy and procedures; the requirement that tenant spaces are to be fit-out with dedicated, accessible recycling areas; and recommendations and guidelines for appropriate sizing of recycling infrastructure.

Retail

Retail projects must identify the project's top-five recyclable waste streams by conducting a waste stream study.

The waste stream study must include, at a minimum, a 24-hour period. In some cases the representative time period may be longer. Project teams will be asked how the time period chosen is a representative sample

The required measurement of each waste stream may be by weight or volume but must be consistent. Visual estimation is not considered an effective metric. Project teams must describe the method of conducting the waste stream study, including location, time period, separation method, safety precautions, and measurement method.

Waste streams comprise two major substreams: waste disposed of via landfills or incinerators and waste diverted from disposal through recycling, reuse, or composting. The results of the waste stream study must divide the waste into at least these two substreams.

Use the findings of the study to evaluate how each type of waste can be reduced and set goals for minimizing waste and disposal costs. This may include source reduction, reuse, and recycling. In addition, check local waste haulers, buyers, and other recycling service providers to investigate the potential disposal and diversion options. For example, a local nursery may be able to use coffee grounds for compost.

If a waste stream study is not feasible, the project team may make an informed estimate using one of the following approaches:

- Make projections based on waste stream study of similar retail operation in close proximity to the project.
- Use historical data from existing stores in other locations of the same retailer of similar size and function.

CAMPUS

Group Approach

All buildings in the group may be documented as one. For campuses, a shared central recycling facility for haulers is acceptable, provided the space accommodates recycling produced by all buildings served.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects	Retail only
Verification of recycled material types	X	
Narrative describing recycling storage and collection strategies	X	
Floor plans indicating recycling storage and collection areas	X	
Methodology and results of waste stream study		X

RELATED CREDIT TIPS

MR Prerequisite PBT Source Reduction—Mercury (**Healthcare**). Mercury-containing lamps and certain types of electronic waste fall under the scope of both this prerequisite and the related prerequisite. Consider both scenarios when designing waste and recycling facilities.

CHANGES FROM LEED 2009

Materials that require dedicated storage now include batteries, mercury-containing lamps, and e-waste; project teams may choose two of the three. For retail projects, the required number of waste streams with dedicated storage has increased from three to four.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

dedicated storage a designated area in a building space or a central facility that is sized and allocated for a specific task, such as the collection of recyclable waste. Signage often indicates the type of recyclable waste stored there. Some waste streams, such as mercury-based light bulbs, sensitive paper documents, biomedical waste, or batteries, may require particular handling or disposal methods. Consult the municipality's safe storage and disposal procedures or use guidelines posted on the U.S. Environmental Protection Agency website, at www.epa.gov.

electronic waste discarded office equipment (computers, monitors, copiers, printers, scanners, fax machines), appliances (refrigerators, dishwashers, water coolers), external power adapters, and televisions and other audiovisual equipment

mixed paper white and colored paper, envelopes, forms, file folders, tablets, flyers, cereal boxes, wrapping paper, catalogs, magazines, phone books, and photos

MATERIALS AND RESOURCES PREREQUISITE

Construction and Demolition Waste Management Planning

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.

REQUIREMENTS

Develop and implement a construction and demolition waste management plan:

- Establish waste diversion goals for the project by identifying at least five materials (both structural and nonstructural) targeted for diversion. Approximate a percentage of the overall project waste that these materials represent.
- Specify whether materials will be separated or commingled and describe the diversion strategies planned for the project. Describe where the material will be taken and how the recycling facility will process the material.

Provide a final report detailing all major waste streams generated, including disposal and diversion rates.

Alternative daily cover (ADC) does not qualify as material diverted from disposal. Include materials destined for ADC in the calculations as waste. Land-clearing debris is not considered construction, demolition, or renovation waste that can contribute to waste diversion.

BEHIND THE INTENT

Construction waste is a significant portion of the waste produced in the world. The U.S. Environmental Protection Agency (EPA) estimated that in the U.S. in 2003, 170 million tons of construction and demolition waste were generated and, of that, 61% from nonresidential construction projects.[1] The European Commission estimates that 510 million metric tonnes of construction waste is generated annually by European Union member nations.[2] Keeping these materials out of landfills prevents ground and water pollution, promotes recycling, and keeps materials in active use longer.

Waste management services vary widely from one location to another; therefore, teams should begin by identifying the technologies, haulers, and facilities in the project's area. Planning for construction waste management (CWM) before construction allows time to identify the most effective waste diversion strategies available. Such strategies typically include reuse, recycling, donation, and salvage; however, source reduction and source separation are also viable and effective. Source reduction eliminates project waste through prefabrication, modular construction, or incorporating standard material lengths or sizes into construction documents. Source separation sorts waste on site into recycling streams, ensuring delivery to the correct facility.

Developing a CWM plan early in the design process allows more time for planning and coordination, identifying appropriate strategies, and developing contractual agreements. Educating project team members, site workers, and waste haulers helps ensure that the plan is followed and material is actually diverted from landfills and incinerators. A well-devised CWM plan can also minimize cost and maximize return by decreasing tipping fees, selling high-valued scrap materials, or identifying materials for reuse.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY WASTE DIVERSION GOALS

Identify at least five construction or demolition material streams for diversion from landfill. It may be easiest to focus on determining the heaviest waste or the waste that generates the most volume.

- Common materials that may be simple to divert include drywall, wood, scrap metals, brick, and concrete.
- Finish materials, such as flooring and ceiling tiles, can often be recycled through the major manufacturers.
- Consider incorporating reuse of finish materials, furniture, or framing into the design early. Reusing existing materials may require design modifications. Some materials must remain intact to be reused (e.g., drywall) or may require additional preparation (e.g., de-nailing).

Source reduction strategies should be incorporated into the design of the project and outlined in the CWM plan. These strategies include modular construction, reduced packaging, using industry-standard measurements, and prefabrication.

STEP 2. SELECT COLLECTION AND DIVERSION METHODS

Explore on-site and off-site waste collection and sorting opportunities and consider the infrastructure needed for implementation (see *Further Explanation, Effective Construction Waste Management Strategies*).

- Projects may use a combination of on-site separation and commingled collection, depending on what is appropriate for the project location, material stream, and available facilities and haulers.
- For on-site separation, common CWM strategies include donation, resale, on-site reuse, recycling, or refurbishment. Crushing asphalt, concrete, and masonry for infill or aggregate is also considered on-site waste diversion.
- The most common off-site strategies are incineration, combustion of wood, and sending commingled waste to a sorting facility.
- Identify diversion options for materials.

1. *epa.gov/osw/nonhaz/municipal/pubs/msw2009rpt.pdf* (accessed July 3, 2013).
2. *ec.europa.eu/environment/waste/pdf/story_book.pdf* (accessed May 28, 2013).

- Incineration may be considered diversion if reuse and recycling methods are not readily available in the project's location; this must be included in the CWM plan. Wood-derived fuel, or wood combustion, is considered diversion and not subject to the additional requirements for incineration (see *Further Explanation, Waste-to-Energy*).
- Using a recycling facility for which recycling rates have been independently certified by a third party, such as the Recycling Certification Institute (recyclingcertification.org), provides assurance that diversion rates are accurate, but it is not required for compliance. Some haulers work with local municipalities to certify their average diversion rates.
- Consider how CWM plan requirements, or the requirement to write a plan, can be included in specification documents under Division 1, General Requirements.

STEP 3. DRAFT CONSTRUCTION WASTE MANAGEMENT PLAN

The CWM plan must be customized for each project. The plan must include an overall project waste diversion goal and identify at least five kinds of materials that will be diverted from landfills or incineration.

- There is no minimum threshold for diversion, though project teams may earn points for meeting the thresholds set in the corresponding credit (see MR Credit Construction and Demolition Waste Management).
- All projects must comply with this prerequisite, including projects located in areas without recycling services and those not intending to pursue the corresponding credit.
- The plan must account for all materials, including land-clearing debris, materials to be used for alternative daily cover (ADC), and other materials not contributing to diversion but not included in the diverted waste total.
- The safe removal and disposal of hazardous materials must also be covered in the CWM plan. Hazardous materials must be tracked separately and not be included in the project's total waste.
- Specify the means and methods of diversion for each of the five selected material streams and the approximate amount of waste of each.
- If possible, provide contracts or sample contract language that describes the waste-sorting strategies and technologies used by the waste hauler and facility. Successful CWM plans start with early establishment of contractual obligations.
- When developing the waste hauler contract, consider including the waste reporting structure, a schedule that identifies the responsible parties and their contact information, and a clear chain and method of communication. Consider involving waste haulers in regular construction meetings.

STEP 4. DECIDE WHETHER TO PURSUE CREDIT

Determine whether the project team will seek to achieve the corresponding credit, which awards points for implementing the plan developed in this prerequisite and meeting diversion thresholds (see MR Credit Construction and Demolition Waste Management). A project team that does not pursue the credit must nevertheless develop the plan and produce a final waste report.

STEP 5. PRODUCE WASTE REPORT

Create a final report on the total construction and demolition waste produced by the project and the total waste diverted, using the following equation.

EQUATION 1. Diversion rate

$$\text{Diversion rate} = (\text{Total waste diverted from landfill} / \text{Total waste produced by project}) \times 100$$

- Units may be weight or volume but must be consistent throughout.
- If the project team is pursuing the corresponding credit, see MR Credit Construction and Demolition Waste Management for additional requirements for the final waste report.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*. This prerequisite has no performance requirement, but the corresponding credit does (see MR Credit Construction and Demolition Waste Management).

EFFECTIVE CONSTRUCTION WASTE MANAGEMENT STRATEGIES

On-site separation (also known as source separation) is most viable if multiple bins are conveniently located and the general contractor and subcontractors enforce careful separation. A best practice for source separation is to target waste materials that are easily separated and have established recycling markets, such as steel, wood, and concrete.

On-site separation is preferable to commingling because separated wastes are more likely to actually be diverted from the landfill. Using easy-to-understand multilingual or symbol-based signage helps prevent contamination of on-site source separation areas.

Commingled collection (or single-stream recycling) may be more appropriate for sites with limited storage area for waste containers. Recyclable materials are mixed in one container but sorted and processed at an off-site recycling facility, which separates them from the waste going to a landfill. Commingled waste may be considered only one material stream unless the facility can provide diversion rates for specific materials.

To count toward the corresponding credit (MR Credit Construction and Demolition Waste Management), commingled recycling facilities must be able to provide diversion rates either specific to the project, or an average diversion rate for the facility that is regulated by the local or state authority. The average recycling rate for the facility must exclude ADC.

Donating surplus or architectural salvage or community donation is permissible as long as the organization can verify and track the material, including how much is received and information for where they are going. Habitat for Humanity Restore is a commonly used donation facility in the U.S. and Canada.

Use of construction waste to infill mining pits is permissible only if the waste is "clean" and the work is overseen by the state or local government or a government sponsored organization.

Leaving items on the curb for people to pick up is not acceptable. Dumping in the ocean is never permissible as a diversion strategy.

WASTE-TO-ENERGY

Waste-to-energy may be considered a viable diversion strategy if the project team follows European Commission Waste Framework Directive 2008/98/EC and European Commission Waste Incineration Directive 200/76/EC. In addition, the facility must meet the applicable European standards based on the fuel type. See *Referenced Standards* for more information on these directives:

- EN 303-1—1999/A1—2003, Heating boilers with forced draught burners
- EN 303-2—1998/A1—2003, Heating boilers with forced draught burners
- EN 303-3—1998/AC—2006, Gas-fired central heating boilers
- EN 303-4—1999, Heating boilers with forced draught burners
- EN 303-5—2012, Heating boilers for solid fuels
- EN 303-6—2000, Heating boilers with forced draught burners
- EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner

The combustion of wood or "wood-derived fuel" is not considered waste-to-energy and is exempt from the above criteria.

Project teams must demonstrate that reuse and recycling strategies were exhausted before sending waste material to energy facilities.

CAMPUS

Group Approach
All buildings in the group may be documented as one. Campus buildings may develop one comprehensive plan for construction waste.

Campus Approach
Ineligible.

REQUIRED DOCUMENTATION

Documentation	All projects
Construction waste management plan	X
Total construction waste	X

RELATED CREDIT TIPS

MR Credit Construction and Demolition Waste Management. See the related credit for additional considerations and waste diversion requirements.

CHANGES FROM LEED 2009

The creation of a CWM plan is a new requirement.

REFERENCED STANDARDS

European Commission Waste Framework Directive 2008/98/EC: www.ec.europa.eu/environment/waste/framework/index.htm

European Commission Waste Incineration Directive 2000/76/EC: www.europa.eu/legislation_summaries/environment/waste_management

EN 303-1—1999/A1—2003, Heating boilers with forced draught burners, Terminology, general requirements, testing and marking: www.cen.eu/cen/Products

EN 303-2—1998/A1—2003, Heating boilers with forced draught burners, Special requirements for boilers with atomizing oil burners: www.cen.eu/cen/Products

EN 303-3—1998/AC—2006, Gas-fired central heating boilers, Assembly comprising a boiler body and a forced draught burner: www.cen.eu/cen/Products

EN 303-4—1999, Heating boilers with forced draught burners, Special requirements for boilers with forced draught oil burners with outputs up to 70 kW and a maximum operating pressure of 3 bar, Terminology, special requirements, testing and marking: www.cen.eu/cen/Products

EN 303-5—2012, Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW: www.cen.eu/cen/Products

EN 303-6—2000, Heating boilers with forced draught burners, Specific requirements for the domestic hot water operation of combination boilers with atomizing oil burners of nominal heat input not exceeding 70 kW: www.cen.eu/cen/Products

EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner of nominal heat output not exceeding 1000 kW: www.cen.eu/cen/Products

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

alternative daily cover (**ADC**) material other than earthen material placed on the surface of the active face of a municipal solid waste landfill at the end of each operating day to control vectors, fires, odors, blowing litter, and scavenging. Generally these materials must be processed so they do not allow gaps in the exposed landfill face. (CalRecycle)

clean waste nonhazardous materials left over from construction and demolition. Clean waste excludes lead and asbestos.

commingled waste building waste streams that are combined on the project site and hauled away for sorting into recyclable streams. Also known as single-stream recycling.

land-clearing debris and soil materials that are natural (e.g., rock, soil, stone, vegetation). Materials that are man-made (e.g., concrete, brick, cement) are considered construction waste even if they were on site.

waste-to-energy the conversion of nonrecyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery

MATERIALS AND RESOURCES PREREQUISITE

PBT Source Reduction—Mercury

This prerequisite applies to: **Healthcare**

INTENT

To reduce mercury-containing products and devices and mercury release through product substitution, capture, and recycling.

REQUIREMENTS

As part of the project's recycling collection system, identify the following:

- types of mercury-containing products and devices to be collected;
- criteria governing how they are to be handled by a recycling program; and
- disposal methods for captured mercury.

Applicable mercury-containing products and devices include, but are not limited to, lamps (such as linear and circular fluorescents, integrally ballasted and nonintegrally ballasted compact fluorescents and HIDs) and dental wastes (such as scrap amalgam, chair side traps, and separator wastes).

In facilities delivering dental care, specify and install amalgam separation devices that meet or exceed the ISO-11143 standard.

Comply with the mercury elimination requirements outlined below, from the 2010 FGI Guidelines for Design and Construction of Health Care Facilities, Section A1.3- 4b, Mercury Elimination.

- 4.2.1.1. New construction: healthcare facilities may not use mercury-containing equipment, including thermostats, switching devices, and other building system sources. Lamps are excluded.
- 4.2.1.2. Renovation: healthcare facilities must develop a plan to phase out mercury-containing products and upgrade current mercury-containing lamps to high-efficiency, low-mercury, or mercury-free lamp technology.

Do not specify or install preheat, T-9, T-10, or T-12 fluorescents or mercury vapor high-intensity discharge (HID) lamps in the project. Do not specify probe-start metal halide HID lamps in any interior spaces.

Specify and install illuminated exit signs that do not contain mercury and use less than 5 watts of electricity.

Fluorescent and high-pressure sodium lamps must meet the criteria in Table 1.

TABLE 1. Maximum mercury content of lamps	
Lamp	**Maximum content**
T-8 fluorescent, eight-foot	10 mg mercury
T-8 fluorescent, four-foot	3.5 mg mercury
T-8 fluorescent, U-bent	6 mg mercury
T-5 fluorescent, linear	2.5 mg mercury
T-5 fluorescent, circular	9 mg mercury
Compact fluorescent, nonintegral ballast	3.5 mg mercury
Compact fluorescent, integral ballast	3.5 mg mercury, ENERGY STAR qualified
High-pressure sodium, up to 400 watts	10 mg mercury
High-pressure sodium, above 400 watts	32 mg mercury

mg = milligram

BEHIND THE INTENT

Mercury is a persistent bioaccumulative toxic (PBT) chemical element and a neurotoxin. PBTs, which break down extremely slowly in the environment, accumulate within animal tissues in increasing concentrations up the food chain. Once present in an organism, mercury can affect the central nervous system, ultimately damaging the brain, spinal cord, kidneys, and liver. Released into the environment, it is difficult to contain.

In buildings, mercury releases come from breakage of lamps containing mercury or from some kinds of equipment. This prerequisite focuses on reducing mercury found in health care building system components and lighting.

A robust recycling program enables collection and recycling of equipment that contains mercury. This prerequisite requires that projects make plans for the handling of mercury in building systems and lighting during design, construction, and major renovations. Strategies include source reduction, operational cost reduction, and prevention of spills that could expose staff and patients to contamination and entail costly remediation measures.

STEP-BY-STEP GUIDANCE

For Projects Reusing Existing Mercury-Containing Equipment and Lamps

STEP 1. INVENTORY EXISTING MERCURY-CONTAINING EQUIPMENT AND LAMPS

Work with the building maintenance department to develop an inventory of all mercury-containing equipment and lamps within the project boundary (see *Further Explanation, Inventory Scope*).

- Building systems and indoor and outdoor lighting equipment must be included in the inventory.
- Medical equipment may also be included.

Collect the following information for the inventory:

- Equipment, building system, lamp type
- Quantity within the project boundary
- Mercury content

List the maximum mercury content allowed for the mercury-containing lamps and identify lamps that do not comply with the prerequisite criteria.

STEP 2. DEVELOP PHASE-OUT AND UPGRADE PLAN

Based on the inventory, develop a phase-out plan to transition any mercury-containing equipment and lamps to mercury-free devices and replace noncompliant mercury lamps with low-mercury or mercury-free lamps.

- Where feasible, completely eliminating mercury in the building is a best practice. It avoids the need to develop ongoing collection, handling, and recycling or disposal procedures.
- If the total elimination of mercury is not feasible given existing equipment within the project's scope of work, develop a plan to phase out mercury in building equipment and lamps.

All Projects

STEP 1. INCORPORATE MERCURY LIMITS INTO PROJECT SPECIFICATIONS

Specify mercury-free building equipment, including thermostats, switching devices, lamps, and other building system sources (see *Further Explanation, Inventory Scope*).

- Consider using digital measurement devices and controls to prevent "hidden" mercury from being installed.

- Specify high-efficiency, low-mercury lamps that meet the credit criteria for the specific lamp type, or specify mercury-free lamps (see *Further Explanation, Lamp Exclusions*).
- Although 8-foot and U-bent lamps are permitted under this prerequisite, they are particularly susceptible to breakage because of their size and configuration. Consider eliminating large and awkward lamps for operational staff safety.
- Include specifications for illuminated exit signs and metal halide lamps that meet the criteria.
- Mercury-free alternatives to low-wattage fluorescent lamps, such as LED or LEC, comply with the credit requirements only if they are at least as energy efficient as comparable mercury-containing lamps.
- If either average and maximum values or ranges are given for mercury content in manufacturer's data, use the highest value.

STEP 2. SPECIFY COMPLIANT AMALGAM SEPARATION FOR DENTAL FACILITIES (IF APPLICABLE)

Specify amalgam separation devices that meet or exceed ISO 11143 standards.

- Separators reduce the amount of amalgam entering the sewage system by removing amalgam particles from the wastewater of a dental treatment center.
- The ISO standard specifies the efficiency of the amalgam separators (in terms of the level of retention of amalgam based on a laboratory test) and the test procedure for determining this efficiency.
- This standard also includes requirements for the safe function of the amalgam separator through integral markings and instructions for use, operation, and maintenance.

STEP 3. TRACK PRODUCTS DURING CONSTRUCTION

Track specified and purchased materials during construction with a material checklist or tracking form (see *Further Explanation, Sample Inventory and Lighting Schedule*).

- Prepare a lighting schedule that includes mercury content, ballast type, and product manufacturers' information for mercury-containing and high-pressure sodium lamps.
- Check material safety data sheets and manufacturers' documentation before installation to ensure that only qualifying products and lamps are used.

STEP 4. PLAN FOR COLLECTING AND RECYCLING MERCURY-CONTAINING EQUIPMENT

Create a mercury collection and recycling program, including storage areas, handling methods, and disposal process. Prepare a narrative that describes the plan.

Consider undertaking the following activities during plan preparation and implementation:

- Coordinate the collection and recycling of mercury-containing devices with MR Prerequisite Storage and Collection of Recyclables. Conduct an audit of a similar facility to identify mercury-containing devices in the project's waste stream and inform the development of appropriate recycling facilities (see *Further Explanation, Mercury-Containing Devices in the Waste Stream*).
- Develop a protocol for collection and disposal of mercury-containing spills and incorporate it into training for operating personnel.
- Coordinate the development of a recycling program for mercury-containing products with representatives from waste management, purchasing, and industrial hygiene.
- Avoid bulb crushers, which can expose workers to mercury vapor and generate hazardous waste, even though crushed bulbs are not classified as universal waste.

FURTHER EXPLANATION

INVENTORY SCOPE

The following building equipment must be included in the prerequisite scope for projects planning to reuse existing mercury-containing equipment and lamps:

- Thermostats
- Switching devices

- Relays
- Lamps

Because the following types of medical equipment could have hidden mercury, and it is recommended that they be included in a mercury inventory and phase-out plan:

- MRI equipment
- Wheelchairs
- Automated beds
- Cantor tubes
- Bed warmers
- Thermometers
- Pressure-measuring devices

Mercury content requirements are specified by lamp type. Figure 1 is an example of typical lamp types in a Healthcare project.

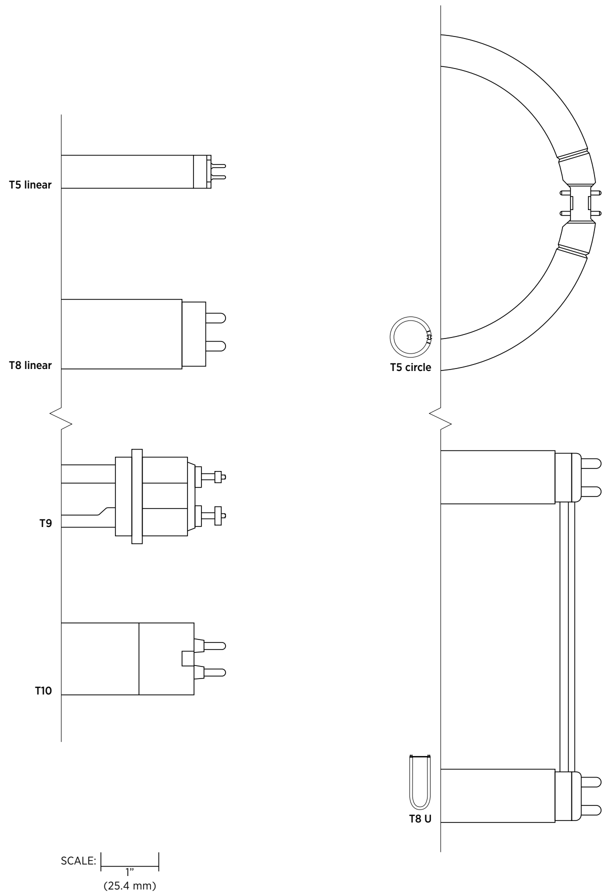


Figure 1. Lamp Types

LAMP EXCLUSIONS

Operating rooms, dental treatment rooms, dental labs, and other spaces in medical military facilities may require lamps with very high CRI and color temperature to comply with UFC 4-501-01. If the prerequisite criteria and UFC 4-501-01 conflict, affected lamps may be excluded from the prerequisite.

If the prerequisite criteria and local code or regulations conflict, affected lamps may be excluded from the prerequisite. Retain a copy of the local code that conflicts with the prerequisite criteria.

MERCURY-CONTAINING DEVICES IN THE WASTE STREAM

Mercury-containing waste to be addressed in coordination with MR Prerequisite Storage and Collection of Recyclables includes the following equipment:

- Linear and circular fluorescent lamps
- Compact fluorescent lamps
- HID lamps
- Dental wastes (scrap amalgam, chair side traps, amalgam separator wastes)

The following data should be captured during an audit to identify mercury-containing devices in the project waste stream:

- Product type
- Quantity of each product type
- Criteria for handling and storage after the end of a product's useful life
- Protocols for spill response
- Disposal methods for captured mercury
- Contact information for coordinators of the mercury-recycling program

SAMPLE INVENTORY AND LIGHTING SCHEDULE

The lamp inventory and lighting schedule include information related to the lamp life. The following data must be included in the lighting schedule:

- Lamp type
- Quantity
- Mercury content
- Ballast type
- Rated life criteria (see *Further Explanation, Finding Lamp Data*)
- Actual rated life

TABLE 1. Sample inventory and lighting schedules

				MR Prerequisite		MR Credit	
Lamp type	**Model**	**Quantity**	**Ballast type**	**Max mercury criteria (mg)**	**Lamp mercury content (mg)**	**Rated life criteria (hours)**	**Lamp rated life (hours)**
T8, 8-ft standard	F32T8	2,000	Instant start	10	1.7	24,000	24,000
T8, 8-ft high output	F48T8 44W	100	Instant start	10	3.5	18,000	18,000
T8, U-bent	FB32T8/6 25W	25	Program start	6	3	25,000	20,000
T5	F28T5/850	50	Program start	2.5	1.4	25,000	25,000
CFL	20W CFL	150	Integral bare bulb	3.5	2.6	10,000	15,000

FINDING LAMP DATA

Manufacturer's documentation typically includes at least one value for mercury content in a simple lamp. The elemental symbol for mercury is Hg, which may appear as the label for mercury content (Figure 2).

Lamp life is typically provided on manufacturer product data sheets. Identify the lamp life correlating with specified ballast type and three hour start.

Product Information

General Characteristics	
Base	Medium Bi-Pin (Medium Bi-Pin Fluorescent)
Base Information	Green Base
Bulb	TB
Rated Average Life (12-Hr Prog St)	36000 hr
Rated Average Life (12-Hr Inst St)	30000 hr
Rated Average Life (3-Hr Prog St)	30000 hr
Rated Average Life (3-Hr Inst)	24000 hr
Mercury Information	
Average Mercury (Hg) Content	1.7 mg
Max Mercury (Hg) Content	2.2 mg
Light Characteristics	
Color Temperature	3000 K
Initial Lumen	2600 Lm
Design Mean Lumens	2470 Lm

Identify the lamp life provided with manufacturer documentation corresponding to the 3 hour start with the appropriate ballast (program start or instant start).

If multiple values are given, use the max given.

Find design mean lumens.

Figure 2. Sample manufacturer's information

CAMPUS

Group Approach

All buildings in the group may be documented as one. Projects that are on existing campuses or part of large health care systems can coordinate lamp selection with purchasing protocols to ensure ongoing compliance with prerequisite requirements.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects
Existing inventory and phase-out plan (for renovation projects)	X
Recycling plan for mercury-containing lamps	X
Lighting schedule including lamp type and mercury content	X
USGBC's PBT source reduction calculator (or equivalent documentation)	X

RELATED CREDIT TIPS

MR Credit PBT Source Reduction—Mercury. In addition to the mercury content information required for this prerequisite, include lamps that meet the rated hours criteria for the related credit.

MR Prerequisite Storage and Collection of Recyclables. The related prerequisite requires safe storage and collection of hazardous wastes, including mercury-containing waste.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

Guidelines for the Design and Construction of Health Care Facilities, 2010 Edition Facility Guidelines Institute: fgiguidelines.org/

ISO-11143, Dentistry, Amalgam Separators: iso.org/iso/catalogue_detail.htm?csnumber=42288

ENERGY STAR: energystar.gov

U.S. Department of Energy ENERGY STAR Qualified Light Bulbs, 2009 Partner Resource Guide: energystar.gov/ia/products/downloads/CFL_PRG.pdf

Toxicological Effects of Methylmercury, Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology, National Research Council, 2000: nap.edu/catalog.php?record_id=9899

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

elemental mercury mercury in its purest form (rather than a mercury-containing compound), the vapor of which is commonly used in fluorescent and other bulb types

lamp a device emitting light in a fixture, excluding lamp housing and ballasts. Light-emitting diodes packaged as traditional lamps also meet this definition.

lamp life the useful span of operation of a source of artificial light, such as bulbs. Lamp life for fluorescent lights is determined by testing three hours on for every 20 minutes off. For high-density discharge lamps, the test is based on 11 hours on for every 20 minutes off. Lamp life depends on whether the start ballast is program or instant. This information is published in manufacturers' information. Also known as rated average life.

persistent bioaccumulative toxic chemical a substance that poses a long-term risk to both humans and the environment because it remains in the environment for long periods, increases in concentration as it moves up the food chain, and can travel far from the source of contamination. Often these substances can become more potent and harmful to ecosystems the longer they persist. See U.S. EPA's website on persistent bioaccumulative toxic chemicals, www.epa.gov/pbt/.

universal waste hazardous items that are easily purchased and commonly used. Examples include batteries, pesticides, mercury-containing equipment, and light bulbs. See epa.gov/osw/hazard/wastetypes/universal/index.htm.

MATERIALS AND RESOURCES CREDIT

Building Life-Cycle Impact Reduction

This credit applies to:

New Construction (2–5 points)
Core and Shell (2–6 points)
Schools (2–5 points)
Retail (2–5 points)
Data Centers (2–5 points)
Warehouses and Distribution Centers (2–5 points)
Hospitality (2–5 points)
Healthcare (2–5 points)

INTENT

To encourage adaptive reuse and optimize the environmental performance of products and materials.

REQUIREMENTS

Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials use through life-cycle assessment. Achieve one of the following options.

OPTION 1. HISTORIC BUILDING REUSE (5 POINTS BD+C, 6 POINTS CORE AND SHELL)

Maintain the existing building structure, envelope, and interior nonstructural elements of a historic building or contributing building in a historic district. To qualify, the building or historic district must be listed or eligible for listing in the local, state, or national register of historic places. Do not demolish any part of a historic building or contributing building in a historic district unless it is deemed structurally unsound or hazardous. For buildings listed locally, approval of any demolition must be granted by the local historic preservation review board. For buildings listed in a state register or the U.S. National Register of Historic Places (or local equivalent for projects outside the U.S.), approval must appear in a programmatic agreement with the state historic preservation office or National Park Service (or local equivalent for projects outside the U.S.).

Any alteration (preservation, restoration, or rehabilitation) of a historic building or a contributing building in a historic district on the project site must be done in accordance with local or national standards for rehabilitation, whichever are applicable. If building is not subject to historic review, include on the project team a preservation professional who meets U.S. federal qualifications for historic architects (or local equivalent for projects outside the U.S.); the preservation professional must confirm conformance to the Secretary of Interior's Standards for the Treatment of Historic Properties (or local equivalent for projects outside the U.S.).

OR

OPTION 2. RENOVATION OF ABANDONED OR BLIGHTED BUILDING (5 POINTS BD+C, 6 POINTS CORE AND SHELL)

Maintain at least 50%, by surface area, of the existing building structure, enclosure, and interior structural elements for buildings that meet local criteria of abandoned or are considered blight. The building must be renovated to a state of productive occupancy. Up to 25% of the building surface area may be excluded from credit calculation because of deterioration or damage.

OR

OPTION 3. BUILDING AND MATERIAL REUSE (2–4 POINTS BD+C, 2-5 POINTS CORE AND SHELL)

Reuse or salvage building materials from off site or on site as a percentage of the surface area, as listed in Table 1. Include structural elements (e.g., floors, roof decking), enclosure materials (e.g., skin, framing), and permanently installed interior elements (e.g., walls, doors, floor coverings, ceiling systems). Exclude from the calculation window assemblies and any hazardous materials that are remediated as a part of the project.

Materials contributing toward this credit may not contribute toward MR Credit Material Disclosure and Optimization.

TABLE 1. Points for reuse of building materials

Percentage of completed project surface area reused	Points BD+C	Points BD+C (Core and Shell)
25%	2	2
50%	3	3
75%	4	5

OR

OPTION 4. WHOLE-BUILDING LIFE-CYCLE ASSESSMENT (3 POINTS)

For new construction (buildings or portions of buildings), conduct a life-cycle assessment of the project's structure and enclosure that demonstrates a minimum of 10% reduction, compared with a baseline building, in at least three of the six impact categories listed below, one of which must be global warming potential. No impact category assessed as part of the life-cycle assessment may increase by more than 5% compared with the baseline building.

The baseline and proposed buildings must be of comparable size, function, orientation, and operating energy performance as defined in EA Prerequisite Minimum Energy Performance. The service life of the baseline and proposed buildings must be the same and at least 60 years to fully account for maintenance and replacement. Use the same life-cycle assessment software tools and data sets to evaluate both the baseline building and the proposed building, and report all listed impact categories. Data sets must be compliant with ISO 14044.

Select at least three of the following impact categories for reduction:

- global warming potential (greenhouse gases), in kg CO_2e;
- depletion of the stratospheric ozone layer, in kg CFC-11;
- acidification of land and water sources, in moles H+ or kg SO_2;
- eutrophication, in kg nitrogen or kg phosphate;
- formation of tropospheric ozone, in kg NO_x, kg O3 eq, or kg ethene; and
- depletion of nonrenewable energy resources, in MJ.

HEALTHCARE ONLY

For all options in this credit, building materials demolished to create courtyards to increase daylighting may be counted as retained in calculations, provided the new courtyards meet the requirements of EQ Credits Daylight and Quality Views.

BEHIND THE INTENT

Over their lifetimes, buildings have local, regional, and global environmental effects. Some occur during the harvest, extraction, manufacture, and transportation of materials; others involve construction and operations; still others take place at demolition and disposal. A life-cycle assessment (LCA) examines as many of these environmental effects as possible. This credit identifies several strategies for reducing harm done to the environment over a building's entire life cycle: restoring existing buildings, reusing building components, and reducing a building's environmental footprint through LCA.

Restoring existing buildings, preserving historic structures, and rehabilitating blighted buildings reduce the energy use and waste associated with demolition and construction. A report by the National Trust for Historic Preservation, titled The Greenest Building: Quantifying the Environmental Value of Building Reuse, found that building reuse almost always offers environmental savings over demolition and new construction. A new, energy-efficient building will not compensate for the climate change effects of its construction for at best 10 years and perhaps 80 years.[1] Restoring existing buildings preserves a site's historical, cultural, and aesthetic values, and reusing or repurposing wood, brick, steel, stone, or other materials from off site can be a cost-effective and sustainable strategy.

For new construction projects, a cradle-to-grave LCA enables building professionals to understand the cumulative energy use and other environmental consequences resulting from all phases of the building's life. A comprehensive, quantitative analysis helps determine which materials best fit the project's needs throughout the building's lifetime. Employed as a design tool, LCA may reduce the amount of materials used ("dematerialization"), which can in turn reduce environmental harms and save money. An LCA also allows the design team to understand the trade-offs of material selection and energy performance and find an appropriate balance between the two. For example, high thermal mass can reduce a building's peak energy demands; an LCA can quantify the environmental damage associated with the additional materials used so that the team can compare those effects with the benefits for energy performance and then make more informed design decisions. By looking at how materials interact within the whole structure and enclosure rather than merely individually, it is possible gain a larger perspective and reduce overall environmental effects over the long term.

The whole-building LCA option takes into account a wide range of such effects. These include global warming potential, stratospheric ozone depletion, acidification of land and water sources, eutrophication, formation of tropospheric ozone, and depletion of nonrenewable energy sources. Those are only some of the most common, measurable, and well-understood environmental impacts that LCA tools evaluate. Current LCA tools cannot accurately measure human health, ecological, and land-use issues; however, those effects are also important to a life-cycle approach to materials and are addressed under other Materials and Resources credits.

STEP-BY-STEP GUIDANCE

Select the appropriate option for the project (see *Further Explanation, Project Type Variations*).

- Options 1, 2, and 3 are for projects that will reuse all or part of an existing building.
- Option 4 is for entirely new buildings but can also be used by projects that are new additions to existing buildings; it involves conducting a life-cycle assessment for the whole building.

Option 1. Historic Building Reuse

STEP 1. DETERMINE WHETHER BUILDING HAS OR IS ELIGIBLE FOR HISTORIC DESIGNATION

Search national, state, and local historic registers to determine whether the existing building has historic designation or is within a historic district.

1. *preservationnation.org/information-center/sustainable-communities/green-lab/lca/The_Greenest_Building_lowres.pdf* (accessed May 28, 2013).

- If the building does not have historic designation, it may be considered eligible if it meets one of the four National Register criteria or meets state or local historic criteria. The U.S. National Register of Historic Places defines a building as historic if it meets at least one of the following criteria:[2]
  - It is associated with events that have made a significant contribution to the broad patterns of our history.
  - It is associated with the lives of significant persons in the past.
  - It embodies the distinctive characteristics of a type, period, or method of construction; represents the work of a master; possesses high artistic values; or represents a significant and distinguishable entity whose components may lack individual distinction.
  - It has yielded, or may be likely to yield, information important in history or prehistory.
- Projects outside the U.S. should consult the historic preservation guidelines set forth in the local or national registry of historic places (see *Further Explanation, International Tips*).

STEP 2. REUSE HISTORIC BUILDING

If the building has or is eligible for historic status, confirm the specific requirements for maintaining that designation during design and construction. Confirm what part(s) of the building can and cannot be altered to maintain its historic status and ensure that the design and construction uphold these requirements.

- This option does not have a threshold for credit compliance. There is no minimum area of the building that must be reused to meet the requirement. However, if its historic designation or eligibility is revoked because of demolition or alteration, the project is no longer eligible for this option.
- Demolition of any part of the historic structure must be reviewed by the appropriate review board or conform to local standards for rehabilitation (U.S. projects must adhere to the secretary of the Interior's Standards for the Treatment of Historic Properties).
- If historic designation is revoked, project teams may pursue Option 3 Building and Material Reuse for the partial reuse of buildings.
- If there is no local review body in place, include on the project team a qualified professional to guide historically sensitive design and construction decisions.

Option 2. Renovation of Abandoned or Blighted Building

STEP 1. DETERMINE WHETHER BUILDING IS ABANDONED OR BLIGHTED

Determine whether the jurisdiction in which the project is located has a program or designation for abandoned or blighted buildings and whether the building meets this definition. If no such program or definition exists, use the LEED definition for abandoned or blighted property to determine whether the project is eligible for this option.

STEP 2. DETERMINE REUSABLE AREA

Identify and quantify the surface areas of the structure and building enclosure that can and cannot be retained. Areas of the structure and building enclosure that are structurally unsound and must be demolished, as determined by a structural engineer, can be excluded from the calculation in Step 3.

STEP 3. CALCULATE PERCENTAGE OF REUSED AREA

- If more than 25% of the building's surface area is considered unsound and must be demolished, the project is ineligible for this option but may pursue Option 3 Building and Material Reuse.
- Calculate the percentage of the total surface area that will be reused (see *Further Explanation, Calculations,* and Table 2).
- Ensure that the reusable areas are clearly defined and incorporated into the design and construction of the project.

2. *nps.gov/nr/publications/bulletins/nrb15/nrb15_2.htm.*

TABLE 2. Calculating reuse for abandoned or blighted buildings			
Structure or envelope element	**Existing area (m^2)**	**Reused area (m^2)**	**Percentage reused**
On-grade floor assembly			
Foundation, slab on grade	3120	2740	87.8%
Subfloor	3000	2000	66.7%
Hardwood flooring	3000	1500	50.0%
2nd-floor assembly			
Structural deck	3120	1050	33.7%
Hardwood flooring	3000	2500	83.3%
Ceiling tiles	2225	1300	58.4%
Roof deck			
Reused roof deck	1905	985	51.7%
Roof deck (structurally unsound and removed)	920	-	-
Asbestos ceiling tiles (hazardous material removed)	1905	-	-
1st-floor wall assemblies (excluding windows)			
Brick enclosure	1525	1525	100.0%
Insulation	1525	765	50.2%
Drywall	1525	0	0.0%
2nd-floor wall assemblies (excluding windows)			
Brick enclosure	1525	1525	100.0%
Insulation	1525	380	24.9%
Drywall	1525	0	0.0%
TOTAL	26 995	16 270	60.3%

Option 3. Building and Material Reuse

STEP 1. CALCULATE EXISTING BUILDING SURFACE AREA AND REUSE EXISTING BUILDING

Identify and quantify the surface areas of the structure, building enclosure, and interior elements (e.g., walls, doors, floor coverings, and ceiling systems) that can and cannot be retained.

- Exclude from the calculation any hazardous materials that are remediated as part of the project.
- Once the scope of reuse is determined, ensure that the areas intended for reuse are well defined and incorporated into the design and construction.

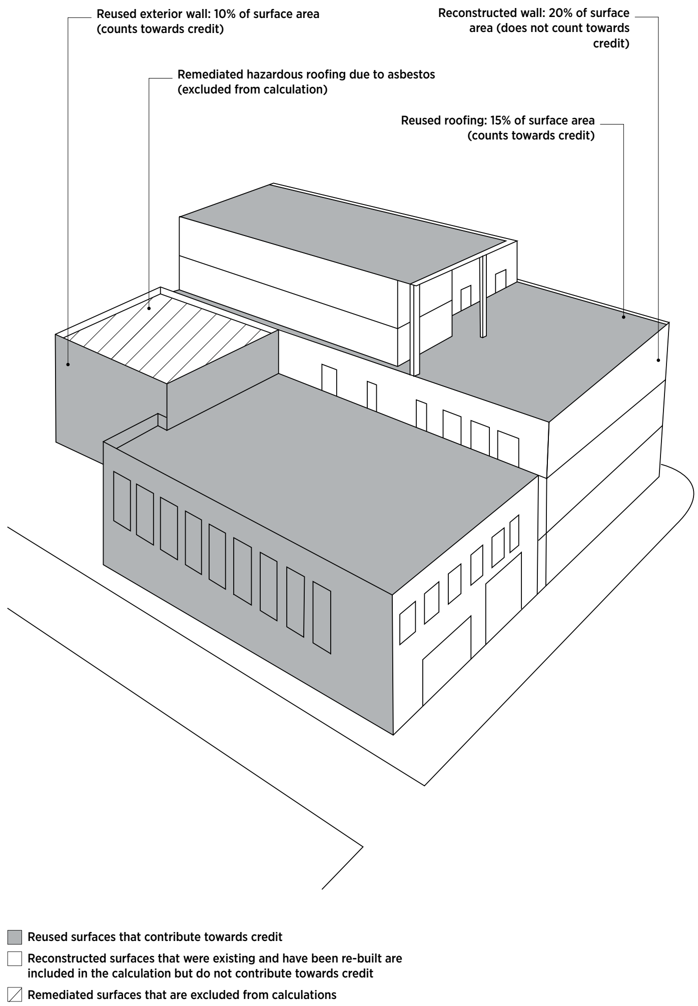


Figure 1. Example existing building reused surface area for credit calculation

STEP 2. REUSE OFF-SITE MATERIALS

Off-site products and materials used in the project may be included in the credit calculations but may not be double-counted for MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, Option 2.

- Any reused product or material may be included in either this credit or MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, Option 2.
- Teams pursuing both credits may count their materials in either credit, whichever is more appropriate for their projects.
- For this credit, building and material reuse is measured in surface area; in MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials reuse is measured by cost or replacement value.

STEP 3. CALCULATE REUSE

Calculate the percentage of total area that will be reused (see *Further Explanation, Calculations*, and Table 3).

TABLE 3. Calculating reuse for existing buildings and materials			
Structure, enclosure, or interior element	**Existing area (ft²)**	**Reused area (ft²)**	**Percentage reused**
On-grade floor assembly			
Foundation, slab on grade	18,230	18,230	100.0%
Subfloor	17,500	15,000	85.7%
Carpet	10,000	0	0.0%
2nd-floor assembly			
Structural deck	18,230	18,230	100.0%
Hardwood flooring	10,000	2,500	25.0%
Salvaged wood flooring from barn	7,500	7,500	100.0%
Ceiling tiles	14,500	7,000	48.3%
Roof assembly			
Roof deck	18,000	7,630	42.4%
Asbestos ceiling tiles (hazardous material removed)	–	–	–
1st-floor wall assembly (excluding windows)			
Brick enclosure	16,460	16,460	100.0%
Sheathing	15,000	8,400	56.0%
Insulation	7,700	0	0.0%
Salvaged doors from off site	105	105	100.0%
2nd-floor wall assembly (excluding windows)			
Brick enclosure	16,460	16,000	97.2%
Steel structure	16,460	16,460	100.0%
Drywall	15,300	9,400	61.4%
TOTAL	**201,445**	**142,915**	**70.9%**

Option 4. Whole-Building Life-Cycle Assessment

This option has only one threshold. To achieve this option the proposed building must demonstrate at least a 10% reduction in global warming potential and a 10% reduction of two of five other impact measures (discussed below) when compared to a baseline building, without increasing any measure by more than 5%.

STEP 1. CALCULATE EXISTING BUILDING SURFACE AREA AND REUSE EXISTING BUILDING

Ensure that the scope of the analysis is a cradle-to-grave assessment, which includes environmental impacts associated with all the life-cycle stages for the building structure and enclosure: resource extraction or harvest, building product manufacture, on-site construction, product maintenance and replacement (where warranted), and deconstruction or demolition and disposal over the assumed 60-year service life. The LCA must address the following:

- **Products.** The LCA must cover the complete building envelope and structural elements, including the material components of footings and foundations, structural wall assembly (from cladding to interior finishes), structural floors and ceilings (not including finishes), and roof assemblies.

- Exclude electrical and mechanical equipment and controls, plumbing fixtures, fire detection and alarm system fixtures, elevators, and conveying systems.
- Exclude excavation and other site development.
- Include parking structures; exclude parking lots.
- Additional building elements, such as interior nonstructural walls or finishes, may be included at the discretion of the project team. The deliberate avoidance of certain interior elements can be accounted for in this option. Inclusion of elements in the baseline building depends on whether it is within standard industry practice for their occurrence in project's building type. Thus, unless otherwise justified, for office, retail and industrial building types, partitions should not be included in the baseline building. And accordingly, floor finishes can be in the reference building for all except industrial.

- **Functional equivalence.** The proposed and baseline buildings have to serve the same function and must have the same gross floor area, orientation, and operational energy usage.
- **Service life.** For LEED, the project team must take into account the entire building structure and enclosure, from design to demolition for an assumed 60-year service life.
  The assumed service life must be the same for the baseline and proposed buildings and must be at least 60 years to properly account for material maintenance and replacement (see *Further Explanation, Product Replacement*).
- **System boundary.** The system boundary of the analysis must be defined to account for cradle-to-grave environmental impacts associated with all the life-cycle stages for the building structure and enclosure as defined in EN 15804-2013 sections A-1 thru A-4, B-1 thru B-5, and C-1 thru C-4.
- Any parameters not defined above may change across the baseline and proposed buildings to achieve desired design and performance objectives.

STEP 2. SELECT APPROPRIATE TOOLS AND DATA SETS FOR LCA ASSESSMENT

Review existing LCA tools and data sets and select the most suitable for the project (see *Further Explanation, LCA Tools Selection*). The choice of tool will determine whether an LCA specialist is required.

- The same LCA software or tool and ISO 14044–compliant data sets must be used to study both the baseline building and the proposed building. Data set selection may be determined by the tool being used and the relevant data sets for the project location (*see Further Explanation, LCA Impact Measures or Indicators*).
- Ensure that the selected tool can be applied at the whole-building level and produce results for the relevant indicators.

STEP 3. CREATE AND MODEL BASELINE BUILDING

Create the baseline building with which the team will compare alternatives early in the design process, once programmatic and size needs have been determined. Input the baseline building into the selected LCA tool (see *Further Explanation, Creating the Baseline Building*).

STEP 4. SELECT RELEVANT IMPACT MEASUREMENT SYSTEMS

Select the appropriate output units for each LCA impact indicator shown in Table 4 (see *Further Explanation, Life Cycle Impact Measures Or Indicators*).

TABLE 4. LCA impact indicator units

LCA impact indicators	TRACI 2.1	CML 2002	ReCiPe
Global warming potential	CO_2e	CO_2e	CO_2e
Ozone depletion potential	CFC-11-eq	CFC-11-eq	CFC-11-eq
Acidification potential (land)	SO_2e	SO_2e	SO_2e
Eutrophication potential (fresh water)	N eq	$PO_4{}^3e$	P eq
Formation of tropospheric ozone (photochemical oxidant formation)	NO_x eq	C_2H_4e	kg NMVOC
Depletion of nonrenewable energy resources	MJ	Weight or volume of raw material	Kg oil eq

STEP 5. USE LCA TO MAKE DESIGN DECISIONS THAT REDUCE ENVIRONMENTAL IMPACTS

Use the proposed LCA model to conduct "what if" scenario analyses and support design decisions to evaluate and select environmentally preferable assemblies and materials. Examples of alternatives analyses could include the following:

- Comparing the environmental consequences of building footprint and shape
- Evaluating different structural system types, such as load-bearing walls versus columns
- Defining the selection of building products and assemblies
- Optimizing structural system design (e.g., column spacing, slab depth)

If the design team wants to use a material, product, or assembly that is not in the selected LCA tool's data set, the results of a critically reviewed LCA or a verified environmental product declaration (EPD) can be used, provided the results cover the required full set of impact indicators for that component. The material, product, or assembly in the model must then be removed and the impact measures for the replacement added as a side calculation, taking account of all related ancillary product use. Any such additions must be documented and the documentation included in the submittal; include the rationale for the change and the source of the replacement impact measures.

STEP 6. INCORPORATE FINAL LCA RESULTS

Review the results, incorporate decisions in design documents, and prepare a narrative that describes the LCA assumptions, scope, and baseline and proposed buildings (see *Further Explanation, Developing an LCA Narrative*).

FURTHER EXPLANATION

CALCULATIONS

For Options 2 and 3, each assembly (vertical or horizontal) may be calculated as up to three layers of surface area: enclosure and finish floor, structure, and interior finish and ceiling finish. See *Further Explanation, Calculating Surface Area*.

EQUATION 1. Percentage of abandoned or blighted building reuse (Option 2)

$$\text{Abandoned or blighted building reuse} = \left(\frac{\text{Surface area reused}}{\text{Existing building surface area} - \text{hazardous or unsafe materials demolished area}} \right) \times 100$$

Exclude hazardous materials and structurally unsound portions of the building from the calculations.

EQUATION 2. Percentage of existing building reuse (Option 3)

$$\text{Existing building reuse} = \left(\frac{\text{Surface area reused on-site} + \text{Surface area reused from off-site}}{\text{Existing building surface area} - \text{hazardous materials area}} \right) \times 100$$

Exclude hazardous materials from the calculations.

CALCULATING SURFACE AREA

Each assembly (vertical or horizontal) may be calculated as up to three layers of surface area. For vertical building elements, the layers are enclosure, interior finish, and structure. For horizontal building elements, the layers are ceiling finish, structure, and floor finish. Structural support elements, such as columns, beams, and studs, are considered part of the larger surfaces they support. Calculate the surface area of these elements as equal to surface area of the wall.

Not all projects will have all layers present at the beginning of construction, depending on the state of the building. If a layer that existed before construction or demolition is removed and replaced with new material, it must be included in the calculation. If an existing layer was removed and not replaced, it is excluded from the credit calculations. Examples:

- A project has a floor assembly consisting of ceiling tiles, structural slab, and carpeting. The ceiling tiles and structural slab are reused, but the carpet is removed and not replaced because the design uses the exposed structural concrete as the finish material. The team excludes the carpeting from the calculation but counts the slab as reused.
- A building has an existing brick enclosure, steel structure, and drywall. The project is reusing the structure and enclosure but replacing the existing drywall with new drywall. The team must include all three existing layers in the denominator, but only the reused portions in the numerator.
- For a building with an existing brick enclosure and steel structure, with no drywall or interior finish, the team includes only those two layers in the reuse calculations.

If before construction and demolition the building has more than three layers that can be counted toward reuse, the project team may choose the three layers to include in the calculation. The three layers chosen should represent the structure of a typical basic wall or floor assembly (enclosure and interior finish, structure, and ceiling; or floor slab, ceiling finish, and floor finish).

If material salvaged from off-site will replace all or a part of an existing layer, count the existing surface area as the area of the entire existing layer. That is, the reused area equals the surface area of the installed salvaged material. Example:

- An existing building has a 100,000-square-foot carpeted floor, of which 90,000 square feet will be removed and replaced with new carpet and 10,000 square feet will be removed and replaced with salvaged wood. The entire surface area of the existing finished floor (100,000 square feet) goes in the denominator, but only the salvaged 10,000 square feet can contribute to the numerator, resulting in 10% reuse for that particular layer (floor finish).

If the salvaged material is a new layer in an assembly, then only the surface area of the installed salvaged material is used for both the existing and reused surface areas in the calculation. Example:

- An existing building has a 100,000-square-foot concrete structural slab, of which 90,000 square feet will be stained as the finished floor. The remaining 10,000 square feet of floor area will be salvaged wood. The surface area of the salvaged wood is used in the denominator as the existing area (10,000 square feet) and the same area is used in the numerator for reuse (10,000 square feet), resulting in 100% reuse.

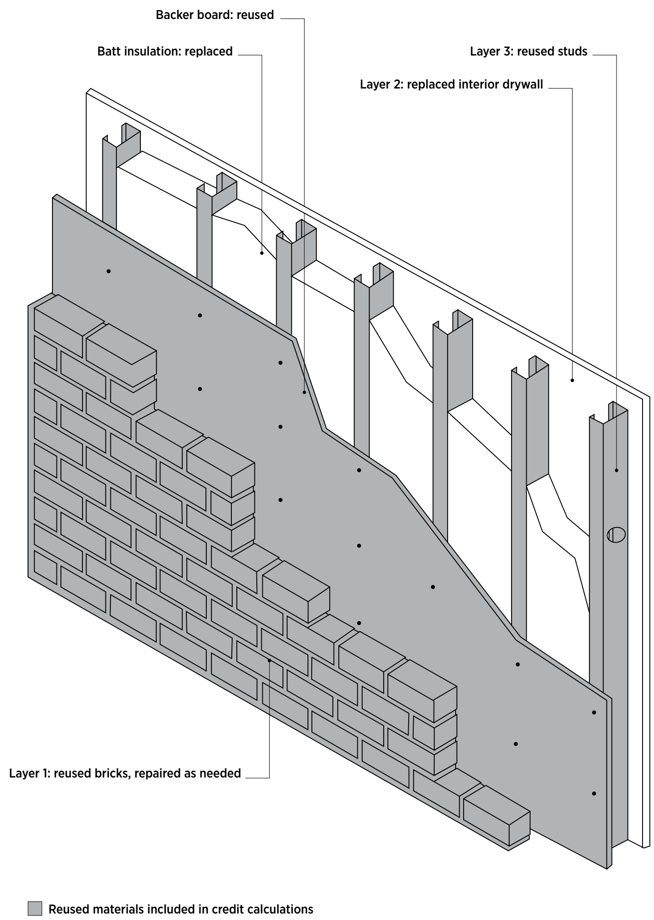


Figure 2. Example of surface area reuse calculations using wall assembly layers

PRODUCT REPLACEMENT

An LCA for this credit uses an assumed building service life of at least 60 years—long enough to capture the replacement cycle of enclosure materials, such as roof systems and curtain walls, but short enough that its basic structure is unlikely to be replaced. Replacement schedules for each product or assembly must reflect their service life and the consequent number of replacements required over the building's assumed service life.

Develop a consistent approach to quantifying the service life of individual products and assemblies, using manufacturers' warranties or empirical data. If the service life of a product is less than 60 years, include the aggregate impacts associated with the number of product replacements necessary to equal the building's service life. For example, if the expected life of a component is 20 years, multiply the impacts by 3 to accurately capture the cumulative effects of the product over the building's assumed 60-year lifetime.

If the service life of a product used in initial construction is greater than the building's assumed service life, the impacts associated with the product may not be discounted to reflect its remaining service life.

Some LCA design tools include service life assumptions and calculations that reflect the approach required for this credit. Check the service life assumption to ensure that it meets the credit requirements.

CREATING THE BASELINE BUILDING

The baseline building design shall be a design that exhibits industry-standard materials and practices for a building that meets the functional requirements of the project. The actual design should demonstrate a design that deviates from those industry-standard materials and practices – for example, the use of lower-impact materials or dematerialization, or a system not commonly used in that application.

The baseline building design can be derived in a variety of ways. Regardless of the approach, care should be taken to ensure that the baseline and actual designs are functionally equivalent. Four basic options for creating the baseline design are as follows.

1. Early design: an early design for the building under study. Documentation should include the draft plans and any modifications necessary to ensure functional equivalence.
2. Existing building: a real-world benchmark. Documentation should include the as-built plans and any modifications necessary to ensure functional equivalence.
3. Building archetype: similar to an existing building, but is a designed-but-unconstructed building. Documentation should include the draft plans and any modifications necessary to ensure functional equivalence.
4. Alternative design: A design that is based on the actual design, but is more reflective of industry-standard material and practices. Documentation should include a description of where the alternative design differs from the actual design with justifications as appropriate. Justifications can be in the form of product-specific EPDs compared against industry-average EPDs; other justifications can be used as needed.

1. Identify the baseline building early in the design process, when the basic project scope has been determined, create the baseline building with which the team will compare design alternatives.

Define the wall, roof, and floor assemblies following the performance requirements of the building envelope as defined in ASHRAE 90.1–2010, Appendix G, Opaque Assemblies, Vertical Fenestration, Skylights, and Roof Solar Reflectance and Thermal Emittance sections, for the project's climate zone. (For projects outside the U.S., see *Further Explanation, International Tips*.)

For this credit, the total area of exterior walls, floors and roofs may differ between the baseline building and the proposed building to account for differing proportions or geometry.

2. Input the baseline building into the chosen tool. Once the baseline building is complete, input the design into the selected tool to estimate the benchmark environmental impacts. Save the baseline building model as a separate LCA project so that the results will be available for comparison with the proposed building and for submission to USGBC.

As the design process proceeds, the baseline building can be modified, modeled, and saved as new LCA versions so that the team can compare the embodied impacts of design alternatives. While iterations of the LCA model may occur during construction, it is not expected that the documentation for the credit be updated after it has been submitted to USGBC.

3. Customize the baseline building for the project to create the proposed building. Modify the initial baseline building design to reduce the environmental effects while meeting the specific needs of the project, but keep the following parameters the same so that the baseline and proposed models can be accurately compared:

- LCA scope requirements. The functional unit and system boundary must be identical for the baseline and proposed buildings.
- Size. The gross floor area of the baseline and proposed buildings must be the same. The two designs can have different massing, provided the gross area is the same.
- Function. The baseline and proposed buildings must serve the same programmatic function. If the project is a mixed-use residential building with retail in the first floor, the baseline building must have the same program, but the elements can be in different locations in the building. If the project is a hospital with stringent air quality and humidity control, both the baseline and the proposed cases must meet those functional requirements.
- Orientation. The orientation—the directional exposure—of the baseline and proposed buildings must be the same, but the shape may differ. Orientation must be the same because exposure to the sun affects solar heat gain within the building and will skew LCA results for energy performance.
- Location. Both the baseline and the proposed buildings must be located in the same ASHRAE 90.1–2010 climate zone and assumed to be on the same site.
- Operating energy performance. The baseline and proposed buildings must meet EA Prerequisite Minimum Energy Performance by adhering to the requirements of ASHRAE 90.1–2010, Appendix G, Opaque Assemblies, Vertical Fenestration, Skylights, and Roof Solar Reflectance and Thermal Emittance sections, because

comparing an energy-efficient proposed building with an underperforming baseline building will skew the results. Increasing wall mass or insulation unnecessarily in the baseline building to show dematerialization in the proposed building is not acceptable. Energy modeling for either building is not required for this credit.

Other portions of the baseline building may be modified from the basic ASHRAE 90.1 requirements to capture the LCA goals of the project team.

SMALL SCALE REUSE

The reuse of building materials can be accounted for in Option 4 - Whole Building Life Cycle Assessment. Typically, projects pursuing large-scale reuse of buildings and materials may pursue other options in this credit - most of which offer more points than Option 4. However, small-scale reuse of materials can be accounted for in this credit along with the project team's other strategies to reduce the life cycle impacts of the building materials. Essentially, the reuse of building materials removes the initial "one time" raw resource extraction and manufacturing stages (A1-A3) from the Proposed building's impact.

The majority of available LCA material or whole building tools do not directly support the modeling of salvaged materials. Therefore, project teams should follow the following steps to account for small-scale material reuse in whole building LCA modeling.

5. Model all materials as "new" in the Baseline building
6. Model all materials as "new" in the Proposed building along with other materials impact reduction strategies being pursued for this credit.
7. Determine the amount of salvaged material that will be used on the project. Be sure to account for losses that tend to occur in repurposing products for a new building. For instance, if one can expect a 5% loss in materials in order to repurpose them, the material quantity used in the next step should only be 95% of what is installed in the building.
8. Using the same LCA tool as above, model only the reused materials for the proposed building and save the environmental impact results from stages of raw material extraction, transportation, and manufacturing (A1-A3) impacts only. Generate and save this information as a separate model file if the tool requires one to do so.
9. Subtract the results of Step 4 from Step 2 to obtain a final result for the proposed building.

Creating the baseline building using an early design for the building (Option #1 above) is recommended. Using LCA tools in the early design phase allows teams to more easily identify material impacts reduction strategies and document their LCA modeling work for this credit. Below is a stepwise approach to creating and refining the baseline building in early design.

LCA TOOLS SELECTION

This credit does not require design professionals to become LCA experts, but the choice of tool can determine whether an LCA specialist is required. Every LCA tool is populated with background data sets that form the basis of the assessment. Some LCA data are specific to the location of the building construction or the location of product manufacture because of the region's electric grid, for example. Different types of tools require varying levels of data set manipulation. There are two types of tools to consider.

Design team LCA tools simplify and streamline the LCA process for non-LCA practitioners. They manage the data and calculations in the background and do not allow the user to add or customize data. The user inputs material selections consistent with the building design and can then explore the environmental effects of design modifications by changing materials, floor area, or other aspects of the building.

Design team LCA tools have calculation factors specific to the country or region for which they were designed. Examples include the following:

- North America: ATHENA® Impact Estimator, athenasmi.org/our-software-data/impact-estimator/. This tool can import a bill of materials from a CAD system.
- United Kingdom: Envest 2, envest2.bre.co.uk/
- Australia: LCADesign. This tool can import a bill of materials from a CAD system.

LCA practitioner tools require the user to select the appropriate data sets and calculation factors. They typically conduct LCAs on a product-by-product basis and may require different methodological decisions for the products being examined. The practitioner then aggregates the results to the whole building level. Examples include the following:

- SimaPro, simapro.co.uk/
- GaBi, gabi-software.com/america/index/

Project teams that choose LCA practitioner tools will likely need to bring in an LCA specialist.

LIFE CYCLE IMPACT MEASURES OR INDICATORS

The impacts measured in LCA are divided into two categories, as described in ISO 21930–2007, which deals with EPDs for building products. Impacts are either expressed in terms of the categories of life-cycle impact assessments (LCIA) or derived from a life-cycle inventory (LCI) and not assigned to impact categories.

LCIA is an additional step in analysis that interprets and quantifies the resulting ecological effects of resources used and waste emitted over the life-cycle of the product. In contrast, LCI simply quantifies flows in and out of the process in terms of resources used and depleted and waste created.

The first five measures specified in the credit requirements are impact categories of LCIA; they are the only LCIA categories cited in ISO 21930. Other LCIA measures are in use or being developed (e.g., human health and ecotoxicity measures) but are less quantifiable than the measures required for LEED, although they may be reported separately. Other impact assessment methods not listed in Table 4 may be used if the reasons are justified and documented.

The sixth measure in the list, depletion of nonrenewable energy resources, is in the second category because it is derived directly from the LCI (defined in the ISO standard as “phase of life-cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life-cycle”).

Several other LCI aggregations are cited in ISO 21930 (e.g., depletion of nonrenewable material resources, use of renewable materials, and consumption of freshwater). These additional measures have not been included in the credit for the sake of simplicity. Teams may take these indicators into account in the LCA but are not required to submit them to meet the credit requirements.

For all the measures listed in Table 4 except depletion of nonrenewable energy resources, the software tool categorizes emissions and then applies characterization factors to create equivalence measures in the units shown in the table.

- In design team LCA tools, the characterization factors for the country or region are automatically generated.
- In LCA practitioner tools, the user must select the characterization factors and corresponding units for the country or region.

North American projects typically use the U.S. Environmental Protection Agency’s TRACI (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts) system. Projects in other parts of the world use the CML (Institute of Environmental Sciences) or ReCiPe system.

The impact assessment method must be no older than the most current version available on the LEED project registration date:

- TRACI, version 2.1 or newer
- CML, version 2001–November 2012 or newer
- ReCiPe, version 1.07 (midpoints) or newer

If these versions are not available in the chosen LCA tool, the project team must explain and justify the use of an alternative. Other impact assessment methods are available. If the chosen LCA tool offers options, the project team should weigh their pros and cons and choose the most appropriate method.

The same assessment method must be used for the baseline and proposed buildings.

For the purposes of complying with this credit, *depletion* means “the amount used,” as opposed to more complex measures involving calculation of the amount used relative to existing physical or economic reserves.

DEVELOPING AN LCA NARRATIVE

The narrative required for Option 4 must describe the LCA assumptions, scope, baseline building, and proposed building. Include the following:

- Life-cycle impact assessment summary, showing outputs of the baseline and proposed building
- Table showing the percentage change for all impact indicators between the baseline and proposed buildings. Describe the differences between the buildings that resulted in those changes.
- Description of the data sets used to represent each material or assembly (proxies may be deemed acceptable)
- Confirmation that the same data sets were used for both the baseline and proposed buildings and their materials and assemblies
- Description of the characterization model used (e.g., TRACI) for all impact category characterization factors
- The service life assumed for the baseline and proposed buildings
- Source of data for product replacement for both the baseline and proposed buildings

EXAMPLE

TABLE 5. Sample table of values based on LCA example report

LCA impact indicators	Total value (using TRACI)
Global warming potential	1,131,284.39 kg CO_2e
Acidification potential (land)	22,382,422 kg H+ moles eq
Eutrophication potential (fresh water)	83.676 kg N eq
Ozone depletion potential	.062 kg CFC-11-eq

RATING SYSTEM VARIATIONS

Healthcare

Materials demolished to create a courtyard may be excluded from calculations for Options 1, 2, and 3. This situation is treated the same as materials demolished and not replaced (see *Further Explanation, Calculating Surface Area*).

PROJECT TYPE VARIATIONS

Existing Buildings with Additions

Project teams may pursue only one option. For an existing building with an addition, the team can pursue either a reuse option (Option 1, 2, or 3) for the existing portions of the building or the LCA option (Option 4) for the new construction addition. In most cases, more points are available for reuse options, but the project team may determine the appropriate option given their sustainability goals.

INTERNATIONAL TIPS

Option 1. Historic Building Reuse

Projects outside the U.S should consult the historic preservation guidelines set forth in the local or national registry of historic places. Many countries have established their own process for determining historic significance of a structure or building. If the project is in a country without a process for determining the historic status of a building, project teams are encouraged to consult the UNESCO website (whc.unesco.org/en/conventiontext) or the Venice Charter (icomos.org/charters/venice_e.pdf) to determine historical significance.

Option 4. Whole-Building Life-Cycle Assessment

For projects outside the U.S. pursuing this option, the baseline building is based on ASHRAE 90.1–2010. The purpose of this requirement is to provide a minimum set of guidelines regarding the performance of the structure and enclosure being studied in the LCA. Projects outside the U.S. are expected to develop a baseline building representing typical construction for their region meeting local applicable building performance requirements. Additional documentation may be needed to demonstrate how the baseline building meets the requirements of the credit.

For European projects, EN standard 15978 may be used as framework for the Life-Cycle-Assessment. Where implementation of EN 15978 conflicts with any of requirements of this credit, the credit requirements prevail, including the life-cycle stages required and treatment of EPD data (See Further Explanation - Incorporation of EPD data in WBLCA Tools). Note that the CML indicators are acceptable per the Further Explanation section of the Reference Guide language of this credit.

CAMPUS

Group Approach
Option 1. Submit separate documentation for each building.
Option 2. Submit separate documentation for each building.
Option 3. All buildings in the group may be documented as one.
Option 4. All buildings in the group may be documented as one. Although each building will need to be modeled separately, each with a baseline and proposed building, the end results may be aggregated across multiple buildings.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3	Option 4
Documentation of historic designation status	X			
Narrative describing demolition (if any)	X			
Documentation of how additions and alterations (if any) meet local review board requirements	X			
Narrative describing abandoned or blighted status		X		
Reused elements table and calculations		X	X	
Description of LCA assumptions, scope, and analysis process for baseline building and proposed building				X
Life-cycle impact assessment summary showing outputs of proposed building with percentage change from baseline building for all impact indicators.				X

RELATED CREDIT TIPS

LT Credit High-Priority Site. Buildings located in a historic district and in an infill site qualify for Option 1 of the related credit.

MR Prerequisite Construction and Demolition Waste Management Planning and MR Credit Construction and Demolition Waste Management. If a project cannot meet the credit's reuse requirements, on-site salvaged materials may count as diversion for this prerequisite and credit.

MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials. Salvaged materials (structural and nonstructural, on-site or off-site) may contribute toward achieving Options 1–3 of this credit or Option 2 of the related credit, depending on which credits the project is pursuing and which calculation makes more sense (surface area versus cost). However, materials may not be double-counted under both credits.

MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations and MR Credit Building Product Disclosure and Optimization—Material Ingredients. These related credits address the ecological and human health consequences of construction materials.

CHANGES FROM LEED 2009

- MR Credit Building Life-Cycle Impact Reduction is a combination of two LEED 2009 credits: MR Credit Building Reuse—Maintain Walls, Floor and Roof and MR Credit Building Reuse—Maintain Interior Nonstructural Elements.
- MR Credit Building Life-Cycle Impact Reduction,Option 3. Building and Material Reuse may incorporate both structural and nonstructural elements as long as they are not double-counted in MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, Option 2, Leadership Extraction Practices.

REFERENCED STANDARDS

ISO 14044: iso.org/

National Register of Historic Places: nrhp.focus.nps.gov/

Secretary of Interior's Standards for the Treatment of Historic Properties: nps.gov/ and nps.gov/hps/tps/standguide/

EXEMPLARY PERFORMANCE

Option 1. Not available.

Option 2. Not available.

Option 3. Reuse 95% of the building.

Option 4. Achieve any improvement over the required credit thresholds in all six impact measures.

DEFINITIONS

abandoned property property left behind intentionally and permanently when it appears that the former owner does not intend to come back, pick it up, or use it. One may have abandoned the property of contract rights by not doing what is required by the contract. However, an easement and other land rights are not abandoned property just because of nonuse. Abandoned land is defined as land not being used at the present time but that may have utilities and infrastructure in place.

cultural landscape an officially designated geographic area that includes both cultural and natural resources associated with a historic event, activity, or person or that exhibits other significant cultural or aesthetic values

enclosure the exterior plus semi-exterior portions of the building. Exterior consists of the elements of a building that separate conditioned spaces from the outside (i.e., the wall assembly). Semiexterior consists of the elements of a building that separate conditioned space from unconditioned space or that encloses semi-heated space through which thermal energy may be transferred to or from the exterior or conditioned or unconditioned spaces (e.g., attic, crawl space, basement).

furniture and furnishings the stand-alone furniture items purchased for the project, including individual and group seating; open-plan and private-office workstations; desks and tables; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted visual-display products (e.g., marker boards and tack boards, excluding electronic displays); and miscellaneous items, such as easels, mobile carts, freestanding screens, installed fabrics, and movable partitions. Hospitality furniture is included as applicable to the project. Office accessories, such as desktop blotters, trays, tape dispensers, waste baskets, and all electrical items, such as lighting and small appliances, are excluded.

hazardous material any item or agent (biological, chemical, physical) that has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors

historic building a building or structure with historic, architectural, engineering, archeological, or cultural significance that is listed or determined to be eligible as a historic structure or building, or as a contributing building or structure in a designated historic district. The historic designation must be made by a local historic preservation review board or similar body, and the structure must be listed in a state register of historic places, be listed in the National Register of Historic Places (or a local equivalent outside the U.S.), or have been determined eligible for listing.

historic district a group of buildings, structures, objects, and sites that have been designated as historically, architecturally, or culturally significant and categorized as either contributing or noncontributing

life-cycle assessment an evaluation of the environmental effects of a product from cradle to grave, as defined by ISO 14040–2006 and ISO 14044–2006

life-cycle inventory a database that defines the environmental effects (inputs and outputs) for each step in a material's or assembly's life cycle. The database is specific to countries and regions within countries.

service life the assumed length of time that a building, product, or assembly will be operational for the purposes of a life-cycle assessment

structure elements carrying either vertical or horizontal loads (e.g., walls, roofs, and floors) that are considered structurally sound and nonhazardous

MATERIALS AND RESOURCES CREDIT

Building Product Disclosure and Optimization— Environmental Product Declarations

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.

REQUIREMENTS

Achieve one or more of the options below, for a maximum of 2 points.

OPTION 1. ENVIRONMENTAL PRODUCT DECLARATION (EPD) (1 POINT)

Use at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the disclosure criteria below.

- Product-specific declaration.
    - Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one quarter (1/4) of a product for the purposes of credit achievement calculation.
- Environmental product declarations which conform to ISO 14025 and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
    - Industry-wide (generic) EPD – Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator are valued as one half (1/2) of a product for purposes of credit achievement calculation.
    - Product-specific Type III EPD – Products with third-party certification (Type III), including external verification in which the manufacturer is explicitly recognized as the participant by the program operator are valued as one whole product for purposes of credit achievement calculation.
- USGBC approved program – Products that comply with other USGBC approved environmental product declaration frameworks.

OPTION 2. MULTI-ATTRIBUTE OPTIMIZATION (1 POINT)

Use products that comply with one of the criteria below for 50%, by cost, of the total value of permanently installed products in the project. Products will be valued as below.

- Third party certified products that demonstrate impact reduction below industry average in at least three of the following categories are valued at 100% of their cost for credit achievement calculations.
    - global warming potential (greenhouse gases), in CO_2e;
    - depletion of the stratospheric ozone layer, in kg CFC-11;
    - acidification of land and water sources, in moles H+ or kg SO_2;
    - eutrophication, in kg nitrogen or kg phosphate;
    - formation of tropospheric ozone, in kg NO_x, kg O3 eq, or kg ethene; and depletion of nonrenewable energy resources, in MJ.
- USGBC approved program – Products that comply with other USGBC approved multi-attribute frameworks.

For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost.

Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Projects with significant amounts of structural and enclosure materials may exceed the 30% limit by calculating an alternative structure and enclosure limit (See Equation 3 under Further Explanation).

BEHIND THE INTENT

This credit recognizes the selection of products for which the environmental impacts are well known because of industry standard life-cycle information and reporting protocols. Environmental product declarations (EPDs) are a standardized way of communicating the environmental effects associated with a product or system's raw material extraction, energy use, chemical makeup, waste generation, and emissions to air, soil, and water. Although a variety of EPD programs exist, the credit requires that EPDs come from program operators who follow the International Organization for Standardization (ISO) standards, the internationally recognized norm for EPDs. Project teams using EPDs can more accurately compare and evaluate similar products, improving their decisions when selecting materials.

As EPDs become commonplace, this credit will recognize the most advanced disclosures available. Giving preference to products with EPDs supports the transition from a "single-attribute" approach to one that relies on more comprehensive reporting and rewards manufacturers whose products are less harmful to the environment.

The diversity of options and compliance paths in this credit is designed to reward both initial first steps and leadership in life-cycle information disclosure. The credit intends to help transform the market for building products and materials for which life-cycle information is available and encourage manufacturers that have verified their environmental performance.

STEP-BY-STEP GUIDANCE

Select which option(s) to pursue. Products may contribute to both Options 1 and 2. Early product research can help the project team capitalize on opportunities for products contributing to multiple credits and options.

The required scope of this credit is permanently installed building products, excluding mechanical, plumbing, electrical, (MEP) and specialty equipment and items purchased for temporary use on the project. Furniture is not considered permanently installed and is not required to be included in the credit. However, furniture as well as other optional MEP products may be included, provided they are also included in the other two cost-based credits, MR Credit Building Disclosure and Optimization—Sourcing of Raw Materials and MR Credit Building Disclosure and Optimization—Materials Ingredients. For more information see *MR Overview, Qualifying Products and Exclusions*.

- Option 1 is for projects with products with product-specific declarations or industry-wide EPDs, or otherwise recognized USGBC-approved program. Products must be sourced from multiple manufacturers, as indicated in the credit requirements. Various thresholds are available to accommodate stages of EPD development in different industries. The weighted value of the product must meet the threshold indicated in the credit requirements.
- Option 2 is for projects with permanently installed products that come from manufacturers adhering to USGBC-approved programs that will certify verified reductions in the multiple impact categories listed in the credit requirements. USGBC will endorse specific third-party programs if their certifications are based on verified data. This information will be available on the USGBC website. The proportion of qualifying materials must meet the threshold indicated in the credit requirements and includes the weighted value of locally sourced products.

Option 1. Environmental Product Declaration (EPD)

STEP 1. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify products from manufacturers for which the available EPDs meet at least one of the credit criteria.

- Include performance requirements or sole-source compliant products as applicable to the selected option(s) in the project specifications. To ensure compliant purchases, consider creating a Division 1, General Requirements, specification for sustainability criteria that meet MR requirements. Reference that section to distinguish it from other sections that cover products and materials (see *Further Explanation, Environmental Product Declarations* and *Documentation of EPD's,* Figure 3).

- Environmental product declarations which conform to ISO 14025 and EN 15804 or ISO 21930 and have at least a cradle to gate scope.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction submittals to ensure that selected products meet credit requirements. To track progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Continually track substitutions and change orders during buy-out and installation to ensure that replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance.
- Because these requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. COUNT COMPLIANT PRODUCTS AND MATERIALS AND COMPILE DOCUMENTATION

With the data collected in a tracking tool or the calculator provided by USGBC, use Equation 1 (see *Further Explanation, Calculations*) to calculate the total number of products that comply with Option 1 requirements. This equation calculates compliance based on the number of products, not their cost.

- A product is the unit of purchase. The requirement for EPDs applies to the final unit of purchase—that is, entire assemblies, not individual components.
- Products with EPDs that meet more than one criterion are weighted at the highest valuation factor (not a combined factor).
- Collect all EPDs and life-cycle assessment (LCA) reports for contributing products for credit documentation. Ensure that EPD documentation includes a summary sheet of measured impacts.
- Retain product data for all materials that contribute to credit achievement and be prepared to provide it on request (see *Further Explanation, Documentation of Product-Specific Declarations* and *Further Explanation, Documentation of EPD's,* Figure 3).

Option 2. Multi-attribute Optimization

STEP 1. RESEARCH PRODUCTS

Identify products that meet one or more of the attributes listed in the credit requirements under Option 2.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

Collect documentation of environmental claims for each product expected to contribute toward credit achievement. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Request documentation via correspondence with the product's manufacturer or third-party certifying body.
- Continually track substitutions and change orders to ensure that the credit threshold will be met.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE COMPLIANCE

Purchase 50%, by cost, of permanently installed products that meet at least one of the requirements listed in Option 2. Calculate compliant materials using Equation 2 and the data collected in the tracking tool (see *Further Explanation, Calculations*).

- Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Once the cap on structural material is met, these products can no longer contribute toward the credit but must be included in the denominator of Equation 2.

- Some products may meet multiple criteria or are part of assemblies (see *MR Overview, Determining Material Contributions*).
- Compile documentation to verify environmental claims for each product. Retain product data for all materials that contribute to credit achievement.

FURTHER EXPLANATION

CALCULATIONS

EQUATION 1. Total number of products with environmental product declarations

$$\text{Total \# of products} = \left\{ \text{\# of products with product specific declarations} \times 0.25 \right\} + \left\{ \text{\# of products with industry specific declarations} \times 0.5 \right\} + \left\{ \text{\# of products with type III EPD} \times 1 \right\}$$

EQUATION 2. Percentage of multi-attribute optimization materials cost

$$\text{\% of materials cost} = \frac{\left\{ \text{product}_1 \text{ cost} \left(\text{criterion valuation factor} \right) \left(\text{location valuation factor} \right) \right\} + \left\{ \text{product}_2 \text{ cost} \left(\text{criterion valuation factor} \right) \left(\text{location valuation factor} \right) \right\} + \ldots}{\text{Cost of all permanently installed prodcuts}} \times 100$$

where

- Product cost = cost of the product contributing toward credit. For assemblies, the cost amount contributing toward credit is based on weight (see *MR Overview, Determining Product Cost*).
- Criterion valuation factor = weighting multiplier for the criterion. This factor will be determined for each certification that becomes available.
- Location valuation factor = multiplier for the extraction, manufacture, and purchase location (see *MR Overview, Location Valuation Factor*).

Equation 3: Alternative Structure & Enclosure Percentage Limit for Option 2

For projects with significant amounts of structure and enclosure materials, the following calculation can be made to determine an alternative limit for the percentage of value that structure and enclosure materials can contribute to credit achievement. Note: this option is only available for projects that use the actual materials cost method (not the default cost method) to determine total project material costs.

EQUATION 3: Alternative Structure and Enclosure limit

$$\text{Alternative Structure and Enclosure limit} = \frac{\text{value \$ of total building materials that are structural or enclosure}}{\text{total actual materials value \$}}$$

Use the results of equation 3 to replace the 30% contribution factor limit in determining compliance with the credit.

ENVIRONMENTAL PRODUCT DECLARATIONS

An EPD is a standardized way of communicating the environmental impacts, such as global warming potential and energy resource depletion, of a product or system. A product category rule (PCR) defines how to standardize this information for a specific product type, such as flooring. The PCR defines scope, system boundary, measurement procedures, impact measures and other technical requirements.

PCR development is the responsibility of the EPD Program Operator and is often organized through standards organizations or industry associations or sponsored by private or government organizations. Many countries maintain lists of PCRs that are publicly available; private Program Operators have PRCs on their websites:

- China EPD program, sepacec.com/cecen
- Japan Ecoleaf program, ecoleaf-jemai.jp/eng
- International EPD system, environdec.com/en/Product-Category-Rules/
- Institut Bauen und Umwelt (Institute Construction and Environment), bau-umwelt.de
- Norway EPD system, epd-norge.no
- Taiwan EPD system, pcr-library.edf.org.tw/product_country/taiwan.asp
- Korean EPD system, eng.keiti.re.kr
- UL Environment EPD system, ul.com/global/eng/pages/offerings/businesses/environment/services/certification/epd/
- Global Environmental Declaration network, gednet.org

Because an EPD must have a corresponding PCR to contribute to this credit, project teams might find it useful to research EPDs by finding out whether a PCR exists for a product type, and if so, the entity that created it. The entity that created the PCR is likely to have used it to create an EPD.

In Option 1 Environmental Product Declaration, different thresholds are designed to accommodate varying levels of development of EPDs across industries. For example, the flooring industry has an established PCR, and as a result, several carpet and resilient flooring companies now provide EPDs. In industries without established PCRs, some manufacturers provide life-cycle assessments in accordance with ISO. The credit-calculated value for an ISO 14040/44 LCA is lower, to encourage manufacturers to work through their industry associations to develop PCRs, which allow more accurate comparisons between products in similar categories. Generic EPDs are a good starting point for manufacturers; they provide a baseline of information for a specific product category, but are not specific to a company or manufacturing plant.

Product-specific declarations are publicly available and critically reviewed (but not necessarily verified) by a third party to ensure that they conform to ISO 14044, which defines how LCAs are critically reviewed.

Industry-wide (generic) declarations have third-party (Type III) certification, which includes verification. The declaration is generic to a product, such as concrete, not specific to a particular manufacturer or company. For the product to be eligible, the manufacturer must claim representation either directly on the EPD or through the Program Operator for the associated EPD.

Product-specific Type III declarations also use third-party certification that includes verification. Unlike generic EPDs, however, product-specific declarations are specific to a particular manufacturer and do not necessarily reflect the practices of the rest of the industry.

A Type III EPD uses data from a life-cycle assessment (LCA) and is defined by the PCR so that all EPDs for a product are comparable. LCA data can also be aggregated to produce a representative EPD of several products in the same family (type). ISO has developed several standards regarding independent verification of quantitative data (the LCA), PCR development, and EPD review and publication. EPDs can be found on manufacturers' websites or the program operator's website or can be requested from the manufacturer.

For this credit, the scope of any EPD must be at least cradle-to-gate—that is, it must cover the part of a product's life cycle from extraction ("cradle") and material processing to creation of the final product ready for sale by the manufacturer ("gate"); it excludes transportation from the factory to distributors or end customers. EPDs that cover only manufacture ("gate to gate") do not contribute toward the credit.

All EPDs must be consistent with ISO standards 14025, 14040, 14044, and EN 15804 or ISO 21930. These standards address how to set up and perform LCA, how LCA feeds into an EPD, and the appropriate level of detail and content to be included in an EPD (see *Referenced Standards*).

For products not included in EN 15804 or the superseded ISO 21930 (i.e., furniture and other items not considered building products), conformance to ISO 14025 only is acceptable.

EN 15804 is a European standard for PCR development. Products using EN 15804 in North America are expected to adapt regionally specific aspects of the EN standard for North America. Declaration Holders should work with the Program Operator to perform these adaptations.

To contribute to the credit threshold, the EPD must include statements of compliance with a specific PCR and compliance with the ISO standards.

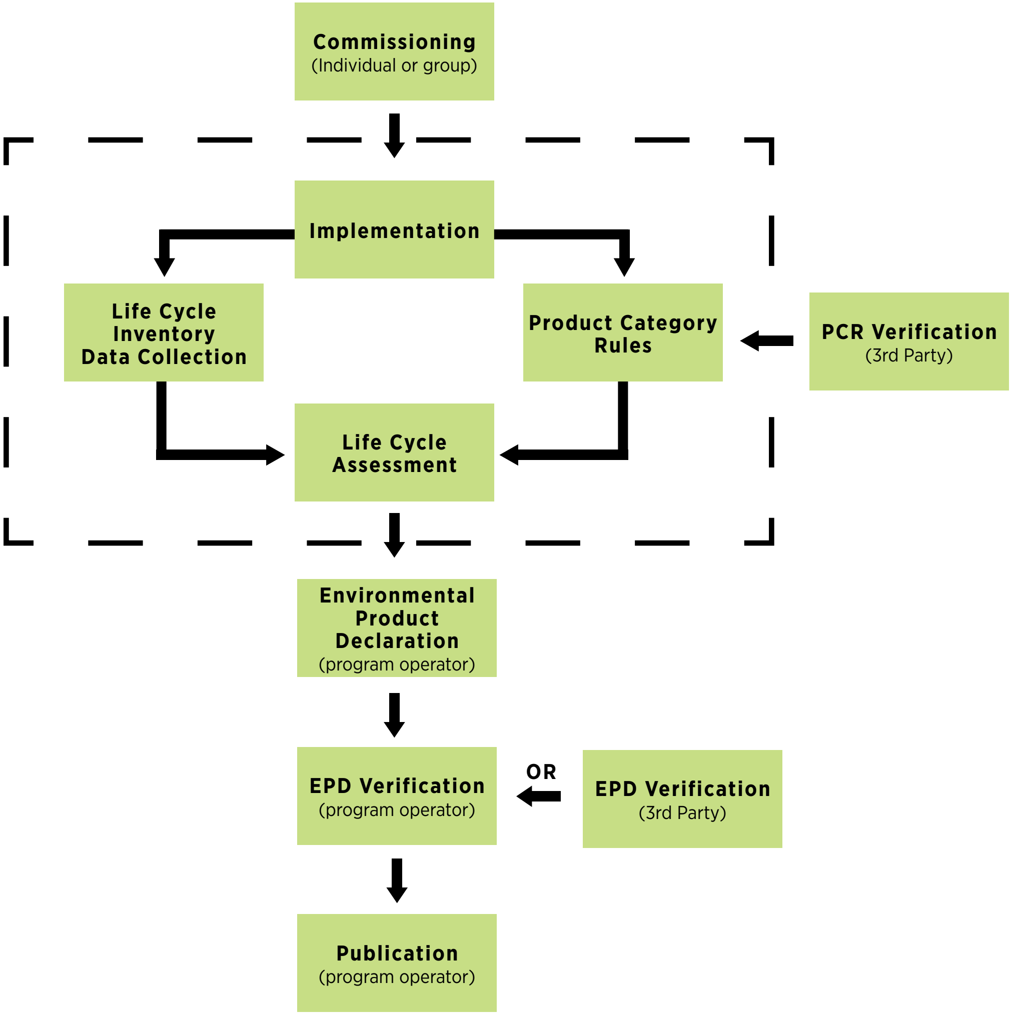


Figure 1. EPD process

TABLE 1. EPD process comparison

	Product-specific declaration	Industry-wide EPD	Product-specific EPD
Data are critically reviewed	X	X	X
Data are specific to product	X		X
Data are reported according to PCR		possibly	X

For a manufacturer, the EPD process is as follows:

1. A manufacturer searches for existing product category rules for its product category (aka the product type) see list above for regional entities that maintain PCR libraries. If a PCR does not exist, manufacturers work with a program operator to convene a group and develop product category rules for the product type. This process includes a proposal, draft creation, open consultation, panel review, and approval and publication of product category rules.
2. The manufacturer conducts a life-cycle assessment, based on the product's goals and functional unit, global warming potential, primary energy demand, contribution to acidification and eutrophication, and other environmental indicators.

3. The manufacturer creates the EPD using this information and initiates verification by a third party, which determines whether the LCA followed the correct ISO processes and the EPD was created according to the PCR.
4. The manufacturer registers the declaration with a program operator, which verifies the EPD according to ISO standards. Examples of program operators include UL Environmental, ICC-ES, ASTM, NSF, FP Innovations, and the Institute for Environmental Research and Education.

DOCUMENTATION OF PRODUCT-SPECIFIC DECLARATIONS

Product-specific declarations are defined for this credit as declarations that are based on a life-cycle assessment of a product but not constituting a full EPD. To document this claim, the project team must provide the following information:

- Name (declaration holder or producer, typically the manufacturer)
- Contact information
- Product type
- Product name
- Product description
- Summary of impact categories measured and overall values
- Functional unit
- Standards met
- Independent review entity's name and statement

DOCUMENTATION OF EPDS

For industry-wide (generic) declarations and product-specific Type III declarations, the project team must provide the following:

- Declaration holder (the company, usually the manufacturer, that the EPD is attributed to)
- EPD program operator (the entity that creates and registers the EPD)
- LCA verifier (the third-party entity that verifies the life-cycle assessment)
- PCR reviewer (the third-party entity that has reviewed the product category rules)

During the selection of products with EPDs, identify two items about the document: the type of EPD it is, and the summary that will be uploaded for credit compliance. Figure 2 illustrates an EPD created by Interface Flor for Type 6 Nylon with GlasBac.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	Interface
DECLARATION NUMBER	110919.11CA29311.101.1
DECLARED PRODUCT	Modular carpet with recycled solution dyed Nylon 6 yarn on GlasBac® backing manufactured by Interface in Lagrange, Georgia USA.
REFERENCE PCR	PCR-Floorcoverings Harmonised Rules for Textile, Laminate and Resilient Floor Coverings
DATE OF ISSUE	September 19, 2011
PERIOD OF VALIDITY	5 years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications
The PCR review was conducted by:	Insitut Bauen und Umwelt e.V Accepeted by the Advisory board Rheinufer 108 53639 Königswinter Germany info@bau-umwelt.com
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☒ EXTERNAL	Loretta Tam
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	Eva Schmincke

This EPD is for a single product

This EPD has a reviewed PCR

This EPD was performed according to ISO 14044

Figure 2. Example of EPD that meets requirements of Type III. Used with permission from Interface.

Such a summary is preferable to the full document, provided it includes the following:

- Name (declaration holder, the producer or group of producers; each producer must be listed to claim the credit)
- Program operator
- Contact information
- Product type
- Product name
- Product description
- Product category rule (title)
- Certification period
- Declaration number
- Summary of impact categories measured and overall values
- Functional unit
- Standards met
- Independent verification body (may be the same as the program operator)

UL CERTIFIED ENVIRONMENTAL PRODUCT DECLARATION

EPD **Transparency Brief**

COMPANY NAME	**InterfaceFLOR**
PRODUCT TYPE	**Modular Carpet Tile**
PRODUCT NAME	Modular Carpet on GlasBac® Nylon 6 Styles
PRODUCT DEFINITION	Modular carpet with recycled solution dyed Nylon 6 yarn face cloth combined with GlasBac® backing. The products are manufactured by InterfaceFLOR in LaGrange, Georgia USA.
PRODUCT CATEGORY RULE (PCR)	**PCR-Floorcoverings** Harmonised Rules for Textile, Laminate and Resilient Floor Coverings
CERTIFICATION PERIOD	**September 19, 2011 - September 19, 2016**
DECLARATION NUMBER	**110919.11CA29311.101.1**

LIFECYCLE IMPACT CATEGORIES

The environmental impacts listed below were assessed throughout the product's lifecycle – including raw material extraction, transportation, manufacturing, packaging, use, and disposal at end of life.

	ATMOSPHERE			WATER		EARTH	
	Global Warming Potential refers to long-term changes in global weather patterns – including temperature and precipitation – that are caused by increased concentrations of greenhouse gases in the atmosphere.	**Ozone Depletion Potential** is the destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation that's harmful to life, caused by human-made air pollution.	**Photochemical Ozone Creation Potential** happens when sunlight reacts with hydrocarbons, nitrogen oxides, and volatile organic compounds, to produce a type of air pollution known as smog.	**Acidification Potential** is the result of human-made emissions and refers to the decrease in pH and increase in acidity of oceans, lakes, rivers, and streams – a phenomenon that pollutes groundwater and harms aquatic life.	**Eutrophication Potential** occurs when excessive nutrients cause increased algae growth in lakes, blocking the underwater penetration of sunlight needed to produce oxygen and resulting in the loss of aquatic life.	**Depletion of Abiotic Resources (Elements)** refers to the reduction of available non-renewable resources, such as metals and gases, that are found on the periodic table of elements, due to human activity.	**Depletion of Abiotic Resources (Fossil Fuels)** refers to the decreasing availability of non-renewable carbon-based compounds, such as oil and coal, due to human activity.
TRACI	**7.81** kg CO2-Equiv.	**1.38E-06** kg CFC 11-Equiv.	**0.38** kg NOx-Equiv.	**1.86** mol H+ Equiv.	**0.0022** kg N-Equiv.		
CML	**7.82** kg CO2-Equiv.	**1.23E-06** kg R11-Equiv.	**0.005** kg Ethene-Equiv.	**0.038** kg SO2-Equiv.	**0.0038** kg Phosphate-Equiv.	**1.06E-05** kg Sb-Equiv.	

FUNCTIONAL UNIT One square meter of carpet, medium face weight (712 grams/square meter, 21 ounces/square yard). The use stage is for one year of carpet life. The reference flow is one square meter of modular carpet.

UL **Environment**

Figure 3. Sample EPD for carpet tile product. Used with permission from Interface.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
MR building product disclosure and optimization calculator or equivalent tracking tool	X	X
EPD and LCA reports or compliant summary documents for 100% of products contributing toward credit	X	
Documentation of compliance with USGBC-approved program		X

RELATED CREDIT TIPS

MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials. Locally sourced materials contributing to the credit may also contribute to this related credit if compliant harvesting or extraction can be confirmed.

MR Credit Building Product Disclosure and Optimization—Material Ingredients. Manufacturers whose products and materials have EPDs may report ingredients. Ensure that the level of detail reported meets the credit requirements. If the level of detail is sufficient, the product can contribute to both this credit and the related credit.

MR Credit Building Life-Cycle Impact Reduction. See MR Credit Building Life-Cycle Impact Reduction, *Further Explanation*, *Life Cycle Impact Measures or Indicators*, for more information on environmental impact measures included in Option 2 of this credit.

CHANGES FROM LEED 2009

- This is a new credit.
- Some materials excluded from MR credits in the past may now be included, such as mechanical fixtures, fittings, and rough-in materials that are considered nonmotorized MEP components.

REFERENCED STANDARDS

International Standard ISO 14021–1999, Environmental labels and declarations—Self Declared Claims (Type II Environmental Labeling): iso.org

International Standard ISO 14025–2006, Environmental labels and declarations (Type III Environmental Declarations—Principles and Procedures): iso.org

International Standard ISO 14040–2006, Environmental management, Life cycle assessment principles, and frameworks: iso.org

International Standard ISO 14044–2006, Environmental management, Life cycle assessment requirements, and guidelines: iso.org

CEN Comité Européen de Normalisation (European Committee for Standardization) EN 15804—2012 Sustainability of construction works, Environmental product declarations, Core rules for the product category of construction products: cen.eu

International Standard ISO 21930–2007 Sustainability in building construction—Environmental declaration of building products: iso.org

Federal Trade Commission, Guides for the Use of Environmental Marketing Claims, 16 CFR 260.7 (e): ftc.gov/bcp/grnrule/guides980427.htm

EXEMPLARY PERFORMANCE

Option 1. Source at least 40 qualifying products from five manufacturers.

Option 2. Purchase 75%, by cost, of permanently installed building products that meet the required attributes.

DEFINITIONS

cradle-to-gate assessment analysis of a product's partial life cycle, from resource extraction (cradle) to the factory gate (before it is transported for distribution and sale). It omits the use and the disposal phases of the product.

enclosure the exterior plus semi-exterior portions of the building. Exterior consists of the elements of a building that separate conditioned spaces from the outside (i.e., the wall assembly). Semiexterior consists of the elements of a building that separate conditioned space from unconditioned space or that encloses semi-heated space through which thermal energy may be transferred to or from the exterior or conditioned or unconditioned spaces (e.g., attic, crawl space, basement).

environmental product declaration a statement that the item meets the environmental requirements of ISO 14021–1999, ISO 14025–2006 and EN 15804, or ISO 21930–2007

life-cycle assessment an evaluation of the environmental effects of a product from cradle to grave, as defined by ISO 14040–2006 and ISO 14044–2006

product (permanently installed building product) an item that arrives on the project site either as a finished element ready for installation or as a component to another item assembled on-site. The product unit is defined by the functional requirement for use in the project; this includes the physical components and services needed to serve the intended function of the permanently installed building product. In addition, similar products within a specification can each contribute as separate products.

structure elements carrying either vertical or horizontal loads (e.g., walls, roofs, and floors) that are considered structurally sound and nonhazardous

MATERIALS AND RESOURCES CREDIT

Building Product Disclosure and Optimization—Sourcing of Raw Materials

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts. To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner.

REQUIREMENTS

OPTION 1. RAW MATERIAL SOURCE AND EXTRACTION REPORTING (1 POINT)

Use at least 20 different permanently installed products from at least five different manufacturers that have publicly released a report from their raw material suppliers which include raw material supplier extraction locations, a commitment to long-term ecologically responsible land use, a commitment to reducing environmental harms from extraction and/or manufacturing processes, and a commitment to meeting applicable standards or programs voluntarily that address responsible sourcing criteria.

- Products sourced from manufacturers with self-declared reports are valued as one half (1/2) of a product for credit achievement.
- Third-party verified corporate sustainability reports (CSR) which include environmental impacts of extraction operations and activities associated with the manufacturer's product and the product's supply chain, are

valued as one whole product for credit achievement calculation. Acceptable CSR frameworks include the following:

- **Global Reporting Initiative (GRI) Sustainability Report**
- **Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises**
- **U.N. Global Compact:** Communication of Progress
- **ISO 26000:** 2010 Guidance on Social Responsibility
- **USGBC approved program:** Other USGBC approved programs meeting the CSR criteria.

OPTION 2. LEADERSHIP EXTRACTION PRACTICES (1 POINT)

Use products that meet at least one of the responsible extraction criteria below for at least 25%, by cost, of the total value of permanently installed building products in the project.

- **Extended producer responsibility.** Products purchased from a manufacturer (producer) that participates in an extended producer responsibility program or is directly responsible for extended producer responsibility. Products meeting extended producer responsibility criteria are valued at 50% of their cost for the purposes of credit achievement calculation.
- **Bio-based materials.** Bio-based products must meet the Sustainable Agriculture Network's Sustainable Agriculture Standard. Bio-based raw materials must be tested using ASTM Test Method D6866 and be legally harvested, as defined by the exporting and receiving country. Exclude hide products, such as leather and other animal skin material. Products meeting bio-based materials criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
- **Wood products.** Wood products must be certified by the Forest Stewardship Council or USGBC-approved equivalent. Products meeting wood products criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
- **Materials reuse.** Reuse includes salvaged, refurbished, or reused products. Products meeting materials reuse criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
- **Recycled content.** Recycled content is the sum of postconsumer recycled content plus one-half the preconsumer recycled content, based on cost. Products meeting recycled content criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
- **USGBC approved program.** Other USGBC approved programs meeting leadership extraction criteria.

For credit achievement calculation, products sourced (extracted, manufactured, and purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the base contributing cost of individual products compliant with multiple responsible extraction criteria is not permitted to exceed 100% its total actual cost (before regional multipliers) and double counting of single product components compliant with multiple responsible extraction criteria is not permitted and in no case is a product permitted to contribute more than 200% of its total actual cost.

Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Projects with significant amounts of structural and enclosure materials may exceed the 30% limit by calculating an alternative structure and enclosure limit (See Equation 3 under Further Explanation).

BEHIND THE INTENT

Raw material extraction has a direct environmental impact on Earth's ecosystems. For example, conventional logging is the largest source of deforestation in Latin America and subtropical Asia, accounting for more than 70% of resource depletion; mining operations clear another 18% of the world's forests. Unmanaged extraction practices can cause not only deforestation but also degradation of water sources, habitat loss, threats to rare and endangered species, releases of toxic chemicals, and the infringement of indigenous peoples' rights.

This credit encourages the use of responsibly sourced and extracted materials through reporting and demonstration of responsible extraction practices. Corporate sustainability reports (CSRs), based on widely recognized frameworks and standards, can shed light on product supply chains and identify sources of raw material extraction. CSRs have become increasingly popular among all types of businesses, from retail organizations to product manufacturers. As sustainability goals become more prominent, CSRs provide frameworks that allow transparency and environmental impacts to be assessed, improved, and compared with other companies.

In addition to seeking the responsible sourcing of virgin materials, teams are also encouraged to reduce raw material usage by selecting reused and recycled materials. Teams may also follow leadership performance standards and certifications that encourage local sourcing. To recognize the rapidly changing marketplace conditions for product and material reporting, this credit has an additional "USGBC-approved program" criterion designed to recognize any leadership certification programs that may be developed in the future.

By increasing the demand for transparency in mining, quarrying, agriculture, forestry, and other industries, this credit rewards environmental impact reductions that go beyond the individual project and have positive effects on the sources of project materials.

STEP-BY-STEP GUIDANCE

Select which option(s) to pursue. Projects can earn a maximum of 2 points by achieving the requirements for both options, and products may contribute to both options simultaneously. Early product research can help the project team capitalize on opportunities for products contributing to multiple credits and options.

The required scope of this credit is permanently installed building products, excluding mechanical, plumbing, electrical, (MEP) and specialty equipment and items purchased for temporary use on the project. Furniture is not considered permanently installed and is not required to be included in the credit. However, furniture as well as other optional MEP products may be included, provided they are also included in the other two cost-based credits, MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations and MR Credit Building Product Disclosure and Optimization—Material Ingredients. For more information see *MR Overview, Qualifying Products and Exclusions*.

- Option 1 Raw Material Source and Extraction Reporting is for projects that have products consisting of materials from manufacturers that have reported sustainable sourcing and extraction methods according to an acceptable framework, as indicated in the credit requirements. Products must be sourced from the minimum number of manufacturers as specified in the credit requirements.
- Option 2 Leadership Extraction Practices is for projects that have products and/or constituent materials that meet at least one of the responsible extraction criteria listed in the credit.

Option 1. Raw Material Source and Extraction Reporting

STEP 1. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify products from manufacturers that can provide reports of raw materials from their suppliers.

- To meet the credit requirements, reports must include information on the following:
  - Raw material supplier extraction locations
  - Commitment to long-term ecologically responsible land use
  - Commitment to reducing environmental harms from extraction and manufacturing processes
  - Commitment to meeting voluntary standards or programs that address responsible sourcing

- The reports may be available in the form of a corporate sustainability report (CSR) (see *Further Explanation, Raw Material Reporting and Corporate Sustainability Reports*).
- Include performance requirements or sole-source compliant products as applicable to the selected option(s) in the project specifications. To ensure compliant purchases, consider creating a Division 1, General Requirements, specification for sustainability criteria that meet MR requirements. Reference that section to distinguish it from other sections that cover products and materials.
- Similar products from the same manufacturer can be counted as separate products if they have distinct formulations but not if they are aesthetic variations or reconfigurations (see *MR Overview, Defining a Product*).
- Research sourcing disclosure reports for contributing products. Third-party verified reports—also called externally assured reports—are counted at full value for credit compliance; self-declared reports are counted at half value. Retain all reports for credit documentation.
- For a material procured directly from a raw material supplier, such as timber from a forest products company or stone from a quarry, verify that any reporting meets the requirements.
- For a product made by a manufacturer that uses raw materials extracted by others, ask the manufacturer or supplier to provide documentation of compliant reporting.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

Track purchasing of products throughout the construction of the project. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator or an equivalent custom tool.

- The best source of documentation is the manufacturer or the organization that manages the reporting program. Reports are typically available online, but in some cases it might be necessary to contact a company representative. Documentation may also be available from third-party websites that compile the information of many companies in one place. Use formal correspondence to request CSRs or other documentation indicating that the required information has been disclosed if it is not readily available.
- Continually track substitutions and change orders to ensure that replacement products meet the credit requirements.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE COMPLIANT PRODUCTS AND MATERIALS AND COMPILE DOCUMENTATION

Using the data collected in the tracking tool, calculate the number of compliant products, using Equation 1 (see *Further Explanation, Calculations*).

- In this option, compliance is based on the number of products, not their cost.
- Collect sourcing disclosure reports. Retain the reports for all materials that contribute to credit achievement.

Option 2. Leadership Extraction Practices

STEP 1. RESEARCH PRODUCTS

Specify products that meet one or more of the criteria listed in the credit requirements.

- Different components or ingredients in an assembled product may contribute to different credit criteria.
- Each product, component, or ingredient that meets several criteria receives credit for each criterion met. For exceptions see *Further Explanation, Calculating FSC Credit Contributions.*

Review preliminary design concepts and identify opportunities to use and procure biobased, qualified wood as well as salvaged and recycled-content materials and products covered by extended producer responsibility, especially for applications that use either significant quantities of materials or small amounts of high-cost materials.

- The amount of biobased content in a product is determined by the manufacturer according to ASTM Standard D6866. Testing per ASTM Standard D6866 may be necessary to determine the fraction of biobased content if it cannot be determined by other means (see *Further Explanation, Documentation for Wood and Biobased Products*).

- Wood must be certified by the Forest Stewardship Council (FSC) unless it is considered reused, salvaged, or recycled. Look for vendors that hold an FSC chain-of-custody certificate. Material covered by both FSC and the Sustainable Agriculture Standard, such as nonwood forest products and bamboo, may be certified under either FSC or Sustainable Agriculture Network standards (see *Further Explanation, Materials Reuse Considerations*).
- Extended producer responsibility (also known as a closed-loop recycling program and as product take-back) puts a used product back into the production stream (see *Further Explanation, Extended Producer Responsibility*). The program can be sponsored by the product's manufacturer or other service.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction product submittals to ensure that the selected products meet credit requirements. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool regularly to track progress toward credit achievement.

- Continually track substitutions and change orders to ensure that replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance.
- Because these requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE PRODUCT AND MATERIAL COSTS AND COMPILE DOCUMENTATION

Use Equation 2 to determine the total value of compliant products (see *Further Explanation, Calculations*). Compliance is based on products' cost.

- Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Once the cap on structural material is met, these products can no longer contribute toward the credit but must be included in the denominator of Equation 2.
- Some products may meet multiple criteria or are part of assemblies (see *MR Overview, Determining Material Contributions*).
- Collect documentation. For certification programs, provide documentation for all products

FURTHER EXPLANATION

CALCULATIONS

EQUATION 1. Number of products with raw material extraction reporting

$$\text{Total \# of products} = \left\{ \text{\# of products with manufacturer-declared reports} \times 0.5 \right\} + \left\{ \text{\# of products with 3rd party verified reports} \times 1 \right\}$$

EQUATION 2. Percentage of responsibly sourced products

$$\text{\% of materials cost} = \frac{\left\{ \left(\begin{array}{c}\text{applicable}\\ \text{product}\\ \text{cost}_1\end{array}\right) \left(\begin{array}{c}\text{criterion}_1\\ \text{valuation}\\ \text{factor}\end{array}\right) \left(\begin{array}{c}\text{location}\\ \text{valuation}\\ \text{factor}\end{array}\right) \right\} + \left\{ \left(\begin{array}{c}\text{applicable}\\ \text{product}\\ \text{cost}_2\end{array}\right) \left(\begin{array}{c}\text{criterion}_2\\ \text{valuation}\\ \text{factor}\end{array}\right) \left(\begin{array}{c}\text{location}\\ \text{valuation}\\ \text{factor}\end{array}\right) \right\} + \dots}{\text{Cost of all permanently installed prodcuts}} \times 100$$

where

Product cost = cost of the product contributing toward credit (see *MR Overview, Determining Product Cost*).

Criterion valuation factor = multiplier assigned to each sourcing criterion:

- Biobased products meeting Sustainable Agriculture Standard, value 1.0, by cost
- Wood products certified to FSC standards, 1.0 value (*see Further Explanation, Calculating FSC Credit Contributions*).
- Reused materials, value 1.0, by cost
- Postconsumer recycled materials, value 1.0, by cost
- Preconsumer recycled materials, value 0.5, by cost
- Location valuation factor = multiplier for the extraction, manufacture, and purchase location (see *MR Overview, Location Valuation Factor*)
- Extended producer responsibility is valued at 50%; that is, the valuation factor is 0.5. Products that are part of an extended producer responsibility program may be counted in their entirety even if only part of the product is recycled.

Equation 3: Alternative Structure & Enclosure Percentage Limit for Option 2

For projects with significant amounts of structure and enclosure materials, the following calculation can be made to determine an alternative limit for the percentage of value that structure and enclosure materials can contribute to credit achievement. Note: this option is only available for projects that use the actual materials cost method (not the default cost method) to determine total project material costs.

EQUATION 3: Alternative Structure and Enclosure limit

$$\text{Alternative Structure and Enclosure limit} = \frac{\text{value \$ of total building materials that are structural or enclosure}}{\text{total actual materials value \$}}$$

Use the results of equation 3 to replace the 30% contribution factor limit in determining compliance with the credit.

RAW MATERIAL REPORTING AND CORPORATE SUSTAINABILITY REPORTS

For a product to count toward credit achievement, its report must be current for the product at its time of installation. Reports published within one year of the project's LEED registration date, or reports that cover a period that ends within that year are acceptable.

A compliant report must be issued by either the manufacturer or the raw material supplier and cover at least the criteria listed in the rating system requirements. At least 90% of the contents of each product must be from raw materials covered by a compliant report; no partial credit is allowed for products that do not meet this threshold. Reports obtained directly from raw material suppliers must verify the use of the raw material in products purchased for the project building. A manufacturer's report must trace activities to the source of extraction of the product's raw materials. In either case, acceptable frameworks for raw material reporting include the following:

Global Reporting Initiative (GRI) Sustainability Report

The GRI reporting framework is widely recognized as the most comprehensive. Its corporate sustainability reporting program offers reporting services, a publicly available database of reports, and tracking of required progress. Reports are assigned a score of A, B, or C, reflecting how closely the framework was followed in the report; this letter grade is not an indicator of quality but pertains only to the application.

The reporting framework also supports third-party verification ("external assurance") through a network of approved assurance providers. A plus sign (+) after the score indicates that the report has been externally assured. For a product to count toward credit achievement, the "assurance scope" must cover either the entire report or all sections of the report that directly address raw materials extraction practices. The "level of assurance" for the relevant sections must be "reasonable/high" for the report to be considered third-party verified. If the level is "limited/moderate," the report is not considered third-party verified for the purposes of this credit. The report can still count as a manufacturer-declared report, however, provided it includes all the information specified in the credit requirements.

A report status of "GRI-checked" or "third-party checked" applies only to the application level. These checks are not the same as external assurance and do not qualify the report as third-party verified for the purposes of this credit.

For more details on these report qualifiers, refer to globalreporting.org/resourcelibrary/GRI-Data-Legend-

Sustianability-Disclosure-Database-Profiling.pdf. The framework can also be used as a stand-alone guidance document. The current version of the framework is G3.1. The next version, G4, is intended to align better with other reporting programs worldwide.

Organization for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises

These guidelines are a comprehensive corporate social responsibility instrument developed by governments. The recommendations, addressed to multinational enterprises operating in or from adhering countries, set forth voluntary principles and standards for responsible business conduct in such areas as employment and industrial relations, human rights, environment, information disclosure, antibribery practices, consumer interests, science and technology, competition, and taxation. The guidelines are general and not intended to define specific reporting requirements, so it is up to the product's manufacturer to ensure that its report covers the required measures and, if it is third-party verified, that the verification process is truly independent. Project teams should seek a signed letter from the manufacturer on company letterhead attesting to that conformance with the credit requirements.

UN Global Compact: Communication of Progress

The UNGC is a policy framework for the development, implementation, and disclosure of 10 sustainability principles in four core areas: human rights, labor, environment, and anticorruption. The GRI Sustainability Reporting Guidelines can be used to produce the Global Compact's annual Communication on Progress, the mechanism that UNGC uses to demonstrate progress toward its principles. The GRI guidelines provide a structure for reporting and independent verification. See the GRI Sustainability Reports section, above, for details on how to use that format to meet the credit requirements. Project teams should seek a signed letter from the manufacturer on company letterhead attesting to conformance with the credit requirements.

ISO 26000: 2010 Guidance on Social Responsibility

ISO 26000 provides guidance on how businesses and organizations can operate in an ethical and transparent way that contributes to the health and welfare of society. Not a standard to which a company's report can be certified, it helps clarify what social responsibility is, helps businesses and organizations translate principles into effective actions, and shares best practices relating to social responsibility.

To document product compliance with Option 1, provide a publicly available document confirming the manufacturer's third-party-verified corporate sustainability report. Reports are often available on websites, but because web pages can change without notice, project teams are advised to print and retain paper copies.

EXTENDED PRODUCER RESPONSIBILITY

Extended producer responsibility (EPR) is a waste management strategy that promotes integrating the life-cycle environmental costs associated with goods into the market price of the products. EPR is based on the idea that because producers have the greatest control over product design, they also have the ability and responsibility to reduce their products' toxicity and waste.

The Organisation for Economic Co-Operation and Development (OECD) defines extended producer responsibility as an environmental policy approach in which a producer's responsibility for a product is extended to the postconsumer stage of the product's life cycle. An EPR policy (1) shifts responsibility (physically and/or economically, fully or partially) upstream toward the producer and away from municipalities; and (2) creates incentives for producers to take into account environmental considerations when designing their products. There are two basic types of EPR programs:

- **Manufacturer-based programs.** The manufacturer of the product has a take-back or recycling program for the product purchased (Figure 1). Documentation for Option 2 can be a brochure describing the EPR program and including contact information, plus proof that the product purchased for the project is included in the program. Documentation may also be a letter from the manufacturer verifying that an EPR program is in place and that the product purchased for the project is eligible, with contact information.
- **Third-party program.** In some cases a separate business collects material and sells or transports it back to manufacturers. Verifying that the material is in fact recycled is of the utmost importance. Acceptable documentation is a brochure that describes the recycling process and states the average rate of return for the material.

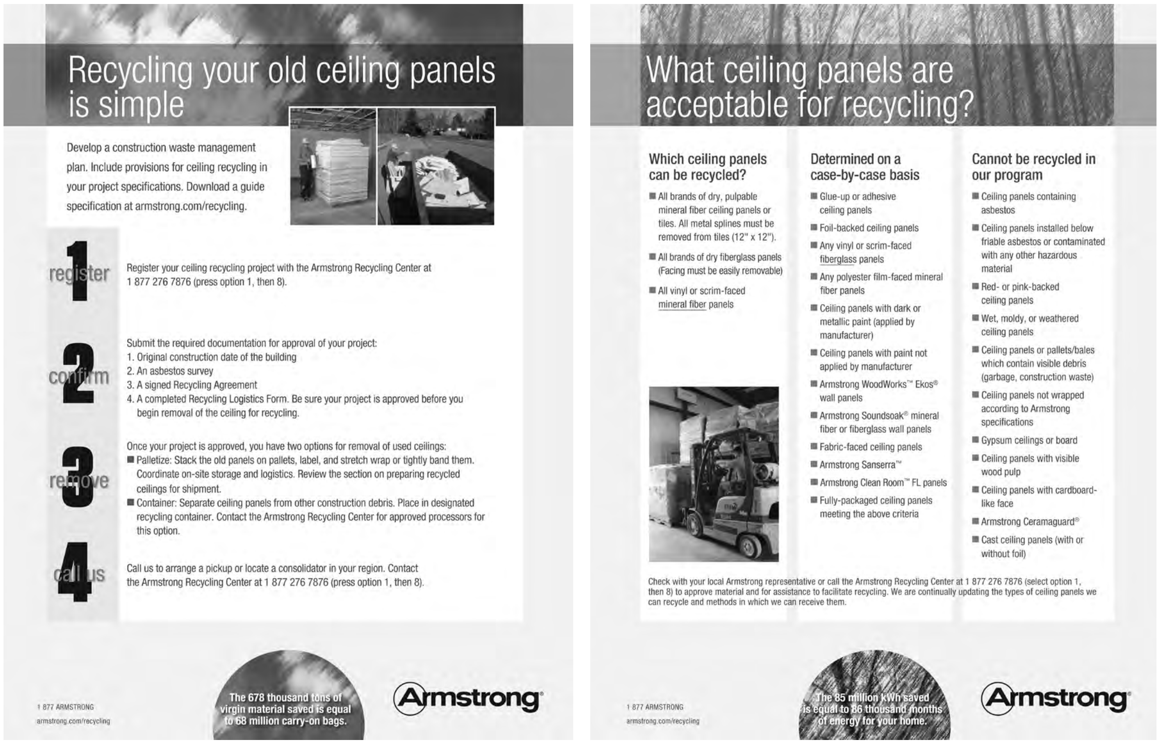


Figure 1. Sample education pamphlet about commercial ceiling tile recycling as part of extended producer responsibility program. Education pamphlet about Extended Producer Responsibility used with permission from Armstrong World Industries.

DOCUMENTATION FOR WOOD AND BIOBASED PRODUCTS

Documentation for Wood

To contribute toward credit achievement, wood products that are not reused, salvaged, or recycled must be certified to the standards of the Forest Stewardship Council. Bamboo, nonwood forest products, and other materials that are not actually wood but are certified by FSC can count toward this credit. Collect vendor invoices for wood products purchased for the project (see *Further Explanation, FSC Chain of Custody*).

Documentation for Biobased materials

Biobased products are defined by ASTM D6866, but testing (by the manufacturer or a contracted party) is not required in all cases. Manufacturers use this test to determine the amount of biobased material in a product. If the percentage of biobased materials, by weight, in the product are known, testing to this standard may not be necessary.

Nonwood products must be grown on farms that meet the Sustainable Agriculture Standard of the Sustainable Agricultural Network (SAN). Products originating on farms that meet the Sustainable Agriculture Standard must adhere to the guidelines and policies of the Rainforest Alliance—including traceability, chain of custody and use of seal—and receive pre-approval from the Rainforest Alliance in order to bear the Rainforest Alliance Certified™ seal. The Rainforest Alliance is a member of SAN and hosts its international secretariat, providing traceability, market linkages, and technical assistance. Several certification bodies in different countries are accredited to conduct Rainforest Alliance certification. A full listing of certified farms and operations can be found on the SAN website, sanstandards.org. A list of Rainforest Certified products can be found at rainforest-alliance.org. To date, nearly all Rainforest Alliance Certified agricultural products are foods, coffee, tea, and cut flowers.

Because the number of Rainforest Alliance–certified crops in building materials is limited, project teams may include products with manufacturer-declared conformance to the Sustainable Agriculture Standard (except bamboo and nonwood forest products that could be FSC certified) under the following three conditions:

- The product's manufacturer provides a signed letter on company letterhead from the raw material supplier attesting that its practices meet the standard.

- The letter includes a link to a publicly available document that specifies how the raw material supplier's practices conform to each paragraph in all 10 sections of the standard and attesting that each "critical criterion" is met.
- Both the letter and the detailed documentation are dated within one year before the date of project registration.

FSC CHAIN OF CUSTODY

Chain-of-Custody (CoC) certification requirements are established by Forest Stewardship Council Chain of Custody Standard 40-004 v3-0. To view this and all FSC standards, see the FSC website, ic.fsc.org, for listings.

Every entity that processes or trades FSC-certified material before it is shipped to the project site must have FSC CoC certification. On-site installers of FSC-certified products must have CoC certification only if they modify the products off the project site.

CALCULATING FSC CREDIT CONTRIBUTIONS

FSC-certified products must be itemized on the vendor's invoice. Their value toward credit contribution is calculated as one of the following, as determined by the FSC claim on the invoice provided by the supplier:

- Products identified as FSC 100% contribute 100% FSC content.
- Products identified as FSC Mix Credit contribute 100% FSC content.
- Products identified as FSC Mix [NN]% contribute the FSC content percentage indicated. For example, a product identified as "FSC Mix 75%" is valued at 75% of the product's cost (Equation 3).

EQUATION 3. Credit contribution of FSC Mix

$$\text{FSC product value (\$)} = \text{Total product cost (\$)} \times \text{FSC Mix [NN] \%}$$

- Products identified as FSC Recycled Credit contribute 100% postconsumer recycled content.
- Products identified as FSC Recycled [NN] % contribute the percentage postconsumer recycled content percentage indicated [NN].

Multiple Sustainable Claims and FSC

FSC and recycled content. Some products identified as FSC Mix Credit or FSC Mix [NN] % also have pre- or postconsumer recycled content, the latter of which is commonly reported separately by the product manufacturer. In these instances the project team must choose whether to classify the product (or some fraction of the assembly) as FSC certified or as recycled content; the material cannot contribute to both claims simultaneously.

FSC and SAN certified products. Products certified by both FSC and to the Sustainable Agriculture Standard they may receive credit for each criteria.

DOCUMENTING FSC CLAIMS

Project teams must document FSC certification for all wood products that contribute to credit achievement. FSC-certified products qualify for credit only when purchased from a vendor with an FSC chain-of-custody certificate that is current at the time of sale. The vendor is defined as the company that sells products to the project contractors and subcontractors who do not modify products off-site. The status of a CoC certification can be verified at info.fsc.org.

Each product shipped to the project site and contributing toward credit must be documented by an invoice from the CoC certificate holder as follows:

- The invoice must have the vendor's CoC certificate code (e.g., RA-COC-001025, SCS-COC-000345, or SGS-COC-002563). The invoice must itemize FSC-certified products and specific FSC claims.
- The invoice may aggregate the value of products, provided the cost of FSC products is isolated from other wood products and the vendor's CoC certificate code is on the invoice.
- The invoice must show the entity being invoiced and indicate the delivery is intended for the LEED project.

An alternative documentation process is available for architectural woodworkers (manufacturers of millwork, casework, and furniture) who supply custom wood products to the project. The purpose of this alternative process is to allow FSC-certified materials used in a custom millwork, casework, or furniture package to contribute toward the credit even if the entire package is not eligible to be invoiced with a FSC claim. Documentation for this alternative process must meet all of the following requirements:

- The woodworker (whether an individual or a company) must be FSC CoC certified, and the CoC certificate number must appear on the project invoice.
- The woodworker must install the custom millwork, casework, or furniture.
- The woodworker's invoice must isolate product costs from installation costs.
- The woodworker must provide a document, separate from the project invoice, detailing FSC-certified wood materials used and total cost of wood materials used. (The woodworker does not need to provide itemized material cost calculations but must maintain calculation records for auditing purposes by the FSC certifying body.)
- The contract cost may include assembly labor but must exclude on-site labor (see *MR Overview, Determining Product Cost*).

The project team should complete a spreadsheet itemizing wood components by cost and identifying FSC-certified and noncertified components to determine overall contributions to the credit, to be entered into the MR calculator. Calculate the FSC-certified contribution value toward the credit by multiplying the percentage of FSC-certified wood by the overall value of the contract. Calculate the percentage of FSC-certified wood by dividing the cost of FSC-certified wood by the total cost of the wood.

Submit the FSC-certified contribution value as well as the total contract amount. Include the woodworker's CoC certificate number, invoice, and itemized costs.

MATERIAL REUSE CONSIDERATIONS

Determine the cost of each material. The cost of reused or reclaimed materials is either the actual cost paid or the replacement value, whichever is higher.

The replacement value can be determined by pricing a comparable material in the local market; exclude labor and shipping. If a project team receives a discount from a vendor, the replacement value should be the discounted price, not the list value.

If the actual cost of the reused or salvaged material is below the cost of an equivalent new item, use the higher value (actual cost) of the new item. If the cost to reclaim an item found on site is less than the cost of an equivalent new item, use the cost of the new item (or replacement cost).

Generally, opportunities to reuse building materials may be limited. Core materials that may be eligible include salvaged brick, structural timber, railroad ties, stone, and pavers. When considering the reuse of salvaged materials, confirm that they do not contain toxic substances, such as lead or asbestos.

Reused materials found on site

Components that are retained either in their original function or in a new role are eligible for this credit. For reused materials found on site, the source location distance is zero.

Reused materials found off site

Materials obtained off site qualify as reused if they were previously used in a building or other application. These materials may be purchased as salvaged, like any other project material, or moved from another facility, including facilities used or owned by the LEED project owner.

For salvaged furniture taken from the owner's previous facility or location, demonstrate that these materials were purchased at least two years before the date of project registration. For example, if the owner is moving to a new building, furniture and furnishings relocated to the new site can contribute to this credit because their reuse will eliminate the need for purchasing new furniture and furnishings. Alternatively, furniture that is leased must have been in service for at least two years before being installed in the current project. Document this claim.

Location valuation factor for salvaged or reused materials

For reused materials, the source location of extraction or harvest is the location of the materials before their removal to the project site.

For material taken directly from another building, the source location is the building. For items purchased from a building materials salvage store or recycling facility, the source location is the store or facility. In this case, it is not necessary to track material to the original building.

RECYCLED CONTENT

Recycled content claims for products must conform to the definition in ISO 14021–1999, Environmental Labels and Declarations, Self-Declared Environmental Claims (Type II Environmental Labeling).

Many common materials have recycled content because of how they are manufactured; examples are steel, gypsum board, and acoustical ceiling tile. Design and construction teams may need to research which materials contain high levels of recycled content or verify which factories and which models of a product line feature the desired recycled content. Average recycled content claims given in a range are not acceptable for the purposes of this criterion.

Although it is a good practice, reusing materials reclaimed from the same process in which they were generated does not contribute toward the recycled content of the material. Putting waste back into the same manufacturing process from which it came is not considered recycling because it was not diverted from the waste stream.

Reuse of materials includes rework, regrind, or scrap product (ISO 14021); these count as preconsumer recycled only if they are used in a different product than the one whose production generated the waste. For example, glass culls that are reused to make new glass products do not count, but planer shavings, plytrim, sawdust, chips, bagasse, and sunflower seed hulls are considered preconsumer recycled content when used to make new products. .

Distinguish between postconsumer and preconsumer recycled content when tracking materials for the purpose of credit calculations.

To calculate the percentage of recycled-content materials used in a project, list all recycled-content materials and products and their costs. For each product, identify the percentage of postconsumer and/or preconsumer recycled content by weight, and list the recycled content information source. The information must come from a reliable, verifiable source, such as the product's manufacturer.

Postconsumer recycled content

Postconsumer recycled content is consumer waste, much of which comes from residential curbside recycling programs for aluminum, glass, plastic, and paper. Other postconsumer feedstock is generated when construction and demolition debris is recycled. To be a feedstock, the raw materials must have served a useful purpose in the consumer market before being used again.

Preconsumer Recycled Content

Preconsumer recycled content comes from process waste that is used to make a different product. For instance, a composite board manufacturer may use sawdust from a lumber mill or waste straw from a wheat farm. This definition does not include in-house industrial scrap or trimmings, which are normally fed back into the same manufacturing process.

The end product must be considered when determining whether a waste product is preconsumer or postconsumer. For example, a power plant's end product is electricity, so waste products from the combustion of coal may be considered preconsumer waste but not postconsumer; the power plant is not an end-use consumer of the coal.

Default recycled content for steel products where no recycled content information is available, assume the recycled content to be 25% postconsumer. No other material is known to have a similarly consistent minimum recycled content.

Many steel products contain 90% or higher recycled content if manufactured by the electric arc furnace process, so it may be beneficial to obtain actual information from the manufacturer rather than relying on the default value.

Average recycled content

Recycled content claims must be specific to the installed product. Installed product refers to an item distinguished by color, type, and/or location of manufacture, as identified to the consumer by SKU or other means.

Project teams may use the average recycled content value provided by a single manufacturer for a single product. Recycled content claims for custom products must be product specific; industry-wide or national averages are not acceptable. In all cases, if recycled content is given as a range, use the lowest recycled-content percentage.

EXAMPLES

Option 2 Example Calculation: MDF Panel with FSC-Certified Veneer

A project is installing $10,000 worth of veneer paneling. The MDF core is 90% of the product by weight, of which 80% is preconsumer waste wood that meets the ISO 14021 requirement. The veneer is 10% of the product by weight and FSC certified. The MDF is extracted, manufactured, and purchased within 100 miles (160 km); the veneer is imported.

TABLE 1. Sample calculation for product assembly meeting sustainable criteria

Component	Percentage of product by weight	Value of component	Sustainable criteria		Location valuation factor?	Sustainable criteria value
			Percentage of component	Requirement		
MDF core	90%	$9,000	80%	Preconsumer recycled content	Yes	$7,200
Veneer	10%	$1,000	100%	FSC certified	No	$1,000
					Total sustainable criteria value	$8,200

Option 2 Example Calculation: Salvaged Doors

A project team purchases 50 doors salvaged from a local deconstruction site and sold through a local Habitat for Humanity ReStore for $500. The value of equivalent new doors is documented at $400 each, or $20,000. Their contribution to the credit is as follows:

$20,000 x 1.0 criterion valuation * 2.0 location valuation = $40,000

$40,000 is the total sustainable criteria value for these doors

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
MR building product disclosure and optimization calculator or equivalent tracking tool	X	X
Corporate sustainability reports for 100% of products contributing toward credit	X	
Documentation of product claims for credit requirements or other USGBC-approved program		X

RELATED CREDIT TIPS

MR Credit Building Life Cycle Impact Reduction. If the project includes a preexisting structure, reused, salvaged, and refurbished products may contribute to either this credit or the related credit but may not be double-counted.

MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations. Products may be double-counted if they meet the requirements of both credits.

MR Credit Building Product Disclosure and Optimization—Material Ingredients. Products may be double-counted if they meet the requirements of both credits.

CHANGES FROM LEED 2009

Multiple criteria from the following LEED 2009 credits have been combined into this credit. Except as noted, the criteria are unchanged from LEED 2009. Other criteria are now incorporated into other MR credits, such as Building Life-Cycle Impact Reduction and Building Product Disclosure and Optimization—Environmental Product Declarations (see *Related Credit Tips*).

- MR Credit Materials Reuse. Materials that are reused on-site are no longer required to be repurposed.
- MR Credit Recycled Content. The requirements for recycled content have not changed; however, this criterion is now combined with other criteria in a single option.
- MR Credit Regional Materials. The 500-mile (805-km) radius requirement was decreased to 100 miles (160 km). The definition of regional has been expanded to include the distribution and purchase location and now includes all points of manufacture.
- MR Credit Rapidly Renewable Materials. Biobased materials are no longer defined by the harvest cycle of the raw materials; instead, products must meet the Sustainable Agriculture Standard to count toward this credit.
- MR Credit Certified Wood. The requirements for certified wood have not changed; however, this criterion is not combined with other criteria in a single option.

REFERENCED STANDARDS

Global Reporting Initiative (GRI) Sustainability Report: globalreporting.org/

Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises: oecd.org/daf/internationalinvestment/guidelinesformultinationalenterprises/

U.N. Global Compact, Communication of Progress: unglobalcompact.org/cop/

ISO 26000—2010 Guidance on Social Responsibility: iso.org/iso/home/standards/iso26000.htm

Forest Stewardship Council: ic.fsc.org

Sustainable Agriculture Network: sanstandards.org

The Rainforest Alliance: rainforest-alliance.org/

ASTM Test Method D6866: astm.org/Standards/D6866.htm

International Standards ISO 14021–1999, Environmental Labels and Declarations—Self Declared Environmental Claims (Type II Environmental Labeling): iso.org/iso/catalogue_detail.htm?csnumber=23146

EXEMPLARY PERFORMANCE

Option 1. Source at least 40 products from five manufacturers.

Option 2. Purchase 50%, by cost, of the total value of permanently installed building products that meet the responsible extraction criteria.

DEFINITIONS

biobased material commercial or industrial products (other than food or feed) that are composed in whole, or in significant part, of biological products, renewable agricultural materials (including plant, animal, and marine materials), or forestry materials. For the purposes of LEED, this excludes leather and other animal hides.

chain of custody (**CoC**) a procedure that tracks a product from the point of harvest or extraction to its end use, including all successive stages of processing, transformation, manufacturing, and distribution

enclosure the exterior plus semi-exterior portions of the building. Exterior consists of the elements of a building that separate conditioned spaces from the outside (i.e., the wall assembly). Semiexterior consists of the elements of a building that separate conditioned space from unconditioned space or that encloses semi-heated space through which thermal energy may be transferred to or from the exterior or conditioned or unconditioned spaces (e.g., attic, crawl space, or basement).

extended producer responsibility measures undertaken by the maker of a product to accept its own and sometimes other manufacturers' products as postconsumer waste at the end of the products' useful life. Producers recover and recycle the materials for use in new products of the same type. To count toward credit compliance, a program must be widely available. For carpet, extended producer responsibility must be consistent with NSF/ANSI 140–2007. Also known as closed-loop program or product take-back.

furniture and furnishings the stand-alone furniture items purchased for the project, including individual and group seating; open-plan and private-office workstations; desks and tables; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted visual-display products (e.g., marker boards and tack boards, excluding electronic displays); and miscellaneous items, such as easels, mobile carts, freestanding screens, installed fabrics, and movable partitions. Hospitality furniture is included as applicable to the project. Office accessories, such as desktop blotters, trays, tape dispensers, waste baskets, and all electrical items, such as lighting and small appliances, are excluded.

postconsumer recycled content waste generated by households or commercial, industrial and institutional facilities in their role as end users of a product that can no longer be used for its intended purpose

preconsumer recycled content matter diverted from the waste stream during the manufacturing process, determined as the percentage of material, by weight. Examples include planer shavings, sawdust, bagasse, walnut shells, culls, trimmed materials, overissue publications, and obsolete inventories. The designation excludes rework, regrind, or scrap materials capable of being reclaimed within the same process that generated them (ISO 14021). Formerly known as postindustrial content.

product (**permanently installed building product**) an item that arrives on the project site either as a finished element ready for installation or as a component to another item assembled on-site. The product unit is defined by the functional requirement for use in the project; this includes the physical components and services needed to serve the intended function of the permanently installed building product. In addition, similar products within a specification can each contribute as separate products.

raw material the basic substance from which products are made, such as concrete, glass, gypsum, masonry, metals, recycled materials (e.g., plastics and metals), oil (petroleum, polylactic acid), stone, agrifiber, bamboo, and wood

recycled content defined in accordance with the International Organization of Standards document ISO 14021, Environmental labels and declarations, Self-declared environmental claims (Type II environmental labeling)

reuse the reemployment of materials in the same or a related capacity as their original application, thus extending the lifetime of materials that would otherwise be discarded. Reuse includes the recovery and reemployment of materials recovered from existing building or construction sites. Also known as salvage.

structure elements carrying either vertical or horizontal loads (e.g., walls, roofs, and floors) that are considered structurally sound and nonhazardous

wood plant-based materials that are eligible for certification under the Forest Stewardship Council. Examples include bamboo and palm (monocots) as well as hardwoods (angiosperms) and softwoods (gymnosperms)

MATERIALS AND RESOURCES CREDIT

Building Product Disclosure and Optimization—Material Ingredients

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances. To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.

REQUIREMENTS

OPTION 1. MATERIAL INGREDIENT REPORTING (1 POINT)

Use at least 20 different permanently installed products from at least five different manufacturers that use any of the following programs to demonstrate the chemical inventory of the product to at least 0.1% (1000 ppm).

- **Manufacturer Inventory.** The manufacturer has published complete content inventory for the product following these guidelines:
  - A publicly available inventory of all ingredients identified by name and Chemical Abstract Service Registration Number (CASRN) and/or European Community Number (EC Number)

- Materials defined as trade secret or intellectual property may withhold the name and/or CASRN/EC Number but must disclose role, amount and hazard screen using either:
  - GreenScreen benchmark, as defined in GreenScreen v1.2
  - The Globally Harmonized System of Classification and Labeling of Chemicals rev.6 (2015) (GHS)
    - The hazard screen must be applied to each trade secret ingredient and the inventory lists the hazard category for each of the health hazards included in Part 3 of GHS (e.g. "GHS Category 2 Carcinogen").
    - Identify in the inventory all hazard classes for which a classification cannot be made because there are insufficient data for a particular endpoint(s).
- **Health Product Declaration.** The end use product has a published, complete Health Product Declaration with full disclosure of known hazards in compliance with the Health Product Declaration open Standard.
- **Cradle to Cradle.** The end use product has been certified at the Cradle to Cradle v2 Basic level or Cradle to Cradle v3 Bronze level.
- **Declare.** The Declare product label must indicate that all ingredients have been evaluated and disclosed down to 1000 ppm.
- **ANSI/BIFMA e3 Furniture Sustainability Standard.** The documentation from the assessor or scorecard from BIFMA must demonstrate the product earned at least 3 points under 7.5.1.3 Advanced Level in e3-2014 or 3 points under 7.4.1.3 Advanced Level in e3-2012.
- **Cradle to Cradle Material Health Certificate.** The product has been certified at the Bronze level or higher and at least 90% of materials are assessed by weight.
- **Product Lens Certification**
- **Facts - NSF/ANSI 336:** Sustainability Assessment for Commercial Furnishings Fabric at any certification level
- **USGBC approved program.** Other USGBC approved programs meeting the material ingredient reporting criteria.

AND/OR

OPTION 2. MATERIAL INGREDIENT OPTIMIZATION (1 POINT)

Use products that document their material ingredient optimization using the paths below for at least 25%, by cost, of the total value of permanently installed products in the project.

- **GreenScreen v1.2 Benchmark.** Products that have fully inventoried chemical ingredients to 100 ppm that have no Benchmark 1 hazards:
  - If any ingredients are assessed with the GreenScreen List Translator, value these products at 100% of cost.
  - If all ingredients are have undergone a full GreenScreen Assessment, value these products at 150% of cost.
- **Cradle to Cradle Certified.** End use products are certified Cradle to Cradle. Products will be valued as follows:
  - Cradle to Cradle v2 Gold: 100% of cost
  - Cradle to Cradle v2 Platinum: 150% of cost
  - Cradle to Cradle v3 Silver: 100% of cost
  - Cradle to Cradle v3 Gold or Platinum: 150% of cost
- **International Alternative Compliance Path – REACH Optimization.** End use products and materials have fully inventoried chemical ingredients to 100 ppm and assess each substance against the Authorization list – Annex XIV, the Restriction list – Annex XVII and the SVHC candidate list, (the version in effect in June 2013), proving that no such substance is included in the product. If the product contains no ingredients listed on the REACH Authorization, Restriction, and Candidate list, value at 100% of cost.
- **USGBC approved program.** Products that comply with USGGBC approved building product optimization criteria.

AND/OR

OPTION 3. PRODUCT MANUFACTURER SUPPLY CHAIN OPTIMIZATION (1 POINT)

Use building products for at least 25%, by cost, of the total value of permanently installed products in the project that:

- Are sourced from product manufacturers who engage in validated and robust safety, health, hazard, and risk programs which at a minimum document at least 99% (by weight) of the ingredients used to make the building product or building material, and
- Are sourced from product manufacturers with independent third party verification of their supply chain that at a minimum verifies:
  - Processes are in place to communicate and transparently prioritize chemical ingredients along the supply chain according to available hazard, exposure and use information to identify those that require more detailed evaluation
  - Processes are in place to identify, document, and communicate information on health, safety and environmental characteristics of chemical ingredients
  - Processes are in place to implement measures to manage the health, safety and environmental hazard and risk of chemical ingredients
  - Processes are in place to optimize health, safety and environmental impacts when designing and improving chemical ingredients
  - Processes are in place to communicate, receive and evaluate chemical ingredient safety and stewardship information along the supply chain
  - Safety and stewardship information about the chemical ingredients is publicly available from all points along the supply chain

Products meeting Option 3 criteria are valued at 100% of their cost for the purposes of credit achievement calculation.

For credit achievement calculation of options 2 and 3, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the value of individual products compliant with either option 2 or 3 can be combined to reach the 25% threshold but products compliant with both option 2 and 3 may only be counted once.

Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Projects with significant amounts of structural and enclosure materials may exceed the 30% limit by calculating an alternative structure and enclosure limit (See Equation 3 under Further Explanation).

BEHIND THE INTENT

The occupants of an average office building, school, or warehouse have little knowledge of the components of the building that surrounds them every day. Often, not even project planners have enough information about construction materials on which to base their own selection criteria, given that disclosure data are hard to acquire. Despite the regulatory safeguards for some toxic chemicals, 96% of the roughly 85,000 chemicals on the U.S. market have never been screened for possible health effects.[1]

Persistent bioaccumulative and toxic chemicals (PBTs) and persistent organic pollutants (POPs) are often found in building products and materials. PBTs linger in the environment, accumulate in organisms high on the food chain (including humans), and can cause harm even in very small doses. PBTs released during the manufacture, use, or disposal of a product can threaten the health of plants and animals many miles away. Even less is known about which chemicals are potential carcinogens, mutagens, neurotoxicants, or developmental toxicants.

By adhering to the precautionary principle and supporting green chemistry, this credit encourages project teams to avoid products containing potentially harmful chemicals, which will ultimately spur innovation in materials from manufacturers. The precautionary principle states, "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[2] Green Chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.[3] Companies conducting green chemistry research are developing safer alternatives to priority chemicals so that one day there will be "green lists" instead of "red lists." Such companies are also developing corporate policies that include the precautionary principle, establish credible monitoring and assurance programs, and strengthen relationships with suppliers.[4]

This credit aims to support manufacturers that disclose information about the ingredients in their products, allowing project teams to make better-informed decisions. The programs described below use hazard assessment approaches that evaluate multiple human and environmental health endpoints at a level of detail that goes beyond the scope of most life-cycle assessments. Project teams may demonstrate responsible product selection by providing manufacturers' reports or by ensuring the absence of materials of concern, using specified programs.

STEP-BY-STEP GUIDANCE

Select which option(s) to pursue. Projects can earn a maximum of 2 points by achieving the requirements for two options, and products may contribute to Options 1 and 2. A project that cannot achieve Option 1 is not precluded from achieving Option 2 and vice versa.

- Option 1 Material Ingredient Reporting is for projects that have at least 20 permanently installed products consisting of materials from manufacturers that have disclosed their ingredient inventory in one of the listed formats, as indicated in the credit requirements. Products must be sourced from at least five manufacturers.
- Option 2 Material Ingredient Optimization and Option 3 Supply Chain Optimization are for projects with 25% permanently installed products,by cost, that meet at least one of the paths listed in the credit requirements.

Option 1. Material Ingredient Reporting

STEP 1. ASSESS OPTION FEASIBILITY

Research at an early phase can help the project team identify products that contribute to multiple credits and options. Review the approved programs and assess the feasibility of finding enough products that meet project requirements (see *Further Explanation, Material Ingredient Reporting*).

- Some of these programs are new and have documented or certified only a few products in a way that complies with the requirements.

1. *"Healthy Business Strategies for Transforming the Toxic Chemical Economy," Clean Production Action (June 2006), http://www.cleanproduction.org/library/CPA-HealthyBusiness-1.pdf (accessed May 29, 2013).*
2. *Report of the United Nations Conference on Environment and Development, http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm (accessed May 29, 2013).*
3. *Anastas and Warner, Green Chemistry: Theory and Practice (New York: Oxford University Press, 2000).*
4. *"Healthy Business Strategies for Transforming the Toxic Chemical Economy," Clean Production Action (June 2006), http://www.cleanproduction.org/library/CPA-HealthyBusiness-1.pdf (accessed May 29, 2013).*

- The Cradle to Cradle Products Innovation Institute publishes a searchable registry of certified products.
- Declare. The Declare product label must indicate that all ingredients have been evaluated and disclosed down to 1000 ppm.
- ANSI/BIFMA e3 Furniture Sustainability Standard. The documentation from the assessor or scorecard from BIFMA must demonstrate the product earned at least 3 points under 7.5.1.3 Advanced Level in e3-2014 or 3 points under 7.4.1.3 Advanced Level in e3-2012.
- Cradle to Cradle Material Health Certificate. The product has been certified at the Bronze level or higher and at least 90% of materials are assessed by weight.
- Products can comply under different programs; it is not necessary to find 20 products that all comply using the same path.

STEP 2. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify at least 20 products, from at least five different manufacturers (see *MR Overview, Qualifying Products and Exclusions*).

- All ingredients in the end product must be characterized through a USGBC-approved program.
- Similar products from the same manufacturer can be counted as separate products if they have distinct formulations, but not if they are just aesthetic variations or reconfigurations.

STEP 3. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction submittals to ensure that the selected products meet credit requirements. To review progress toward credit achievement, regularly enter the information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Continually track substitutions and change orders to ensure that replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance.
- Because these requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 4. COUNT COMPLIANT PRODUCTS AND COMPILE DOCUMENTATION

Using the data collected in the tracking tool, tally the number of products that comply with Option 1 requirements. Collect all ingredient disclosure reports for contributing products for credit documentation.

- Documentation availability varies by reporting program.
- Retain product data for all materials that contribute to credit achievement and be prepared to provide the information on request.
- The best source of documentation is the manufacturer or the organization that manages the reporting program. Reports are typically available online, but in some cases it might be necessary to contact a company representative.
- Documentation may also be available from third-party websites that collect the information of many companies.

Option 2. Material Ingredient Optimization and Option 3. Supply Chain Optimization

STEP 1. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify products meeting one or more of the criteria listed in the credit requirements. Note that these options evaluate complete products; therefore, the criteria for assemblies found in other MR credits do not apply to these options.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction submittals to ensure selected products meet credit requirements. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Continually track substitutions and change orders to ensure that replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance.
- Because these requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE PRODUCT AND MATERIAL COSTS AND COMPILE DOCUMENTATION

Using Equation 1 and Equation 2, determine the total value of compliant products (see *Further Explanation, Calculations*). These options calculate compliance based on product cost.

Collect relevant documentation:

- For regional and local claims, provide a representative sample of documentation.
- For certification programs, provide documentation for all products.

FURTHER EXPLANATION

CALCULATIONS

Use the following equation for Option 2 Material Ingredient Optimization (see *Further Explanation, Material Ingredient Optimization*).

EQUATION 1. Percentage of compliant materials' cost

$$\text{\% of materials cost} = \frac{\left\{\text{product}_1\text{ cost}\left(\begin{matrix}\text{criterion}\\\text{valuation}\\\text{factor}\end{matrix}\right)\left(\begin{matrix}\text{location}\\\text{valuation}\\\text{factor}\end{matrix}\right)\right\} + \left\{\text{product}_2\text{ cost}\left(\begin{matrix}\text{criterion}\\\text{valuation}\\\text{factor}\end{matrix}\right)\left(\begin{matrix}\text{location}\\\text{valuation}\\\text{factor}\end{matrix}\right)\right\} + \ldots}{\text{Cost of all permanently installed products}} \times 100$$

where:

Product cost = price charged to the project owner for the product. Each product can be counted only once, even if it meets the requirements of multiple programs.

Program valuation factor = multiplier assigned to each compliance program:

- GreenScreen benchmark. Products that have fully inventoried chemical ingredients to 100 ppm:
  - All ingredients assessed using GreenScreen List Translator and have no Benchmark-1 hazards, 100% value (by cost)
  - All ingredients have undergone a full GreenScreen assessment and have no Benchmark-1 scores, 150% value (by cost)
- Cradle to Cradle Certified version 2.1.1:
  - Gold, 100% value (by cost)
  - Platinum, 150% value (by cost)
- Cradle to Cradle Certified version 3.0:
  - Silver, 100% value (by cost)
  - Gold or Platinum, 150% value (by cost)

- REACH Optimization. This is an alternative compliance path for projects outside the U.S. If the product contains no ingredients listed on the REACH authorization or candidate list, value it at 100% of cost.

Location valuation factor = multiplier for the extraction, manufacture, and purchase location (see *MR Overview, Location Valuation Factor*).

Use the following equation for Option 3 Supply Chain Optimization (see *Further Explanation, Supply Chain Optimization*). Products that meet the requirements of Option 3, as outlined below, contribute toward earning LEED credit at 100% of the product cost. To encourage actions beyond those minimum requirements, additional credit can be earned in a number of ways.

EQUATION 2. Percentage Supply Chain Optimization of compliant materials cost.

$$\text{\% of materials cost} = \frac{\left\{\left(\text{product cost}_1\right)\left(\text{criterion valuation factor}\right)\left(\text{supply chain depth factor}\right)\left(\text{location valuation factor}\right)\right\} + \left\{\left(\text{product cost}_2\right)\left(\text{criterion valuation factor}\right)\left(\text{supply chain depth factor}\right)\left(\text{location valuation factor}\right)\right\} + \cdots}{\text{Cost of all permanently installed products}} \times 100$$

where:

Criteria valuation factor = multiplier assigned to number of enhanced achievement measures

- 100% value (by cost) where the minimum requirements are met.
- 150% value (by cost) where the minimum requirements plus:
  - Inventory and screening performed to 99.9% level.

OR

Use GHS Category 2 criteria for hazard screening for carcinogens, mutagens, reproductive toxicants, and skin irritants for determining which ingredients are subject to management, reporting, and optimization (the basic requirement stops at GHS Category 1 for these endpoints). See Table 1.

OR

The building product manufacturer shall require either self-declared or third-party validated environmental management and health & safety management systems as described in the requirements in Section 4 for ALL ingredients up to the 99% threshold, not just those that fail the initial hazard screen. If the building product manufacturer is also seeking extra credit in the Supply Chain Depth factor, this would also apply to all ingredients at the additional tier or tiers. The building product manufacturer shall document substitution or elimination of at least one ingredient that was flagged in the hazard screening process. Where substitution occurs, manufacturer shall take action based on that alternatives assessment such that the hazard is no longer flagged at the Enhanced Achievement hazard Criteria level (table 1) in place of the original ingredient.

200% value (by cost) where the minimum requirements are met plus any two of the four above options.

Supply chain depth factor = multiplier assigned to level of supply chain engagement

- 100% value (by cost) where the minimum requirements are met.
- 150% value (by cost) where the minimum requirements plus one of these two:
  - The building product manufacturer has met the Option 3 minimum requirements for the entire business unit or company.

OR

All tier 2 suppliers have documented processes in place as described for tier 1 suppliers. This multiplier is not available to products with only tier 1 suppliers in their supply chain.

200% value (by cost) where the minimum requirements plus:

- All suppliers in the supply chain of the product have documented processes in place as described for tier 1 suppliers.
- This multiplier is not available to products with only tier 1 and tier 2 suppliers in their supply chain.

Equation 3: Alternative Structure & Enclosure Percentage Limit for Option 2

For projects with significant amounts of structure and enclosure materials, the following calculation can be made to determine an alternative limit for the percentage of value that structure and enclosure materials can contribute to credit achievement. Note: this option is only available for projects that use the actual materials cost method (not the default cost method) to determine total project material costs.

EQUATION 3: Alternative Structure and Enclosure limit

$$\text{Alternative Structure and Enclosure limit} = \frac{\text{value \$ of total building materials that are structural or enclosure}}{\text{total actual materials value \$}}$$

Use the results of equation 3 to replace the 30% contribution factor limit in determining compliance with the credit.

MATERIAL INGREDIENT REPORTING

Under Option 1, products can be documented as compliant and thus contribute to credit achievement in any of three ways (Table 1).

TABLE 1. Manufacturers' documentation for compliant products

Program	What has to be reported?	To whom?	Based on what framework?
Manufacturer's inventory	All ingredients at or above 0.1%; Report hazards associated with LT-1, LT-P1 (GS List Translator) or Benchmark 1 (full GreenScreen) scores	Public	GreenScreen (GS) (either GS Translator List or full GreenScreen assessment)
Health Product Declaration	All ingredients down to 0.1% and full disclosure of health hazards from ingredients; some ingredients can remain unnamed but health hazards must still be reported	Public	HPD authoritative lists (closely match GreenScreen List Translator)
Cradle to Cradle	All ingredients down to 0.01%, with some banned substances	Independent, accredited assessors (some data protected under nondisclosure agreement between the assessor and suppliers); data not disclosed under NDA may be made public at manufacturer's discretion	Version 2.1.1: C2C proprietary screening Version 3.0: Material Health Assessment Methodology (includes hazard screening and risk assessment)

Manufacturer's Inventory

Manufacturers may publicly disclose all ingredients by name and Chemical Abstract Service (CAS) registry number. No third-party verification is required for this option, but the information must be publicly available; direct disclosure to the designer or contractor is not acceptable.

If a specific ingredient cannot be disclosed for proprietary reasons, the manufacturer may withhold the name and CAS registry number but still provide the following information:

- Role or function in the product
- Amount, as a percentage of total product content or ppm
- GreenScreen LT score (GS List Translator) or GS Benchmark score (full GS). Report hazard levels and hazard endpoints that result in scoring the ingredient as LT-1 or LT-P1 using GS List Translator (e.g. High for Carcinogenicity) or hazard levels and hazard endpoints that result in scoring the ingredient as Benchmark 1 using full GreenScreen. It is not necessary to report hazards associated with higher Benchmark levels or LT-UNK (Unknown) using GS List Translator.

All ingredients that constitute 0.1% (1,000 ppm) or more of the product must be accounted for. This threshold is 10 times lower than the typical 1% minimum threshold for reporting on a material safety data sheet (MSDS).

Health Product Declaration Open Standard

Disclosure is done through Health Product Declaration (HPD), which is an open standard for reporting product ingredients and their associated health hazards. Manufacturers that use HPDs must provide the nonproprietary information listed above (role or function, amount, and health hazards) for every ingredient, not just those whose names have been withheld. The manufacturer affirms “full disclosure of known hazards” on the front summary page and further affirms the level of disclosure with residuals/impurities. For the material to comply with the credit requirements, the HPD standards for the 1,000-ppm level must be attained and the appropriate box on the summary page checked.

An HPD is several pages long, with a one-page summary listing company information, metadata about the report, and ingredients, and continuing on subsequent pages with more detail about individual ingredients and their associated health hazards, plus details on any certifications and associated materials. GreenScreen List Translator scores and/or Benchmarks, if any, are listed for each ingredient in HPDs, in the contents section. A report from a certified GreenScreen profiler may also be used to document the GreenScreen benchmarks for a product’s ingredients.

Manufacturers that use the standard HPD format reduce uncertainty about whether the information that they have provided meets the credit requirements, and they create a report that should be useful in other settings as well.

Qualifying HPDs developed under the Open Standard version 1.0, 2.0, 2.1 or subsequent versions of the standard are eligible for documenting credit achievement if the HPD is still valid at the time that the product is purchased and used on a project.

Cradle to Cradle Certified, version 2.1.1 and version 3.0

Project teams may also select Cradle to Cradle Certified (C2C) products. C2C requires that ingredients be disclosed to an independent, accredited C2C assessor. The percent of the product defined and assessed impacts the level of certification. Products certified under v2.1.1, have had at least 95% by weight of their materials assessed at any level and 100% of their materials assessed at the Gold and Platinum levels. Products certified under v3.0, have had at least 75% or 95% by weight of their materials assessed at the Bronze and Silver levels respectively, and 100% of their materials at the Gold and Platinum levels. Eligible products will have their scorecard available in the C2C product registry. The product scorecard shows the level of achievement for all five standard attributes, the overall certification level for the product (Basic, Bronze, Silver, Gold, or Platinum), the certificate expiration date, and the version of the standard that the product is certified against. For each certified product the registry includes an image of the product, the product description and certification level, and the expiration date of the current certification. Product certification claims from manufacturers’ websites should always be verified against this registry because they may be out-of-date (see *Further Explanation, Example, Cradle to Cradle (C2C) certification*). During the material health assessment, assessors review the scientific literature available for all chemical ingredients contained in a material above 100 ppm, use structure activity relationship models and chemical analog data to fill data gaps, and compare the collected information against the C2C hazard criteria. Through this process, the environmental and human health hazards of the chemical ingredients are classified using a green–yellow–red rating system. In a second step, assessors evaluate whether exposure to any of the identified or suspected hazardous chemicals are plausible in the context of the materials containing these chemicals and the product use and end of life scenarios. If avenues for exposure to these chemicals in a material exist, the material will receive an overall risk assessment rating of ‘x’. Gold and Platinum certified products do not contain any x-assessed materials. Products certified at the Silver level under v3.0 do not contain materials that have been x-assessed due to the presence of a carcinogen, mutagen, or reproductive toxicant (CMR). Products certified at any level under v3.0 do not contain banned list chemicals. Chemicals on the v3.0 banned lists include PVC and related compounds, certain flame retardants, PFOS and PFOA, certain phthalates, halogenated hydrocarbons and toxic heavy metals. C2C certification addresses a total of five product attributes and ingredient screening is just one part of the program.

Other USGBC-approved programs

As the industry evolves, additional programs and protocols for reporting on material ingredients are likely to emerge. USGBC will determine whether any new programs are acceptable and issue rating system addenda to include them as additional approaches to earning the credit.

MATERIAL INGREDIENT OPTIMIZATION

Under Option 2, GreenScreen (a program of Clean Production Action), Cradle to Cradle Certified, and the European Union’s REACH program (for projects outside the U.S.) can be used as frameworks for documenting the substitution of potentially problematic substances.

Option 2 goes beyond Option 1's reporting requirement and encourages the use of products that are made without problematic ingredients. It offers these four approaches:

- No GreenScreen Benchmark 1 materials (see the following section)
- Cradle to Cradle certified gold or platinum certification (see above, under *Material Ingredient Reporting*)
- REACH (see *Further Explanation, International Tips*)
- Other programs that may be approved by USGBC in the future

GreenScreen Benchmark 1

The GreenScreen hazard assessment method evaluates individual chemicals. GreenScreen is based on a toxicological assessment that starts with a collection of authoritative lists of "chemicals of concern" published by governmental and nongovernmental organizations (GreenScreen List Translator).

These substances are known to be associated with certain health problems. The assessment then proceeds to reviews of the scientific literature, use of structure activity relationship models and chemical analog data to fill data gaps (Full GreenScreen). Chemicals are assigned to one of four main categories: those of highest concern, as indicated in the authoritative lists, are assigned Benchmark 1. Chemicals that are not on the major authoritative lists and pass a toxicological review based on Clean Production Action's protocols can be assigned benchmarks that indicate lower levels of concern; Benchmark 4 is the lowest level of concern. A full GreenScreen assessment overrides the results of screening using the GreenScreen List Translator only.

The GreenScreen List Translator has been automated by two software providers. It can be accessed through the Chemical and Material Library found in Healthy Building Network's Pharos Tool, the ToxNot website, and in the GS List Translator module in the GreenWERCS software tool by The Wercs. The Interstate Chemicals Clearinghouse has created a website where GreenScreen assessments can be posted by various participating State governments and shared with no costs or restrictions. The GreenScreen Store is another source for some freely available full assessments: www.greenscreenchemicals.org/gs-assessments.

Option 1 of this credit requires only the GreenScreen List Translator review of ingredients to ensure that none of the ingredients are on the authoritative lists and thus flagged as Benchmark 1 substances. Project teams should look for documentation from manufacturers that either identifies all ingredients in the product or identifies and characterizes any benchmark hazards.

Option 2 requires the Full GreenScreen toxicological assessment to ensure that none of the ingredients are Benchmark 1. Project teams should look for documentation from manufacturers that shows each ingredient in the product has been subject to a full GreenScreen assessment by a licensed GreenScreen Profiler and that the product contains only Benchmark 2 and higher ingredients.

Products using GreenScreen version 1.2, 1.3, or subsequent versions are eligible for documenting credit achievement if the analysis/scores are valid at the time that the product is purchased and used on a project.

For Manufacturers and Suppliers

GreenScreen's List Translator assigns hazard classifications based on the various governmental and authoritative hazard lists including lists of chemicals classified using the Globally Harmonized System of Classification and Labeling. The GreenScreen List Translator can be used to identify chemicals that achieve or may achieve the Benchmark 1 level of concern. Under Option 1, manufacturers that keep certain ingredients proprietary must characterize any health hazards from those ingredients, as indicated by the List Translator or a full GreenScreen assessment.

Under Option 2, the manufacturer must warrant that no ingredients in the product at levels of 0.01% or more (100 ppm) are designated as Benchmark 1 chemicals based on the referenced lists defined by the List Translator. These products achieve compliance at the first level of the option.

The second level of compliance requires that all ingredients be Benchmark 2 or higher. There is no definitive List Translator for Benchmark 2, so manufacturers must engage an independent third party to screen all their ingredients, using the screening protocol defined by GreenScreen, and certify that none of them are Benchmark 1.

Products using GreenScreen version 1.2, 1.3, or subsequent versions are eligible for documenting credit achievement if the analysis/scores are valid at the time that the product is purchased and used on a project.

SUPPLY CHAIN OPTIMIZATION

These requirements build on programs that many companies already have in place, specifically environmental management systems (EMS) such as ISO 14001 and health and safety management systems such as OHSAS 18000, to meet and document compliance with Option 3. To comply with this option, the building product manufacturer (BPM), and any company that supplies it with ingredients or components that are significant health hazards, must have a robust program for continual improvement in environmental management and health & safety management. Specific industry programs that are consistent with ISO 14001:2015 include:

- RC14001:2013 Responsible Care
- ChemStewards Integrated Management System-2011

Guiding Principles

The building product manufacturer publishes a publicly available set of guiding principles for the optimization of ingredients and products in their supply chain with an emphasis on human and environmental health. The principles may be a standalone document or part of a website or other document. The principles include, at a minimum and in the building product manufacturer's own words, the following:

a. a commitment toward continual improvement (e.g., actual or attempted reduction in use of hazardous chemicals) in their supply chain;
b. a commitment toward greater communication and transfer of information within their supply chain and with their industry partners; and
c. a commitment to applying the principles of green chemistry and principles of green engineering

These principles should be endorsed by top management and referenced in documentation relating to Option 3 conformance.

Inventory

The manufacturer of permanently installed building products determines the composition of the ingredients and components it's buying, based on final composition of the product in question, to at least the 99% level by mass; no more than 1% of the contents can remain undetermined. A product disclosed via an approved method for Option 1 (such as Declare or HPD or other manufacturers inventory) could also be used to demonstrate conformance. If a supplier chooses to withhold the chemical identity of materials defined as trade secret or intellectual property, they may withhold the name and/or CASRN but must disclose role, amount and associated GHS Hazard classification of each ingredient via Safety Data Sheet and/or supplier's documentation on company letterhead, signed by a company official. In the case of mixtures, each ingredient in the mixture must be documented. The manufacturer will typically obtain this information from its first-tier suppliers, although if those suppliers provide manufactured components it may be necessary to reach further back into the supply chain to obtain content information to the 99% level.

Hazard Screen

All documented ingredients representing at least 99% by mass of the final product shall be screened for human health and environmental hazard characteristics according to the most current available criteria of the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). For each product, any ingredient that is flagged against the hazard criteria identified in Table 2 is determined to "not pass" the hazard screen, and shall be addressed by the building product manufacturer's environmental and health & safety management systems and supplier engagement (see below). While the GHS Screening is required, it is encouraged to go beyond the GHS screening criteria. For example, if a hazardous chemical is present at 0.05% in product but the GHS screening level is at 0.1%, the building product manufacturer is encouraged but not required to flag the ingredient. Ingredients with data gaps (no information available on the substance for one or more endpoints) should be flagged (i.e., should not pass) the hazard screen. If the 99% of ingredients to be screened includes recycled content, the building product manufacturer shall document its best management practices to characterize the sources of pre- and post-consumer recycled material and reduce or eliminate hazards associated with these materials.

TABLE 2. GHS Hazard Criteria by Endpoint for Option 3 Screening		
Endpoint	**If a substance falls into this category, it fails the minimum requirements hazard criteria and is "flagged"/does not pass**	**If a substances falls into this category, it fails the Enhanced Achievement Option Hazard Criteria (see Section 3 and Note 3)**
Carcinogenicity (C)	Category 1 (1A, 1B)	Category 2
Mutagenicity & Genotoxicity (M)	Category 1 (1A, 1B)	Category 2
Reproductive Toxicity (R)	Category 1 (1A, 1B)	Category 2
Acute Mammalian Toxicity (AT) (oral, dermal, and inhalation routes)	Category 1,2,3	
Systemic Toxicity & Organ Effects (ST-single exposure)	Category 1	
Skin Irritation (IrS)	Category 1 (1A, 1B, 1C)	Category 2
Eye Irritation (IrE)	Category 1 or 2A	
Aspiration Hazard	Category 1	
Systemic Toxicity & Organ Effects* Repeated Exposure sub-endpoint (ST-repeat)	Category 1	Category 2
Skin Sensitization (SnS)	Category 1A	
Respiratory Sensitization (SnR)	Category 1A	
Acute hazards to the aquatic environment (note 1)	Category 1 or 2 (note 1a)	
Chronic hazards to the aquatic environment (note 1)	Category 1 or 2 (note 1b)	

Note 1: For the purposes of this option, USGBC has mapped the GHS Hazard Categorizations to low, moderate, high, and very high. Persistence and bioaccumulation characteristics are factored into the aquatic environment hazards endpoints. As an alternative, if GHS categorizations for the aquatic endpoints are not available and specific empirical science is also not available, then the online PBT Profiler (http://www.pbtprofiler.net/) can be used to determine if the substance falls within the associated GHS categories:
Note 1a: If the fish chronic value (ChV) in the PBT Profiler (or more appropriate metric, as approved by the auditor) is less than 10 mg/L the substance is screened as having a Category 1 or 2 Acute Hazard GHS classification.
Note 1b: If the fish chronic value (ChV) in the PBT Profiler is less than 0.1 mg/L the substance is screened as having a Category 1 or 2 Chronic Hazard GHS classification.
Note 2: In general, this table establishes GHS Category criteria for each endpoint so that chemicals with only "low" or "moderate" hazard classifications for each endpoint pass the rapid hazard screening criteria. The exception is skin irritation, where chemicals characterized as GHS Category 2 (defined as "skin irritation, reversible adverse effects in dermal tissue") will pass through the screen at the base level of achievement.
Note 3: For Enhanced Achievement in the Rapid Hazard Screen, in addition to the Base Level of Achievement, the inclusion of GHS Category 2 for the Carcinogenicity, Mutagenicity, and Reproductive Toxicity ("CMR"), and Systemic Toxicity & Organ Effects Repeated Exposure sub-endpoint (ST-repeat) endpoints allows only chemicals with a "low" hazard condition to pass through the screen. Under GHS language, GHS Category 2 chemicals in one or more CMR endpoints show evidence of having the specific hazard characteristic to be "suspected" of being carcinogenic, etc. This is in contrast to chemicals that are GHS Category 1A or 1B for one or more of the CMR endpoints, which indicate higher hazard evidence that the chemical is a "known" or "presumed" carcinogen, etc. Similarly, the Enhanced Achievement Criteria adds GHS Category 2 for Skin Irritation as a trigger for further action in addition to CMR endpoints. To receive Enhanced Achievement Credit via the Rapid Hazard Screen, only chemicals showing evidence of moderate or low hazard for Skin Irritation (GHS Category 3) will pass the Enhanced Achievement Rapid Hazard Screening Criteria.

Environmental and Health & Safety Management Systems

Building product manufacturers shall have programs for environmental and health & safety management that include all the essential elements listed below and cover the facility, facilities, or portion of a facility where the building products for which the manufacturer seeks credit under Option 3 are manufactured. Building product manufacturers may need to specify new requirements or processes as compared to existing ISO or Responsible Care systems to meet these requirements. This step describes an environmental or health and safety management system as the framework, with health and safety criteria added to the EMS, but the systems can be combined differently as long as they contain the same elements.

For the purposes of documenting conformance with Option 3, all building product manufacturer's environmental and health & safety management systems must meet requirements 1 through 3 for the facility, facilities, or portion of a facility where the building product in question is manufactured, whether these systems are separate or combined into one:

1. Publicly available policy statement signed by top management that describes the company's commitment and what the environmental or health and safety management system is intended to achieve.
2. Processes or controls that address continual improvement based on a list of existing and potential environmental aspects and impacts or health and safety risks. The plan must include:

a. Targets and objectives addressing all significant environmental aspects or health and safety risks on list.
b. Monitoring and measurement of key elements in the operation that have relevant impacts.
c. Documented activities implementing the plan.
d. Internal evaluation, corrective action and audits of conformance to plan.
e. Communication to top management about results of audits.

3. The management system policy and plan shall include chemical safety & health as objectives with specific targets and goals in the plan. Joint objectives and targets set at both the corporate level and operational level are found to be most effective as they show a level of commitment throughout the organization. As a general framework, the plan should seek to, on a continual improvement basis:
   a. eliminate the use of hazardous ingredients,
   b. minimize the use of hazardous ingredients where elimination is not possible,
   c. transition to more effective control measures where hazardous ingredients remain, and
   d. manage those remaining hazardous ingredients responsibly with a goal of zero exposure and discharge to humans and the environment.

Building product managers with one or more hazard flagged ingredients must further meet requirements 4 through 6:

4. For any building product for which the manufacturer seeks credit under Option 3, at least 99% by mass of the ingredients comprising that product must be identified and screened for hazardous characteristics pursuant to Sections 2.2 and 2.3. ,
5. The building product manufacturer shall share hazardous characteristics for each ingredient that fails the hazard screen with customers to inform their appropriate handling, installation, and management of the product, and with suppliers as an input to their management system prioritization.
6. The management system shall have a continual improvement plan to evaluate and eliminate or reduce chemical hazards and exposure to the ingredients in the final building products as well as chemical hazards and exposures during the manufacturing processes.
   a. For optimization purposes established frameworks that contain steps for the comparative or alternatives assessment that meet the intent of this requirement are listed below, but others can also be used as long as they are known as acceptable equivalents. Frameworks that factor in broader environmental impacts such as climate change and resource extraction impacts are encouraged but not required.
      i. National Academy of Sciences (National Research Council) Alternatives Assessment Framework
      ii. BizNGO Chemical Alternatives Assessment Protocol
      iii. Interstate Chemicals Clearinghouse Alternatives Assessment Guide

Supplier Engagement

Suppliers of any chemical ingredient or component flagged in the hazard screen must have systems for environmental and health & safety management as described above, items 1–3. The building product manufacturer will notify its immediate (first-tier) suppliers that this requirement is due to the presence of flagged ingredients or components.The supplier provides documentation of its management system(s) to the building product manufacturer. This documentation can be third party verification or a self-declaration stating that processes are in place for the ingredients and/or components supplied. Any self-declaration must be accompanied by supporting documentation, which must be reviewed as part of the third-party verification of the building product manufacturer's environmental and health & safety management systems.

Verification

The building product manufacturer obtains third-party validation of fulfillment of the requirements of Option 3. Pre-existing audit processes may be acceptable if the audit process specifically includes validation of Option 3-related steps, including confirming that the steps listed above are completed and a review of documentation from the suppliers about their corresponding programs. Audits are to be repeated at least every three years.If no ingredients are hazard-flagged, then the fact that the hazard screen was completed is the only specific element required beyond basic conformance with the environmental and health & safety practices described above in parts 1-3. Procedures for building product manufacturer's assessment of ingredient hazards must be disclosed to the auditor.

Customer Communication

The building product manufacturer provides a certificate from a third-party verifying its Option 3-conforming program to anyone seeking to specify or purchase its product for a LEED project. The certificate must include a brief summary of the manufacturer's continual improvement objectives specific to that product or product line.

Supply Chain Optimization Enhanced Achievement Options

In addition to the minimum requirements described in Further Explanation – Supply Chain Optimization, building product manufacturers have the option of pursuing more advanced supply chain optimization measures, which can help their products contribute more value towards earning the LEED point, as described in Calculations. Seven enhanced achievement options are available for this LEED point, described below. Each relates only to the product for which the building product manufacturer is seeking credit under Option 3.

Additional ingredient inventory

Instead of identifying ingredients to the 99% level, the building product manufacturers identifies and includes in the screening (and, if appropriate, additional requirements) all ingredients to the 99.9% level (1,000 ppm).

Additional hazard screening

Use GHS Category 2 criteria for hazard screening for carcinogens, mutagens, reproductive toxicants, skin irritants, and Systemic Toxicity & Organ Effects Repeated Exposure sub-endpoint (ST-repeat) for determining which ingredients are subject to management, reporting, and optimization (the basic requirement stops at GHS Category 1 for these endpoints). See Table 2.

Supplier documentation for all ingredients

To address hazardous substances that do not persist into ingredients comprising the end product, the building product manufacturer shall require either self-declared or third-party validated environmental management and health & safety management systems for ALL ingredients up to the 99% threshold, not just those that fail the initial Hazard Screen. If the building product manufacturer is also seeking extra credit in the Supply Chain Depth factor, this would also apply to all ingredients at the additional tier or tiers.

LEED Documentation

Project teams specify and install products that have verified processes in place for assessing and improving the health impact of the product along the supply chain. The team must obtain third party-verification that the building product manufacturer has processes in place for the specific product, as defined above. The LEED project team submits that certification with its LEED application as evidence that the products or materials purchased contribute to the 25% by cost threshold for Options 2 & 3 in the credit.

Green chemistry optimization

The building product manufacturer takes actions to design and improve chemical ingredients within their supply chain. To demonstrate compliance, building product manufacturer must:

- Take at least one supply chain ingredient that triggered a Hazard Criteria in Table 1 and conduct a comparative assessment on that ingredient.
- Based on the comparative hazard assessment, the building product manufacturer must substitute or eliminate (e.g. product design change or process change) that ingredient.
- Where substitution occurs, manufacturer shall take action based on that alternatives assessment such that the hazard is no longer flagged at the Enhanced Achievement hazard Criteria level (table 2) in place of the original ingredient.
- After substitution or elimination, safety and stewardship information about the chemical ingredient is publicly available for all points along the supply chain.

Ingredients that are substituted must have been incorporated within 3 years of the alternative assessment date, and the ingredient being replaced must have been present in the product manufacturing processes no more than 6 years prior to the alternatives assessment and a subject of said alternatives assessment (e.g., the alternatives assessment was intended for the ingredient).

Enterprise-wide application of the EMS

The building product manufacturer has met the Option 3 minimum requirements for the entire business unit or company.

Extension of supplier engagement to Tier 2

All Tier 2 suppliers have documented environmental and health & safety management systems as described for Tier 1 suppliers. Building product manufacturer must procure third party verification or self-declaration with documentation that all first and second tier suppliers have those systems in place for the material they are supplying.

Extension of supplier engagement to source

All suppliers in the supply chain of the product have documented processes in place as described for Tier 1 suppliers. Building product manufacturer must procure third party verification or self-declaration with documentation that all suppliers have processes in place for the material they are supplying.

Customer Communication

The building product manufacturer provides a certificate from a third-party verifying its Option 3-conforming program to anyone seeking to specify or purchase its product for a LEED project. The certificate must include a brief summary of the manufacturer's continual improvement objectives specific to that product or product line.

EXAMPLES

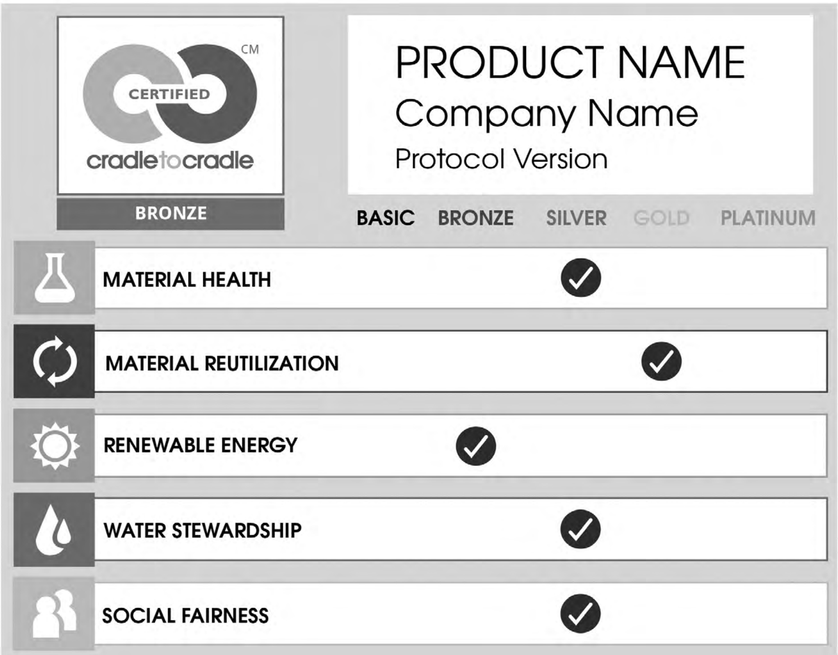


Figure 1. Cradle to Cradle (C2C) certification

Example GreenScreen List Translator Result

The GreenScreen List Translator identifies each list that GreenScreen references, including its source, which hazards in the GreenScreen it covers, whether it is "authoritative" or "screening," and which GreenScreen hazard level and subsequent Benchmark score applies, along with other data.

Table 2. GreenScreen List Translator Result (version 1.2 shown). Used with permission from Clean Production Action.

TABLE 2. GreenScreen List Translator Result. Used with permission from Clean Production Action

ID	List	List category	GreenScreen hazard	List type	A or B	Hazard range	Display III hazard box (see notes)	Benchmark score
154	IARC	Group 2A: Agent is probably carcinogenic to humans	Carcinogenicity	Authoritative	A	H	H	1
158	MAK	Carcinogenic Group 1	Carcinogenicity	Authoritative	A	H	H	1
159	MAK	Carcinogenic Group 2	Carcinogenicity	Authoritative	A	H	H	1
174	NIOSH-C	Occupational Cancer	Carcinogenicity	Authoritative	A	H	H	1
175	NTP-OHAaT	Clear Evidence of Adverse Effects - Developmental Toxicity	Developmental Toxicity	Authoritative	A	H	H	1

INTERNATIONAL TIPS

Alternative Compliance Path for International Projects: Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

The European Union's REACH legislation requires all chemicals sold in quantity in the EU to be registered in a central database and prioritized for evaluation and possible avoidance based on their hazard profile. The program maintains several lists of "Substances of Very High Concern."

Products can contribute to Option 2 under this credit if they come with clear documentation from the supplier that they do not contain any substances on the "Authorization List" (chemicals that can only be used with special authorization) nor on the "Candidate List" (chemicals being considered for the Authorization List). Because these lists can change over time, the supplier documentation must be dated; if a substance in the product was added to one of these lists after that documentation was produced and after the project's registration date, the product is still considered compliant. Projects in the U.S. may not use this alternative compliance path.

- Authorization List: echa.europa.eu/web/guest/addressing-chemicals-of-concern/authorisation/recommendation-for-inclusion-in-the-authorisation-list/authorisation-list
- Candidate List: echa.europa.eu/web/guest/candidate-list-table

REACH also provides for a "Restriction List" of chemicals that are to be banned from production and use, but as of August 2013 no substances had made it onto that list. Any substances that are moved from the Authorization List and Candidate List to the Restriction List continue to be treated as substances to be avoided in Option 2-compliant products.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3
MR building product disclosure and optimization calculator or equivalent tracking tool	X	X	
Documentation of chemical inventory through Health Product Declaration, Cradle to Cradle certification labels, manufacturers' lists of ingredients with GreenScreen assessment reports for confidential ingredients, or USGBC-approved programs (if applicable)	X		
Verification of ingredient optimization through Cradle to Cradle certification labels, manufacturers' lists of ingredients with GreenScreen Benchmark or LT scores listed for all ingredients, or manufacturers' declaration (for REACH), or USGBC-approved programs (if applicable)		X	
Documentation of supply chain optimization			X

RELATED CREDIT TIPS

MR Credit Building Life-Cycle Impact Reduction. This credit requires more detailed ingredient information than is typically used in a building life-cycle assessment study.

MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations. This credit is structured similarly to the related credit, but because it requires more detailed ingredient information than typically used for an environmental product declaration, it reveals different information about the products.

MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials. This credit is structured similarly to the related credit and uses the same calculation methodology.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

Chemical Abstracts Service: cas.org/

ChemStewards Integrated Management System: www.socma.com/chemStewards/?subsec=478

Cradle-to-Cradle Certified[CM] Product Standard: c2ccertified.org/product_certification

GHS: Globally Harmonized System. A Guide to the Globally Harmonized System of Classification and Labelling, also known as the 'Purple Book"; most current version: www.osha.gov/dsg/hazcom/ghs.html

GreenScreen: cleanproduction.org/Greenscreen.v1-2.php

Health Product Declaration: www.hpdcollaborative.org/

ISO 14001:2004 Environmental Management Systems: www.iso.org/iso/home/standards/management-standards/iso14000.htm or most current version

OHSAS 18001:2007: www.ohsas-18001-occupational-health-and-safety.com/ or most current version

Registration, Evaluation, Authorisation and Restriction of Chemicals (**REACH**)**:** echa.europa.eu/support/guidance-on-reach-and-clp-implementation

Responsible Care RC-14001 program: http://responsiblecare.americanchemistry.com/

EXEMPLARY PERFORMANCE

Option 1. Purchase at least 40 permanently installed building products that meet the credit criteria.

Option 2. Purchase at least 50%, by cost, of permanently installed building products that meet the credit criteria.

DEFINITIONS

building product manufacturer any company making an product for incorporation into the project that would arrive at the job site.

business unit a logical segment of a company that represents a specific operational function or production of a product type. Also called department, division, or a functional area.

component uniquely identifiable input, part, element, piece, assembly or subassembly, system or subsystem, that (1) is required to complete or finish an activity, item, or job, (2) performs a distinctive and necessary function in the operation of a system, or (3) is intended to be included as a part of a finished, packaged, and labeled product. Components are usually removable in one piece and are considered indivisible for a particular purpose or use. Commonly, items of very small or insignificant cost are not considered components.

facility one or more buildings or locations, or part of a building, that it is clearly delineated in the EMS and includes all process associated with the relevant building product (in the case of a Building Product Manufacturer) or ingredient or component (in the case of a supplier to the building product manufacturer).

first-tier supplier any company providing components or ingredients directly to a building product manufacturer.

green chemistry the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances (Anastas, P. T. and Warner, J. C. Green Chemistry: Theory and Practice. Oxford University Press: New York, 1998, p. 30).

green engineering the development and commercialization of industrial processes that are economically feasible and reduce the risk to human health and the environment (Anastas, P.T., and Zimmerman, J.B., ″Design through the Twelve Principles of Green Engineering″, Env. Sci. Tech. 2003, 37(5), 94A-101A).

ingredient a substance or single constituent of fixed composition, characterized by its molecular structure(s) used to make a compound, mixture, or finished product. Ingredients can be active (help directly in achieving a performance objective(s)) or inert (facilitate acceptance, application, stability, handling or marketing of the product, or delivery of the active ingredients). Ingredients typically have an associate CAS RN (and may also have synonym CAS RNs).

optimization developing a product or process with the highest achievable combination of functional performance, cost, and positive social, environmental, and health impacts by maximizing desired factors and minimizing undesired ones. For the purposes of LEED's Material Ingredients credit "optimization" implies giving human and environmental health higher priority among the multiple factors than is typically the case.

product (**permanently installed building product**) an item that arrives on the project site either as a finished element ready for installation or as a component to another item assembled on-site. The product unit is defined by the functional requirement for use in the project; this includes the physical components and services needed to serve the intended function of the permanently installed building product. In addition, similar products within a specification can each contribute as separate products.

second-tier supplier a supplier providing ingredients to another supplier that end up in the product being considered by the building product manufacturer.

MATERIALS AND RESOURCES CREDIT

PBT Source Reduction—Mercury

This credit applies to: **Healthcare (1 point)**

INTENT

To reduce the release of persistent, bioaccumulative, and toxic (PBTs) chemicals associated with the life cycle of building materials.

REQUIREMENTS

Specify and install fluorescent lamps with both low mercury content (MR Prerequisite PBT Source Reduction—Mercury) and long lamp life, as listed in Table 1.

TABLE 1. Criteria for rated life of low-mercury lamps

Lamp	Maximum content	Lamp life (hrs)
T-8 fluorescent, eight-foot	10 mg mercury	Standard output - 24,000 rated hours on instant start ballasts (3-hour starts) High output – 18,000 rated hours on instant start ballasts or program start ballasts (3-hour starts)
T-8 fluorescent, four-foot	3.5 mg mercury	Both standard and high output - 30,000 rated hours on instant start ballasts, or 36,000 rated hours on program start ballasts (3 hour starts)
T-8 fluorescent, two-foot and three-foot	3.5 mg mercury	24,000 rated hours on instant start ballasts or program start ballasts (3-hour starts)
T-8 fluorescent, U-bent	6 mg mercury	18,000 rated hours on instant start ballasts, or 24,000 rated hours on program start ballasts (3-hour starts)
T-5 fluorescent, linear	2.5 mg mercury	Both standard and high-output - 25,000 rated hours on program start ballasts
Compact fluorescent, nonintegral ballast	3.5 mg mercury	12,000 rated hours
Compact florescent, integral ballast, bare bulb	3.5 mg mercury, ENERGY STAR qualified	Bare bulb - 10,000 rated hours Covered models such as globes, reflectors, A-19s – 8,000 hours
High-pressure sodium, up to 400 watts	10 mg mercury	Use noncycling type or replace with LED lamps or induction lamps
High-pressure sodium, above 400 watts	32 mg mercury	Use noncycling type or replace with LED lamps or induction lamps

Do not specify or install circular fluorescent lamps or probe start metal halide lamps.

BEHIND THE INTENT

Lamps that contain mercury, a persistent bioaccumulative toxin, represent the majority of mercury-containing devices in modern health care facilities. Longer lamp life contributes to lower mercury use because replacement is less frequent, which lowers hazardous waste disposal costs. Less frequent replacement also decreases the likelihood of spills, which could expose staff and patients to contamination and entail costly remediation procedures. By focusing on installing long-lasting mercury fluorescent lamps, this credit expands on the requirements of the corresponding prerequisite for mercury reduction.

STEP-BY-STEP GUIDANCE

STEP 1. SPECIFY COMPLIANT LAMPS

For projects that meet the prerequisite by using a phase-out plan, lamp life requirements in this credit must be met for both existing and new mercury-containing lamps. See *Further Explanation, Lamp Exclusions*, for a list of lamps that may be excluded from this credit.

Incorporate low-mercury lamp requirements into the project specifications:

- Specify lamps that meet the credit criteria for increased lamp life.
- Specify linear and U-bend fluorescent lamps meeting the rated hours and ballast type criteria.
- Do not specify circular fluorescent lamps. These lamps are prohibited because of the high rate of breakage and associated risk of exposure for staff and patients to contamination.
- Use pulse-start instead of probe-start metal halide lamps. The latter are prohibited because of their relatively short lamp life.
- Consider installing high-efficiency, nonmercury lamps such as LEDs to replace high-pressure sodium (HPS) lamps to further reduce mercury in buildings. Alternatively, avoid cycling HPS ballasts.

STEP 2. CREATE LIGHTING SCHEDULE AND TRACK PRODUCTS THROUGHOUT CONSTRUCTION

Track specified and purchased lamps during construction with a material checklist or tracking form.

- Prepare a lighting schedule that specifies the mercury-containing lamp type (fluorescent, compact fluorescent, high-pressure sodium, metal halide, etc.), ballast type, rated hours, and mercury content.
- Review manufacturers' documentation before installation to ensure that only qualifying lamps are used.
- See MR Prerequisite PBT Source Reduction—Mercury for sample documentation schedules and lamp manufacturers' documentation

FURTHER EXPLANATION

LAMP EXCLUSIONS

- Operating rooms, dental treatment rooms, dental labs, and other spaces in medical military facilities may require lamps with very high CRI and color temperature to comply with UFC 4-501-01. If the credit criteria and UFC 4-501-01 conflict, affected lamps may be excluded from the credit.
- If the credit criteria and local code or regulations conflict, affected lamps may be excluded from the prerequisite. Retain a copy of the local code that conflicts with the criteria.

CAMPUS

Group Approach
All buildings in the group may be documented as one. Projects that are on existing campuses or part of large health care systems can coordinate lamp selection with purchasing protocols to ensure ongoing compliance with prerequisite requirements.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects
Lighting schedule (including lamp life hours)	X
Narrative explaining lamps excluded from credit	X
USGBC's MR PBT source reduction calculator (or equivalent documentation)	X

RELATED CREDIT TIPS

MR Prerequisite PBT Source Reduction—Mercury. Ensure that the mercury-containing lamps meet the mercury content criteria for the tracking tool includes the information required in this prerequisite as well.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

elemental mercury mercury in its purest form (rather than a mercury-containing compound), the vapor of which is commonly used in fluorescent and other bulb types

lamp a device emitting light in a fixture, excluding lamp housing and ballasts. Light-emitting diodes packaged as traditional lamps also meet this definition.

lamp life the useful span of operation of a source of artificial light, such as bulbs. Lamp life for fluorescent lights is determined by testing three hours on for every 20 minutes off. For high-density discharge lamps, the test is based on 11 hours on for every 20 minutes off. Lamp life depends on whether the start ballast is program or instant. This information is published in manufacturers' information. Also known as rated average life.

persistent bioaccumulative toxic chemical a substance that poses a long-term risk to both humans and the environment because it remains in the environment for long periods, increases in concentration as it moves up the food chain, and can travel far from the source of contamination. Often these substances can become more potent and harmful to ecosystems the longer they persist. See U.S. EPA's website on persistent bioaccumulative toxic chemicals, www.epa.gov/pbt/.

universal waste hazardous items that are easily purchased and commonly used. Examples include batteries, pesticides, mercury-containing equipment, and light bulbs. See epa.gov/osw/hazard/wastetypes/universal/index.htm.

MATERIALS AND RESOURCES CREDIT

PBT Source Reduction—Lead, Cadmium, and Copper

This credit applies to: **Healthcare (2 points)**

INTENT

To reduce the release of persistent, bioaccumulative, and toxic (PBT) chemicals associated with the life cycle of building materials.

REQUIREMENTS

Specify substitutes for materials manufactured with lead and cadmium, as follows.

Lead

- For water intended for human consumption, specify and use solder and flux to connect plumbing pipe on site that meets the California AB1953 standard, which specifies that solder not contain more than 0.2% lead, and flux not more than a weighted average of 0.25% lead for wetted surfaces. The "lead free" label as defined by the Safe Drinking Water Act (SDWA) does not provide adequate screening for the purposes of this credit because the SDWA defines "lead free" as solders and flux containing 0.2% lead or less.
- For water intended for human consumption, specify and use pipes, pipe fittings, plumbing fittings, and faucets that meet the California law AB1953 of a weighted average lead content of the wetted surface area of not more than 0.25% lead.
- Specify and use lead-free roofing and flashing.
- Specify and use electrical wire and cable with lead content less than 300 parts per million.
- Specify no use of interior or exterior paints containing lead.
- For renovation projects, ensure the removal and appropriate disposal of disconnected wires with lead stabilizers, consistent with the 2002 National Electric Code requirements.

Lead used for radiation shielding and copper used for MRI shielding are exempt.

Cadmium

- Specify no use of interior or exterior paints containing intentionally added cadmium.

Copper

- For copper pipe applications, reduce or eliminate joint-related sources of copper corrosion:
  - use mechanically crimped copper joint systems; or
  - specify that all solder joints comply with ASTM B828 2002, and specify and use ASTM B813 2010 for flux.

BEHIND THE INTENT

Both lead and cadmium are persistent bioaccumulative toxins (PBTs).[1] PBTs released during the manufacture, use, or disposal of a product can travel far beyond their source point by wind and water, becoming more harmful the longer they persist in the food chain and posing risks to ecosystems on a wide scale. PBTs have a wide range of health effects, including cancer, endocrine disruption, immune system disorders, impaired brain development, and birth defects.

Copper, another PBT, corrodes when exposed to acidic air or water. Copper pipe corrosion can release high levels of copper into aquatic ecosystems, not only creating potentially toxic conditions for aquatic life but also affecting human health as it bioaccumulates and moves up the food chain. The procedures specified in this credit ensure that copper is not released during soldering or from unsoldered joint systems, thus reducing opportunities for copper piping to "shed" copper atoms. This credit seeks to secure both human health and environmental benefits by encouraging project teams to avoid building materials with lead and cadmium and to use construction methods and materials that protect against lead and copper corrosion.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY LEAD, CADMIUM, AND COPPER PRODUCTS AND MATERIALS

Review preliminary project design and material specifications to identify building materials that may contain any of the substances in the credit requirements. Examples include the following:

- Roofing and flashing materials (lead)
- Plumbing pipes, pipe and plumbing fittings, faucets (pipes and fittings) that convey water for human consumption (lead, lead soldering, lead flux, joints in copper piping)
- Electrical wire and cable (lead)
- Paints (lead, cadmium)
- For renovation projects, disconnected wires (lead stabilizers)

Certain medical equipment and preexisting PBT-containing building materials in renovation projects may be excluded (see *Further Explanation, Excluded Products and Materials*).

STEP 2. IDENTIFY AND SPECIFY LEAD- AND CADMIUM-FREE PRODUCTS

For all applicable building materials and equipment, research alternative PBT-free products and their suppliers (see *Further Explanation, Lead-Free and Cadmium-Free Products*).

- Identify flux, pipe, pipe fittings, and fixtures that comply with the California AB1953 standard by looking for ANSI-approved third-party certification.
- Identify lead-free roofing and flashing through manufacturers' information.
- Identify electrical wire and cabling with lead content less than 300 parts per million (ppm).
- Identify lead- and cadmium-free paints using Green Seal certification for metal-free paints or an equivalent source of lead- and cadmium-free documentation.

Add product specifications for alternative products and performance requirements for corrosion prevention to relevant Construction Specifications Institute MasterFormat classifications.

- In some cases, an addition to Division 1 for LEED-specific requirements may be appropriate for overlapping work sections.
- Specifications for products and installation practices may be more appropriate in the work results category, such as Division 22, Plumbing.

STEP 3. DESIGN PLUMBING SYSTEMS TO PREVENT COPPER CORROSION

Improper installation is a common reason for copper corrosion and leaching. Design plumbing systems to prevent copper from leaching into water (see *Further Explanation, Preventing Corrosion Strategies*).

1. *Lent, Tom, "Green Guide for Health Care: PBT Elimination," http://www.gghc.org/tools.technical.php (accessed May 29, 2013).*

- Follow the ASTM B828 standard for making capillary joints by soldering of copper and copper alloy tube and fittings for solder joints.
- Emphasize correct use of ASTM B813 fluxes or use O-ring gaskets and crimping tools for jointing.
- Minimize flow direction and piping size changes.
- Minimize hot water temperature and velocity.
- Use compatible materials (e.g., copper straps for copper pipes) to reduce galvanic corrosion and similar problems.

STEP 4. EDUCATE CONTRACTORS

Provide education and training to contractors and subcontractors on PBT source reduction goals, common problem areas, and targeted strategies. Some best practices include the following:

- Provide a PBT source reduction plan to contractors, for them to distribute to subcontractors and field personnel.
- If possible, specify applicable plan components in contracts.
- For renovation projects, ensure that removal of disconnected wires with lead stabilizers is in compliance with 2002 U.S. National Electric Code requirements or a local equivalent.

STEP 5. TRACK PRODUCTS THROUGHOUT CONSTRUCTION

Track specified and purchased materials during construction with a material checklist or PBT tracking form. Check the products' material safety data sheets (MSDS) and manufacturers' documentation before installation to ensure that only qualifying materials are used. At a minimum, review the following:

- Roofing and flashing
- Electrical wiring and cabling
- Indoor and outdoor paints
- Flux and solder
- Pipes, pipe fittings, and fixtures

The following information about each product or material is recommended for inclusion in a tracking tool:

- Product type
- Manufacturer
- Product name
- Allowable lead, cadmium, and copper content
- Actual lead, cadmium, and copper content, with source of data
- Compliance with the lead- and cadmium-free standard

FURTHER EXPLANATION

LEAD-FREE AND CADMIUM-FREE PRODUCTS

Many pipes, faucets, and other plumbing products may be labeled "lead-free" to comply with the U.S. Safe Water Drinking Act; however, "lead-free," as defined by EPA, allows for minimal amounts of lead and is not adequate for compliance with this credit.

Instead, this credit uses California AB1953, part of the California Health and Safety Code (Section 116875), which sets a standard for the lead content of pipes, pipe fittings, and other products that convey water for human consumption. It defines the standard using a weighted average of <0.25% for all wetted surfaces; however, consumers and specifiers need only look for products certified to this standard by an independent ANSI-approved third-party organization. Currently, NSF International certifies products to this standard under NSF 61, Annex G, Section 9, or NSF 372.

Solder, flux, pipe, pipe fittings, and fixtures must meet the California AB1953 standard for lead content. Several states and local municipalities have adopted California AB1953; check product literature carefully for compliance statements.

Roofing and flashing must not contain any lead.

Lead-free electrical wire and cable for construction applications are not industry standard; most wiring and cable jacketing currently contains lead but the amount is not disclosed. Therefore, not every contractor may be aware of lead content information in electrical wire and cable. Project teams are encouraged to ask vendors about wire and cable that complies with lead-free standards, such as RoHS in the European Union.

Lead- and cadmium-free paints may be identified by industry standards, such as Green Seal. However, because lead and cadmium are often added as pigment to the base, it may be necessary to ask manufacturers whether both the base and the pigment are lead and cadmium free.

EXCLUDED PRODUCTS AND EQUIPMENTS

Some equipment, such as relay contacts, may have minute amounts of hidden cadmium; these uses are allowed.

For renovations, existing products and materials that are not included in the scope of work may be excluded. Examples of existing items include solder, flux, pipes, pipe fittings, faucets, roofing, flashing, electrical cable, cable, paints, and mechanical pipe connections.

For health care facilities, copper used for MRI shielding equipment and lead used for radiation shielding are exempt from credit requirements, but teams are encouraged to consider alternative shielding materials.

COPPER CORROSION PREVENTION STRATEGIES

Consider implementing strategies from "Preventing Corrosion Protects San Francisco Bay: A Fact Sheet for Designers" (bacwa.org/Portals/0/Committees/BAPPG/Archive/cu_designers_05_03.pdf) and the Copper Development Association Inc. resources and tools (copper.org/). Some best practices from these resources include the following:

- Use large-diameter piping to keep velocities low—less than 8 feet per second (2.5 meters per second) for cold lines and less than 4–5 feet per second (1.2–1.5 meters per second) for hot lines.
- Ensure that return lines in a circulating hot water system have the same diameter as the supply lines.
- Avoid stagnant sections by minimizing direction and size changes.
- Prevent electrical currents by grounding directly to a copper rod driven into the ground. Do not attach a grounding wire to water pipes.
- Do not allow galvanized nails to touch copper piping.
- Avoid induced stresses, provide enough pipe support, and allow for thermal expansion.
- Carefully ream cut ends to reduce turbulence. Unreamed tubing corrodes and fails at a higher rate.
- Use stainless-steel piping and components for industrial process water supplies, heat exchangers, chillers, and condensers when operation temperatures exceed 140 degrees F (60 degrees C).

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
Product documentation demonstrating credit criteria have been met (manufacturer's data or proof of certification)	X
Narrative explaining any excluded materials	X
Description of pipe jointing processes (for copper pipe only)	X
Verification of appropriate disposal of wires and lead stabilizers (for renovation projects only)	X

RELATED CREDIT TIPS

EQ Credit Low-Emitting Materials. Specifying interior and exterior paints that are GreenSeal compliant will ensure that they are also free of lead and cadmium.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

ASTM B813 for copper flux: astm.org/Standards/B813.htm

ASTM B828, Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings: www.astm.org/Standards/B828.htm

California AB1953 standard for lead water pipes used to convey water for human consumption: leginfo.ca.gov/pub/05-06/bill/asm/ab_1951-2000/ab_1953_bill_20060930_chaptered.html

GreenSeal: greenseal.org

2002 National Electric Code requirements for removal and disposal of disconnected wires with lead stabilizers: nfpa.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

lead-free a label defined by U.S. Environmental Protection Agency regulations under the Safe Drinking Water Act that allows small amounts of lead in solders, flux, pipes, pipe fittings, and well pumps

persistent bioaccumulative toxic chemical a substance that poses a long-term risk to both humans and the environment because it remains in the environment for long periods, increases in concentration as it moves up the food chain, and can travel far from the source of contamination. Often these substances can become more potent and harmful to ecosystems the longer they persist. See U.S. EPA's website on persistent bioaccumulative toxic chemicals, www.epa.gov/pbt/.

MATERIALS AND RESOURCES CREDIT

Furniture and Medical Furnishings

This credit applies to: **Healthcare (1-2 points)**

INTENT

To enhance the environmental and human health performance attributes associated with freestanding furniture and medical furnishings.

REQUIREMENTS

Use at least 30% (1 point) or 40% (2 points), by cost, of all freestanding furniture and medical furnishings (e.g., mattresses, foams, panel fabrics, cubicle curtains, window coverings, other textiles) that meets the criteria in one of the following three options.

Include built-in casework and built-in millwork in the base building calculations, even if manufactured off site. The dollar value of any individual product may be included in the total qualifying value if the product meets the requirements.

OPTION 1. MINIMAL CHEMICAL CONTENT

All components that constitute at least 5%, by weight, of a furniture or medical furnishing assembly, including textiles, finishes, and dyes, must contain less than 100 parts per million (ppm) of at least four of the five following chemical groups:

- urea formaldehyde;
- heavy metals, including mercury, cadmium, lead, and antimony;
- hexavalent chromium in plated finishes consistent with the European Union Directive on the Restriction of the Use of Certain Hazardous Substances (EU RoHS);
- stain and nonstick treatments derived from perfluorinated compounds (PFCs), including perfluorooctanoic acid (PFOA); and
- added antimicrobial treatments.

AND/OR

OPTION 2. TESTING AND MODELING OF CHEMICAL CONTENT

All components of a furniture or medical furnishing assembly, including textiles, finishes, and dyes, must contain less than 100 parts per million (ppm) of at least two of the five chemicals or materials listed in Option 1.

New furniture or medical furnishing assemblies must be in accordance with ANSI/BIFMA Standard Method M7.1–2011. Comply with ANSI/BIFMA e3-2010 Furniture Sustainability Standard, Sections 7.6.1 and 7.6.2, using either the concentration modeling approach or the emissions factor approach. Model the test results using the open plan, private office, or seating scenario in ANSI/BIFMA M7.1, as appropriate. USGBC-approved equivalent testing methodologies and contaminant thresholds are also acceptable. Documentation submitted for furniture must indicate the modeling scenarioused to determine compliance.

Salvaged and reused furniture more than one year old at the time of use is considered compliant, provided it meets the requirements for any site-applied paints, coatings, adhesives, and sealants.

AND/OR

OPTION 3. MULTI-ATTRIBUTE ASSESSMENT OF PRODUCTS

Use products that meet at least one of the criteria below. Each product can receive credit for each criterion met. The scope of any environmental product declaration (EPD) must be at least cradle to gate.

- Product-specific declaration.
  - Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one quarter (1/4) of a product for the purposes of credit achievement calculation.
- Environmental Product Declarations which conform to ISO 14025, 14040, 14044, and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
  - Industry-wide (generic) EPD -- Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator are valued as one half (1/2) of a product for purposes of credit achievement calculation.
  - Product-specific Type III EPD -- Products with third-party certification (Type III), including external verification in which the manufacturer is explicitly recognized as the participant by the program operator are valued as one whole product for purposes of credit achievement calculation.
- **Materials reuse.** Use salvaged, refurbished, or reused products.
- **Recycled content.** Use products with recycled content. Recycled content is the sum of post-consumer recycled content plus one-half the pre-consumer recycled content.
- **Extended producer responsibility.** Products purchased from a manufacturer (producer) that participates in an extended producer responsibility program or is directly responsible for extended producer responsibility.
- **Bio-based materials.** Bio-based products must meet the Sustainable Agriculture Network's Sustainable Agriculture Standard. Bio-based raw materials must be tested using ASTM Test Method D6866 and be legally harvested, as defined by the exporting and receiving country. Exclude hide products, such as leather and other animal skin material.
- **Wood products.** Wood products must be certified by the Forest Stewardship Council or USGBC-approved equivalent.

Products that meet the above criteria are valued according to source location (extraction, manufacture, and purchase point must be within the distances noted below):

For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost.

BEHIND THE INTENT

Sustainably sourced furniture and furnishings can improve indoor environmental quality, protect long-term public health, and reduce a health care facility's ecological footprint.

Minimizing emissions from furniture and furnishings reduces the risk of exposure for sensitive patients. Persistent bioaccumulative toxins (PBTs) can travel far beyond their source point, becoming more harmful the longer they persist in the food chain. PBTs have a wide range of health effects, including cancer, endocrine disruption, brain and nervous system damage, birth defects, and impaired childhood development. Avoiding materials with PBT chemicals, heavy metals, hexavalent chromium, perfluorinated compounds, and other substances of concern reduces risks to ecosystems and lessens the concentration of these substances in the population. Antimicrobial treatments may contain nanomaterials, which can cross biological barriers that protect human organs and tissues. Given uncertainty about the toxic effects and environmental infiltration of nanomaterials, a precautionary approach regarding their use is appropriate.[1]

This credit encourages project teams to select furniture and furnishings without substances that harm indoor air quality and human health. Additionally, it supports the use of products with environmentally responsible attributes and products from manufacturers that have taken steps to document and disclose quantified environmental product data in accordance with international standards.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY FURNITURE AND FURNISHINGS

Identify all free-standing furniture and medical furnishings that could contribute to credit achievement.

- Examples of items that are eligible under all three options include office and lounge furniture, surgical tables, procedure and supply carts, mobile technology carts, lifting and transfer aids, supply closet carts and shelving, and overbed tables (see *MR Overview, Qualifying Products and Exclusions*).
- Exclude base building elements, such as cabinets and casework; they are covered under the MR building product disclosure and optimization credits. (Conversely, furniture and medical furnishings are not eligible under building product disclosure and optimization.)

STEP 2. SPECIFY AND SELECT COMPLIANT PRODUCTS

Include performance requirements or sole-source compliant products in project specifications.

- Many products may contribute to multiple options. Early product research can help the project team find these opportunities and maximize the credit contribution of high-cost items.
- Added microbial treatments are typical for mattresses and textiles. Identifying products that meet performance requirements and sustainable requirements may involve additional research.
- Urea formaldehyde typically appears in adhesives and pressed-wood products. These are found in furniture with veneer finishes or composite wood cores. Alternatives are available.
- Hexavalent chromium is used in chrome-plated products to protect against wear and tear. One standard is the European Union's Restriction of Hazardous Substances Directive (RoHs), which limits the concentration of hexavalent chromium allowed in plating.
- Because credit compliance is based on percentage of total cost, it may be helpful to develop the furniture and furnishing budget early to ensure that the value of compliant products specified is sufficient to achieve the targeted point threshold.

STEP 3. TRACK FURNITURE AND MEDICAL FURNISHING PURCHASES

For each product expected to contribute to credit achievement, collect manufacturer's documentation that includes each product's environmental characteristics (e.g., hazardous chemical content, emissions, and recycled content). Collect cost information for all furniture and medical furnishings purchased for the project.

1. *Green Guide for Health Care Technical briefs; Tom Lent, Low Emitting Materials, Tom Lent, PBT Elimination form building Materials, and Lorissa MacAllister, Furniture and Medical Furnishings. http://www.gghc.org/tools.technical.php (accessed August 14, 2013).*

- Consider giving the contractor and vendors a tracking tool to record furniture and furnishing purchases. Table 1 shows a sample tracking tool that can be used to collect information and calculate credit compliance.
- Examples of acceptable documentation from manufacturers include product data sheets, manufacturers' letters, and test reports.
- Components that make up less than 5% of the product by weight do not need to be included in the calculations.
- If the actual cost to purchase a salvaged or reused item is not known, use its replacement value in the credit calculation: obtain pricing for a comparable item in the local market, excluding labor and shipping.
- If a vendor discount would typically be given to the product when purchased new, the replacement value should be the discounted price, not the list price.
- If the actual cost of the salvaged or reused item is greater than the replacement value, use the higher value (actual cost) of the new, equivalent item.

TABLE 1. Sample Tracking tool

Total furniture material cost (excluding labor):	$200,000
Total sustainably sourced furniture and medical furnishings (Option 1 + Option 2 + Option 3):	$110,000
Percentage sustainably sourced furniture and medical furnishings:	55%
Total points (30%: 1 point; 40%: 2 points):	2

Product information				
Description of product	**Manufacturer or vendor name**	**Material cost per item**	**# Purchased**	**Total value as purchased ($)**
Workstation Chairs	Sit-EZ Distributors	$200.000	100	$20,000
Waiting Room Chairs	Sit-EZ Distributors	$150.00	25	$3,750
Modular Workstations	NU Modular, Inc	$1,000.00	100	$1000,000

Chemical groups (Option 1 = 4 minimum, Option 2 = 2 minimum)						**Option 2**
Contains less than 100 parts per million (ppm) of urea-formaldehyde resin?	Contains less than 100 parts per million (ppm) of heavy metals including mercury, cadmium, lead, antimony?	Contains less than 100 parts per million (ppm) of hexavalent chromium in plated finishes (per RoHS)	Contains less than 100 parts per million (ppm) of stain and non-stick treatments derived from Perfluorinated Compounds (PFCs), including Perfluorooctanoic Acid (PFOA)?	Contains less than 100 parts per million (ppm) of added antimicrobial treatments?	Total # Chemical Compliant Groups	Product meets or exceeds IAQ requirements of CDPH/EHLB Standard Method 1.1?
Yes	Yes	Yes	Yes	No	4	No
Yes	Yes	Yes	No	No	3	Yes
n/a	n/a	n/a	n/a	n/a	0	No

Option 1 and 2 totals		Option 3									Option 3 Total
Total product value of products compliant with option 1	Total product value of products compliant with option 2	Materials Reuse	% Pre-Consumer Recycled Content * .5	% Post-Consumer Recycled Content	Extended Producer Responsibility	Industry Wide (generic) EPD * .5	Product Specific Declaration (LCA) * .25	Product Specific Type III EPD *1	Base contributing cost of products	% Locally Sourced	Total Sustainable Criteria Value with location valuation factor
$20,000		0%	0%	10%	Yes	No	No	Yes	$42,000	0%	$42,000
	$3,750	0%	10%	5%	No	Yes	No	No	$2,250	0%	$2,250
		$0	30%	0%	No	No	Yes	No	$40,000	5%	$42,000
Sub-total Option 3:		$0	$15,188	$2,188	$20,000	$3,750	$50,000	$200	$84,250		$86,250

STEP 4. CALCULATE SUSTAINABLE CRITERIA VALUE OF ALL COMPLIANT PRODUCTS

Using the data collected in the tracking tool, calculate the percentage of materials, by cost, that complies with the requirements for each option.

- For Options 1 and 2, the total value of each product that meets the criteria is included in the qualifying value for the credit.
- For Options 1 and 2, each component that makes up at least 5% of the product's weight must meet the requirement for chemical avoidance to qualify as sustainably sourced. Exclude components that constitute less than 5% (see *Further Explanation, Examples*). Additionally, for Option 2, products must also meet emissions requirements for the entire assembly.
- For Option 3, modify actual product costs as indicated in the credit requirements. This includes multipliers for certain options and calculating the compliant value for assemblies.
  - For product declaration guidance, see MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations, Option 1 Environmental Product Declaration.
  - For guidance regarding materials reuse, recycled content, biobased content, certified wood, and extended producer responsibility, see MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, Option 2 Leadership Extraction Practices.
- For products that meet criteria for more than one option, the total value can be counted for each option for which the product is fully compliant (see *Further Explanation, Examples*).

STEP 5. DETERMINE CREDIT ACHIEVEMENT

EQUATION 1. Percentage of sustainably sourced furniture and furnishings

$$\text{Total \%} = \left\{ \frac{(\text{Option 1 compliant value} + \text{Option 2 compliant value} + \text{Option 3 compliant value})}{\text{Total furniture and medical furnishing cost}} \right\} \times 100$$

Product cost = cost of the product contributing toward credit. For assemblies, the cost amount

contributing toward credit is based on weight (see *MR Overview, Determining Product Cost*).
Criterion valuation factor = multiplier assigned to each sourcing criterion:

- Products with product specific declarations, value .25, by cost
- Products with industry wide (generic) EPD, value .5, by cost
- Products with product specific Type III EPD, value 1.0, by cost
- Materials reuse, value 1.0, by cost
- Postconsumer recycled materials, value 1.0, by cost
- Preconsumer recycled materials, value 0.5, by cost
- Extended producer responsibility is valued at 50%; that is, the valuation factor is 0.5. Products that are part of an extended producer responsibility program may be counted in their entirety even if only part of the product is recycled.
- Biobased nonwood products meeting Sustainable Agriculture Standard, 1.0 value
- New wood products certified to FSC standards, value 1.0, by cost

Location valuation factor = multiplier for the extraction, manufacture, and purchase location (see *MR Overview, Location Valuation Factor*).

FURTHER EXPLANATION

CALCULATIONS

See calculation in *Step-by-Step Guidance*.

BUILDING PRODUCT DISCLOSURE AND OPTIMIZATION CREDITS REFERENCES

For information about EPDs and documentation of product-specific declarations, see MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations, *Further Explanation*.

For information about documentation for wood and biobased products, FSC chain of custody, recycled content definition and assemble determination, and extended producer responsibility, see MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, *Further Explanation*.

EXAMPLES

Evaluating Chemical Content

A nurses station chair consists of treated fabric, plastic components, fastening hardware (bolts and screws), steel post, metal base, and wheels. All components that constitute at least 5% of the product's total weight must comply with the chemical content limits for Option 1 or Option 2. Because it represents only 2% of the chair's weight, the fastening hardware does not need to comply.

Products That Comply with More Than One Option

A nurses station task chair has a materials cost of $500. According to the product data sheet, all components that constitute at least 5% of the chair, by weight, contain less than 100 ppm each of urea formaldehyde, mercury, lead, and hexavalent chromium. Therefore, the chair complies with Option 1.

Additionally, the manufacturer's documentation indicates that the chair has been tested and complies with the appropriate ANSI/BIFMA testing methodology, and thus it meets Option 2 requirements.

Because the chair meets the criteria for both options, its full cost, $500, can be applied twice, for a total sustainability value of $1,000.

Figure 1. Example of product assembly's contribution to multiple sustainable criteria

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3
MR furniture and medical furnishings calculator provided by USGBC	X	X	X
Documentation of product claims for credit criteria	X	X	X

RELATED CREDIT TIPS

MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations, Sourcing of Raw Materials, and Material Ingredients. Built-in casework is considered permanently installed and is included in the total cost calculations for materials in the three Building Product Disclosure and Optimization credits. It is therefore not included in the calculations for this credit. Furniture and medical furnishings cannot be counted toward any Building Product Disclosure and Optimization credits.

CHANGES FROM LEED 2009

- Air testing protocols for Option 2 have been updated to reflect leadership standards.
- Requirements in Option 3 have been modified to reflect changes to related Materials and Resources credits.

REFERENCED STANDARDS

Restriction of the Use of Certain Hazardous Substances of the European Union Directive (EU RoHS): eur-lex.europa.eu

American National Standard and The Business and Institutional Furniture Manufacturers Association Standard M7.1–2011: ANSI/BIFMA M7.1–2011:bifma.org/standards/standards.html

Furniture Sustainability Standard and level™ Certification Program. American National Standard and The Business and Institutional Furniture Manufacturers Association Standard e3–2011 for Furniture Sustainability: ANSI/BIFMA e3–2011: levelcertified.org

International Standard ISO 14025–2006, Environmental labels and declarations, Type III environmental declarations, Principles and procedures: iso.org

International Standard ISO 14040–2006, Environmental management, Life cycle assessment principals and frameworks: iso.org

International Standard ISO 14044–2006, Environmental management, Life cycle assessment Requirements and guidelines: iso.org

International Standard ISO 21930–2007, Sustainability in building construction, Environmental declaration of building products: iso.org

International Standards ISO 14021–1999, Environmental Labels and Declarations, Self-Declared Environmental Claims (**Type II Environmental Labeling**)**:** iso.org

EXEMPLARY PERFORMANCE

Use at least 50%, by cost, of all freestanding furniture and medical furnishings that meet the credit criteria.

DEFINITIONS

added antimicrobial treatment a substance added to a product (e.g., paint, flooring) to kill or inhibit the growth of microorganisms. Some products, such as linoleum, exhibit natural antimicrobial properties. Despite current practice, science has not proven that antimicrobial treatments reduce infection transfer in building finishes more effectively than standard cleaning procedures. Also known as added microbial agent. See U.S. EPA factsheet, Consumer Products Treated with Pesticides (www.epa.gov/pesticides factsheets/treatart.htm).

engineered nanomaterial a substance designed at the molecular (nanometer) level. Because of its small size, it has novel properties generally not seen in its conventional bulk counterpart. See the Australian National Industrial Chemicals Notification and Assessment Scheme, nicnas.gov.au/publications/information_sheets/general_information_sheets/nis_nanomaterials_pdf.pdf.

medical furnishing an item of furniture designed for use in health care. Examples include surgical tables; procedure, supply, and mobile technology carts; lifting and transfer aids; supply closet carts and shelving; and overbed tables.

persistent bioaccumulative toxic chemical a substance that poses a long-term risk to both humans and the environment because it remains in the environment for long periods, increases in concentration as it moves up the food chain, and can travel far from the source of contamination. Often these substances can become more potent and harmful to ecosystems the longer they persist. See U.S. EPA's website on persistent bioaccumulative toxic chemicals, www.epa.gov/pbt/.

MATERIALS AND RESOURCES CREDIT

Design for Flexibility

This credit applies to: **Healthcare (1 point)**

INTENT

Conserve resources associated with the construction and management of buildings by designing for flexibility and ease of future adaptation and for the service life of components and assemblies.

REQUIREMENTS

Increase building flexibility and ease of adaptive use over the life of the structure by employing at least three of the following strategies.

- Use interstitial space. Design distribution zone utility systems and equipment including HVAC, plumbing, electrical, information technology, medical gases, and life safety systems to serve the occupied zones and have the capacity to control multiple zones in clinical spaces.
- Provide programmed soft space, such as administration or storage, equal to at least 5% of departmental gross area (DGA). Locate soft space adjacent to clinical departments that anticipate growth. Determine a strategy for future accommodation of displaced soft space.
- Provide shell space equal to at least 5% of DGA. Locate it such that it can be occupied without displacing occupied space.
- Identify horizontal expansion capacity for diagnostic and treatment or other clinical space equal to at least 30% of existing floor area (excluding inpatient units) without demolition of occupied space (other than at the connection point). Reconfiguration of additional existing occupied space that has been constructed with demountable partition systems is permitted.
- Design for future vertical expansion on at least 75% of the roof, ensuring that existing operations and service systems can continue at or near capacity during the expansion.
- Designate space for future above-grade parking structures equal to 50% of existing on-grade parking capacity, with direct access to the main hospital lobby or circulation. Vertical transportation pathways that lead directly to the main hospital lobby or circulation are acceptable.
- Use demountable partitions for 50% of applicable areas.
- Use movable or modular casework for at least 50% of casework and custom millwork. Base the calculation on the combined value of casework and millwork, as determined by the cost estimator or contractor.

BEHIND THE INTENT

Health care practices and technologies are rapidly evolving, often requiring changes to the physical layout of health care facilities. In 2010, renovation projects accounted for more than 45% of the total cost of U.S. hospital construction.[1] Because health care facilities are not typically designed to accommodate future changes, the constant renovations can produce more debris than the initial new construction, increasing waste and environmental consequences over the life of the building. In addition, constant change can make it difficult to maintain energy efficiency and cost-effective operation.

Health care facilities intentionally designed for adaptive use are easier to renovate, reducing the resource inputs and waste generation associated with renovation. Movable wall partitions, for example, reduce the solid waste generated by demolition of permanent walls while avoiding raw material extraction for new walls. Rooms that use modular systems and standard design elements can be more easily altered for new technology and space requirements, extending the life of the building. This credit concentrates on flexibility for the portions of the building typically subject to change: the space plan (such as department layouts), services (such as HVAC or water), and movable items (such as furniture). Concentrating such flexible systems in areas subject to frequent renovations reduces source inputs and waste.

STEP-BY-STEP GUIDANCE

STEP 1. DEVELOP FLEXIBILITY GOALS

Establish goals and metrics for future flexibility to help focus the project team's efforts on a design that will work for both current and long-term needs.

- Obtain early commitment from the owner, architect, medical planner, design engineers, and contractor, among others, to design the facility for future flexibility.
- Work with the owner and other members of the project team in the predesign and schematic design phases to clarify possible scenarios for future renovation and expansion, and discuss how the design can help accommodate those potential changes.
- Resist the pressure to establish critical programmatic adjacencies and customize the building to specific program sizes and functional requirements; doing so early in the design phase can preclude strategies that offer flexibility.
- Determine which clinical programs are likely to grow, and locate shell or soft space to permit their expansion without major disruption or reconfiguration.

STEP 2. IDENTIFY AT LEAST THREE STRATEGIES TO MEET CREDIT REQUIREMENTS

Determine which design strategies outlined in the credit requirements will best help achieve the project team's goals for future flexibility.

- Some strategies focus on providing flexibility for future expansion; others prioritize changes within the existing building envelope, such as space planning modifications, mechanical system upgrades, and technology improvements.
- If expansion is anticipated, identify the likely size, location, and space types (see *Further Explanation, Designing for Future Expansion*).
- If the project site is constrained and vertical expansion is the only option, plan for additional structural, mechanical, and egress requirements.
- If flexibility is needed within the existing building envelope, select strategies like interstitial space, soft space, and shell space that allow for changes to rooms and building systems (see *Further Explanation, Designing for Future Flexibility within Existing Space*).

STEP 3. PRELIMINARY CALCULATIONS

Conduct preliminary calculations to determine whether the strategy thresholds are achievable. Calculations that will be helpful include the following:

- Departmental gross area. Add the area of all clinical departments in the building program, starting from the centerline of walls (see *Further Explanation, Determining Departmental Gross Area*).

1. *Carpenter, David, and Suzanna Hoppszallern, "2010 Hospital Building Report: Proceed with Caution," HFM Magazine (February 2010): 11–15, http://www.hfmmagazine.com/hfmmagazine/jsp/articledisplay.jsp?dcrpath=HFMMAGAZINE/Article/data/02FEB2010/1002HFM_FEA_CoverStory&domain=HFMMAGAZINE (accessed May 29, 2013).*

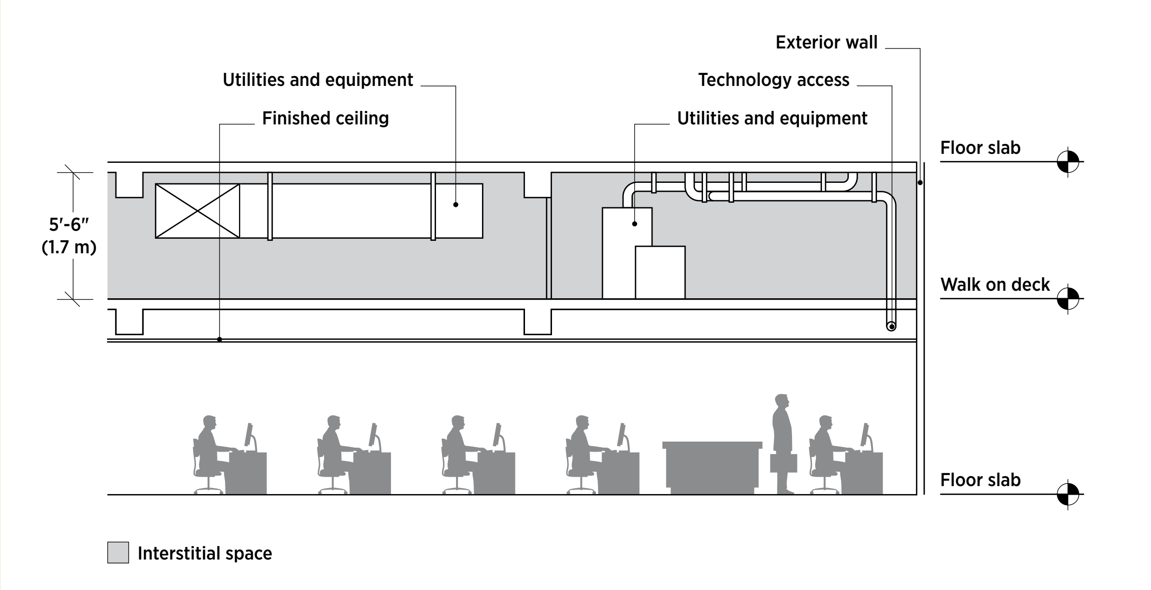
- Expansion area. For both vertical and horizontal exterior walls, determine the potential for areas eligible as expansion areas—places that allow for future additions without demolition of occupied space.
- Existing area (floor and parking). This is the area of the current project (whether a new building or a major renovation of an existing building), plus parking.
- Demountable partition area (see *Further Explanation, Applicable Areas for Demountable Partitions*).

STEP 4. CONFIRM THAT STRATEGIES MEET CREDIT REQUIREMENTS

Review the list of strategies to determine whether the scope of each selected project strategy achieves the required credit thresholds.

- Interstitial space. No calculation is required for this strategy; any use of space meeting the definition of interstitial space meets the requirements of this strategy. Design ample floor-to-floor heights with raised-floor distribution systems or systems in interstitial space to simplify future modifications. Install undifferentiated "technology floors" that can accommodate surgery, cardiology, and radiology programs in equally sized, adaptable modules.

Figure 1. Example of interstitial space between floors.



- Soft space. Calculate the percentage of total soft space area; it must be at least 5% of the total departmental gross area. Soft space is an area of which the function can be easily changed. One example is administrative offices or conference rooms adjacent to a lab, the specialized equipment and infrastructure of which are difficult to relocate; if the lab needs to expand, the offices or conference rooms can be moved. Optimize space by planning multiple uses for individual spaces. Office "hoteling" (flexible workstations shared by multiple users) and universal sizing (standardized rooms and workstations) contribute to soft space.
- Shell space. Calculate the percentage of total shell space area; it must be at least 5% of the total departmental gross area. Shell space is an area designed to be fitted out for future expansion. It is enclosed by the building envelope but otherwise left unfinished; it may not be climate controlled or illuminated, but adding these utilities would not disrupt hospital functions. Future fit-out of shell space is recommended to meet the same sustainable requirements as the rest of the project. The project team is encouraged to develop a set of fit-out guidelines for future use.
- Horizontal expansion. Calculate the percentage of area available for horizontal expansion; it must be more than 30% of the floor area available at the time of future expansion. Demolition of adjacent occupied areas is not permitted for horizontal expansion. Horizontal expansion of diagnostic or other clinical treatment space cannot go through an area occupied for other purposes, such as inpatient units, mechanical space, and circulation, unless the area has demountable partitions.

- Vertical expansion. Calculate the roof area and identify a portion that could accommodate vertical expansion without critically disrupting existing operations and service systems; it must be at least 75% of the total roof area.
    - Critical disruption typically means HVAC service is disrupted for critical areas or electricity for the building has to be cut off. It is up to the project team to determine a reasonable threshold for critical disruption.
    - Vertical expansion may be infeasible if the structure is not designed to accommodate additional loads. Ensure that the design of the structural elements (e.g., columns, bearing walls, lateral bracing, shear walls, transfer beams, foundations) can accommodate increased vertical loads, lateral loads, sliding, and overturning moments.
- Future parking structure. Calculate the area required to accommodate an additional 50% of existing on-grade parking in an above-grade parking structure and identify an on-site location for this expansion, based on the credit requirements. The expanded parking area must lead directly to the main lobby; the circulation pathway may include vertical systems such as elevators, stairs, or escalators to direct occupants to the main lobby.
- Demountable partitions. Calculate the total length, in linear distance, of full-height interior partitions within and around applicable areas. Ensure that the demountable partitions account for at least 50% of full-height interior partitions. To incorporate demountable and reconfigurable systems, designs may include prepackaged systems and detailing may call for screws and bolts in place of nails and adhesives. Consider systems that enable lighting and controls to be moved throughout an interior space without the need to rewire or reconfigure.
- Casework and millwork. Calculate the value of casework and custom millwork that is movable or modular; it must be at least 50% of the total value of all casework and millwork in the project. Include delivery and taxes but not installation or labor.

STEP 5. TRACK IMPLEMENTATION OF STRATEGIES THROUGHOUT PROJECT

Develop a system for tracking the implementation of selected strategies, particularly at major project milestones. Strategies that support future flexibility are often at risk of being removed during the design process because of space or budget pressures.

- Planning for shell space early in the design process may help avoid costly changes when new programmatic requirements are identified late in the design process.
- Programmed soft space may be reduced to accommodate required space changes in the design development phase.
- Review "at risk" strategies at major project milestones and work with the project team to ensure that optimal design flexibility is maintained.
- Ensure clear communication among all disciplines by clearly indicating strategies on a floor plan and in design documents.

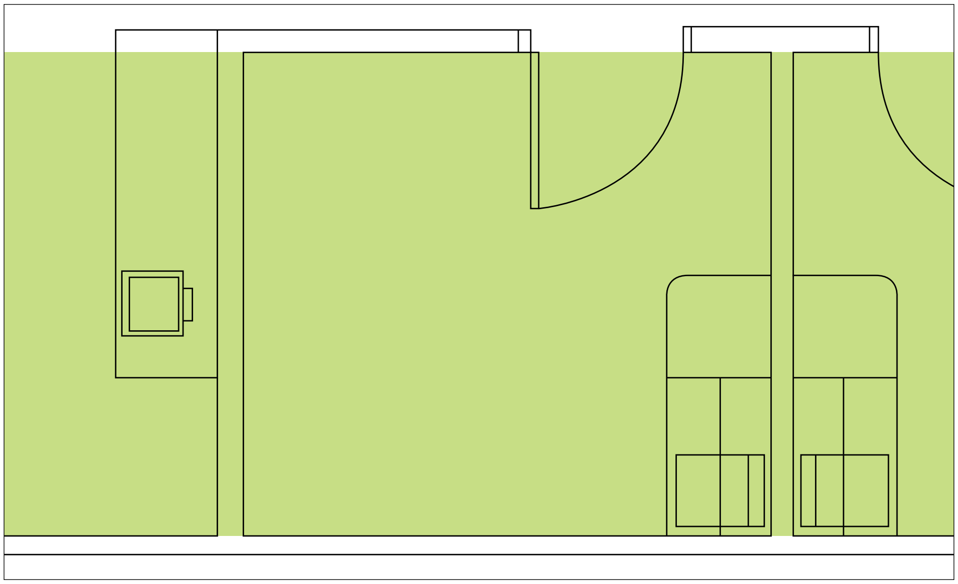
FURTHER EXPLANATION

DETERMINING DEPARTMENTAL GROSS AREA

Calculate the project's departmental gross area (DGA) by adding the area of all clinical departments in the building program, starting from the centerline of walls.

Include everything interior to the department and all areas required to support that department, such as hallways, interior walls and circulation spaces, and dedicated storage.

Do not include inpatient rooms, building equipment rooms, facilities departments, or storage and administration areas not associated with a diagnostic, treatment, or clinical department.



Gross Area: The area inside the centerline of the walls separating adjoining rooms.

GA

Figure 2. Floor area included in Gross Area calculation

OVERALL STRATEGIES FOR DESIGNING FOR FUTURE EXPANSION

Corridors and stairways should support future additions without demolition of occupied space. Locate stairs to provide an alternative to elevator use, and avoid exit tunnels. This will cause less disruption during future construction as well as reduce waste from demolition.

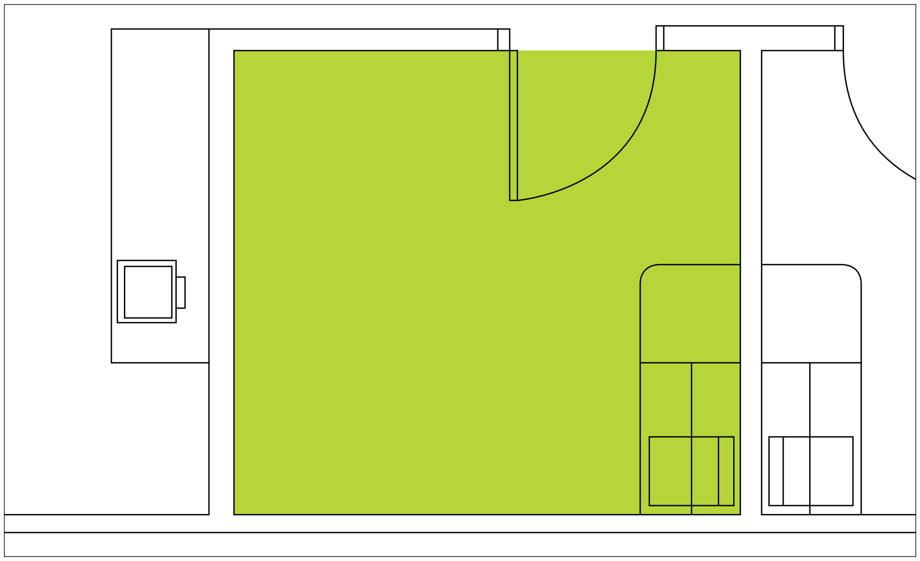
Oversize corridors, exit doors, and egress stairs to accommodate higher use. Design the structural system to accommodate vertical expansion through increased vertical loads, lateral loads, sliding, and overturning moments of structural elements (columns, bearing walls, lateral bracing, shear walls, transfer beams, foundations). If horizontal expansion is planned, design the façade to accommodate new openings and additions.

It is recommended that structural serviceability issues resulting from future expansion, such as vibration, vertical deflection, and drift, also be addressed.

APPLICABLE AREAS FOR DEMOUNTABLE PARTITIONS

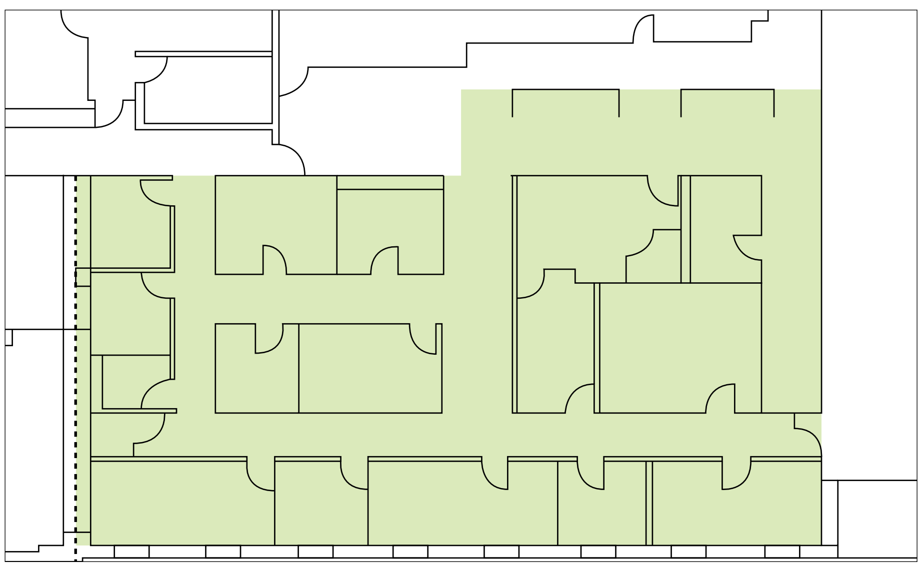
When determining which areas have linear surface applicable for demountable partitions, exclude the following:

- Areas that require medical staff to have emergency access to patients or where safety is a concern. These may be areas where drapery and screens are more appropriate privacy devices than walls.
- Walls that have life, safety, or health requirements by code, such as fire separation, detention, or smoke control. Examples include inpatient nursing units (such as ICU), surgery theaters, postanesthesia care units, emergency department treatment areas, and acute trauma. If other areas are excluded, provide the rationale.



Net Area: The area within the walls of a room or the usable floor area assigned to a function in an open area e.g., cubicles or workstations. The space includes casework, fixtures and door swings but does not include wall thickness.

NA



Departmental Gross Area (DGA): The area inside the centerline of the walls separating a department from adjoining areas; include internal walls, corridors, etc.

DGA

Figure 3 and 4. Net area and department gross area

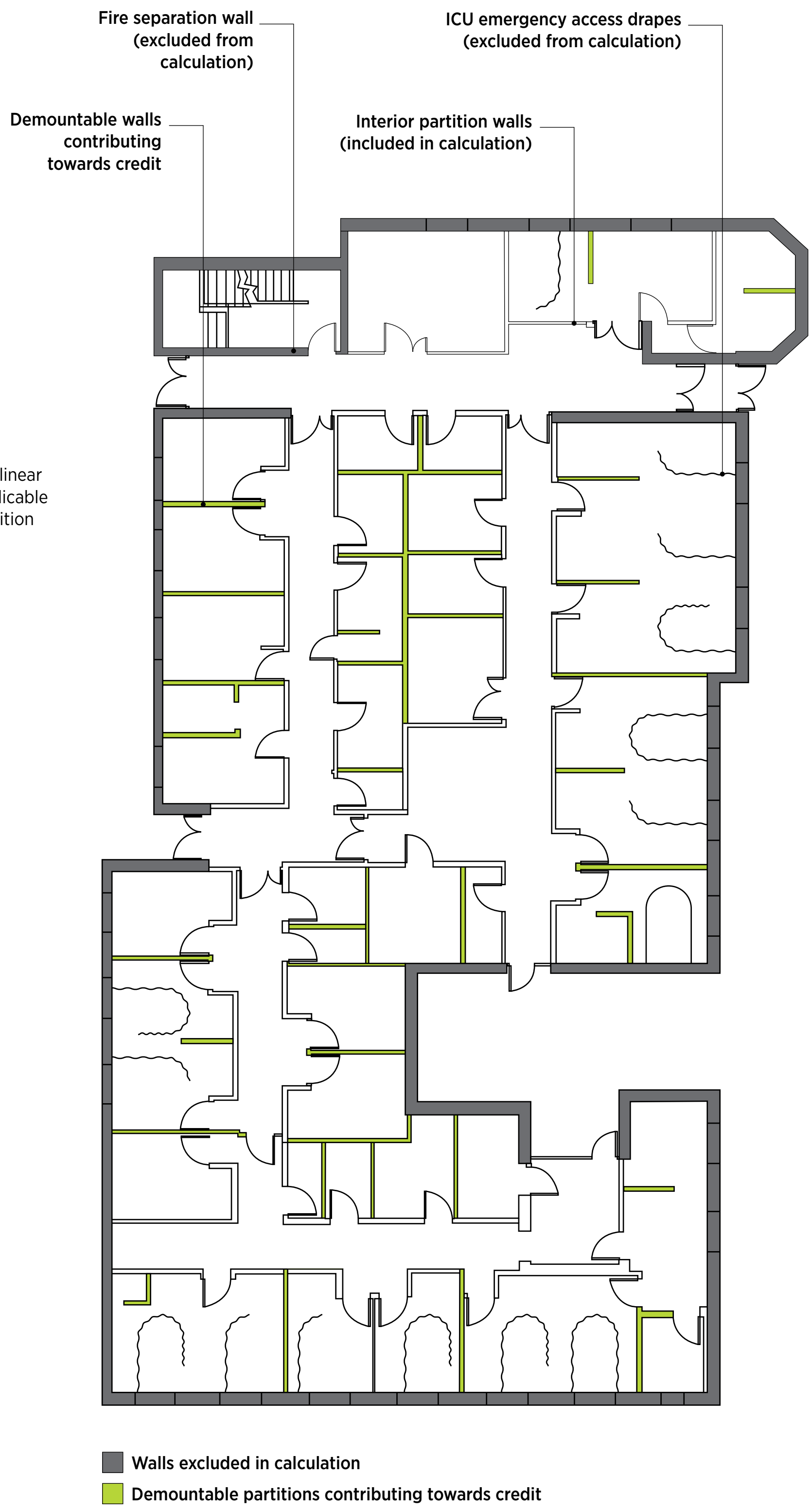


Figure 5. Example of linear surface locations applicable for demountable partition calculation

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects
Description of overall flexible design strategy	X
Calculations for departmental gross area showing areas required for each selected strategy	X
Floor plans or other documentation for areas using flexible design strategies	X
Calculations of floor area for soft space, shell space, expansion capacity, and future parking (if applicable)	X
Calculations of linear area for demountable partitions and description of excluded areas (if applicable)	X
Calculation of product costs for movable and modular casework (if applicable)	X

RELATED CREDIT TIPS

MR Prerequisite Construction and Demolition Waste Management Planning. Using modular systems and standard design elements can reduce waste generation during the construction phase.

MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations, Sourcing of Raw Materials, and Material Ingredients. Built-in casework is considered permanently installed and is included in the cost calculations for materials in the three related credits.

CHANGES FROM LEED 2009

There is no longer a minimum requirement for interstitial space.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

demountable partition a temporary interior wall that can be easily reconfigured. In a health care facility, acoustical concerns and embedded equipment, as in a surgery suite, may prevent demountable partitions from being used

departmental gross area (**DGA**) the floor area of a diagnostic and treatment of clinical department, calculated from the centerline of the walls separating the department from adjacent spaces. Walls and circulations space within the department are included in the calculation. This calculation excludes inpatient units.

interstitial space an intermediate space located between floors with a walk-on deck, often used to run the majority of the utility distribution and terminal equipment, thus permitting convenient installation, maintenance, and future modifications

modular and movable casework shelving and cabinetry designed to be easily installed, moved, or reconfigured. In a retail setting, items that are movable but semipermanently attached using mechanical fastening systems for operational use are considered furniture and not base building elements (e.g., a table or display bolted to the floor, or shelving attached to a wall)

shell space an area designed to be fitted out for future expansion. Shell space is enclosed by the building envelope but otherwise left unfinished.

soft space an area whose functions can be easily changed. For example, hospital administrative offices could be moved so that this soft space could be converted to a laboratory. In contrast, a lab with specialized equipment and infrastructure would be difficult to relocate.

structure elements carrying either vertical or horizontal loads (e.g., walls, roofs, and floors) that are considered structurally sound and nonhazardous

MATERIALS AND RESOURCES CREDIT

Construction and Demolition Waste Management

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.

REQUIREMENTS

Recycle and/or salvage nonhazardous construction and demolition materials. Calculations can be by weight or volume but must be consistent throughout.

Exclude excavated soil and land-clearing debris from calculations. Include materials destined for alternative daily cover (ADC) in the calculations as waste (not diversion). Include wood waste converted to fuel (biofuel) in the calculations; other types of waste-to-energy are not considered diversion for this credit.

However, for projects that cannot meet credit requirements using reuse and recycling methods, waste-to-energy systems may be considered waste diversion if the European Commission Waste Framework Directive 2008/98/EC and Waste Incineration Directive 2000/76/EC are followed and Waste to Energy facilities meet applicable European Committee for Standardization (CEN) EN 303 standards.

OPTION 1. DIVERSION (1–2 POINTS)

Path 1. Divert 50% and Three Material Streams (**1 point**)
Divert at least 50% of the total construction and demolition material; diverted materials must include at least three material streams.

OR

Path 2. Divert 75% and Four Material Streams (**2 points**)
Divert at least 75% of the total construction and demolition material; diverted materials must include at least four material streams.

OR

OPTION 2. REDUCTION OF TOTAL WASTE MATERIAL (2 POINTS)

Do not generate more than 2.5 pounds of construction waste per square foot (12.2 kilograms of waste per square meter) of the building's floor area.

BEHIND THE INTENT

Diversion of construction waste has increased greatly in recent years because of new market incentives, better recycling and reuse infrastructure, and more sophisticated sorting technology. However, the majority of diverted materials are those that occur in high volume, such as structural waste, or are easily resold, valuable materials such as metals.

Both planning and implementation are critical to reducing construction waste. This credit rewards projects that implement the plan created in MR Prerequisite Construction and Demolition Waste Management Planning. It encourages the diversion of a greater quantity and diversity of materials across multiple material steams by setting thresholds for both an overall diversion percentage and a minimum number of material streams. With an option that rewards waste reduction, the credit also offers an alternative to diversion.

For more on the benefits of diverting construction and demolition waste, please refer to the prerequisite.

STEP-BY-STEP GUIDANCE

The process for waste management should be developed as part of the construction waste management (CWM) plan in the corresponding prerequisite. Review the steps in MR Prerequisite Construction and Demolition Waste Planning and select an option.

- Option 1 focuses on diverting construction and demolition waste from landfills by implementing the CWM plan created in the prerequisite and meeting minimum thresholds.
- Option 2 is appropriate for projects implementing source reduction strategies in both the design and construction phases. Before selecting this option, estimate the amount of waste produced by the project to see whether the performance threshold is realistic.

Option 1. Diversion

STEP 1. IMPLEMENT CWM PLAN

Implement the procedures outlined in the CWM plan developed for the corresponding prerequisite to achieve diversion goals and meet minimum thresholds.

- Establish on-site infrastructure, practices, and policies for off-site sorting, and develop a tracking system, as applicable. Identify at least three material streams that will be diverted (see *Further Explanation, Identifying Material Streams*).
- Track all the construction and demolition waste leaving the site. Retain waste hauler reports for documentation. Record estimated weight or volume of materials that are reused on site or salvaged for reuse on other projects by subcontractors or vendors.
- Retain receipts and estimate weight or volume for materials donated to charities, reuse retailers, or other recipients that can verify and track incoming and outgoing materials.

To contribute to this credit, commingled waste diversion must comply with one of the following requirements:

- The waste-sorting facility provides a waste diversion percentage specific to the project's waste based on measurement of each component waste material. Visual inspection is not an acceptable method of evaluation for documenting this percentage.
- The project team uses the facility's average diversion rate, which must be regulated by the local or state authority and must exclude alternative daily cover (ADC). This system must be a closed system; shipping waste to another municipality to manage, thus burdening another system, does not count as diverting the waste.

STEP 2. CALCULATE DIVERSION RATE

Applying Equation 1 to the total waste generated and diverted, determine the construction and demolition waste diversion rate. To ensure that the credit requirements will be met, project teams should calculate the diversion rate periodically (e.g., monthly or bimonthly) so that adjustments can be made to meet diversion goals.

EQUATION 1. Diversion rate

$$\text{Diversion rate} = \frac{\text{Total waste diverted from landfill}}{\text{Total waste produced by project}} \times 100$$

- The performance threshold requires both a minimum diversion percentage and diversion of at least three (Path 1) or four (Path 2) material streams.
- Ensure that units are consistent for all materials, in either weight or volume.
- Diverted waste includes all recycled, salvaged, reused, and donated materials.
- ADC does not count as diversion but must be included in total construction and demolition waste.
- Exclude hazardous waste, land-clearing debris, soil, and landscaping materials.
- Projects that cannot meet the credit threshold via reuse or recycling are eligible to claim diversion through waste-to-energy systems, provided they meet applicable standards and requirements (see *Further Explanation, Waste-to-Energy*). Wood-derived fuel may contribute toward diversion.

STEP 3. PRODUCE CWM REPORT

Create a final waste report for the project that includes the following information:

- Total construction and demolition waste produced by the project
- Types of waste material and quantity of each material
- Total waste diverted and diversion rate (percentage)

The report must address ADC and other materials that are included in the calculation even if they do not count toward diversion. If a single hauler is used for all waste, this company may be able to provide this report. If multiple haulers or diversion strategies are used, the project team must compile waste management information from all sources into a single report.

Option 2. Reduction of Total Waste

STEP 1. DESIGN FOR REDUCED WASTE

Project teams should consider design strategies that will greatly reduce the amount of waste generated on site. Strategies such as prefabrication, modular construction, and designs that use industry standard sizes greatly reduce the amount of waste that needs to be managed and diverted from landfills and incinerators (see *Further Explanation, Source Reduction*).

STEP 2. CALCULATE TOTAL WASTE REDUCTION

Calculate threshold achievement using Equation 2.

EQUATION 2. Waste per area calculation

$$\text{Waste per area} = \frac{\text{Total construction and demolition waste generated}}{\text{Project gross floor area}}$$

- Under Option 2, materials reused on site do not count as waste.
- Include all waste materials donated, sent to reuse facilities, or reused on other projects.
- Include all waste materials sent to recycling facilities, landfills, and incinerators.

FURTHER EXPLANATION

CALCULATIONS

See credit calculations in *Step-by-Step Guidance*.

WASTE TRACKING (OPTION 1)

One best practice is tracking waste throughout the entire project. The project team may determine the best strategy for ongoing tracking, which will then feed into the construction and demolition waste management calculator provided by USGBC or an equivalent tracking tool.

Web-based tools can provide contractors with an easy, step-by-step process for electronically tracking and submitting waste management and recycling plans. Electronic tracking can save them time and money by identifying materials that can be recycled, locating the nearest recycling facilities, following recycling progress in real time, gathering comprehensive statistics, and creating reports regarding waste generation and recycling for project, clients, company, government, as well as for green rating systems.

Some tools provide LEED credit templates so that data can be transferred directly to LEED report formats.

TABLE 1. Sample waste-tracking tool

Material stream		Diverted waste per report date				Total	Units
		Sept	Oct	Nov	Dec		
Material streams contributing toward credit	Plastic	1.25	2.5	10	5	18.75	yards
	Carpet	2.5	2.5	2.5	0	7.5	yards
	Paper/Cardboard	5	2.5	2.5	5	15	yards
	Clean Wood	0	25	0	1.25	26.25	yards
	Metal	1.25	2.5	5.5	7	16.25	yards
	Sheetrock	2.5	2.5	4	5	14	yards
	Brick/Concrete Masonry	10.5	2.5	5.5	8.75	27.25	yards
	Asphalt Shingles	10	0	0	0	10	yards
					Total diverted waste	135	yards
Material streams not contributing toward credit	Landfill	10.75	7.5	15	10	43.25	yards
	Screen Fines (ADC)	5	1.25	0	2.5	8.75	yards
	6″ Minus (ADC)	1.25	1.25	5	5.5	13	yards
					Total landfill/ADC waste	65	yards
					Total waste	200	yards
					Percent (%) diverted	67.5	%

IDENTIFYING MATERIAL STREAMS

Under Option 1 of this credit, project teams must divert at least three material streams from landfill. A material stream is defined as a flow of materials coming from a job site into markets for building materials. A stream can be either of the following:

- a specific material category that is diverted in a specific way; or
- a mixture of several material categories that are diverted in a specific way.

Examples of material streams include deconstructed materials sent to reuse markets, commingled waste sent to mixed-waste recycling facility, source separation where each material is sent to a specific facility, manufacturers' or suppliers' take-back of materials, and reuse of deconstructed materials on-site.

As a best practice, a material stream should constitute at least 5% (by weight or volume) of total diverted materials. The option requires that multiple material streams be diverted for several reasons: to stimulate markets for recovered materials by keeping materials separated at the job site, thus increasing recycling rate of materials; to encourage better project planning, job site diversion best practices, and new sorting and diversion techniques; and to encourage manufacturers to use closed-loop product systems.

WASTE-TO-ENERGY

Waste-to-energy may be considered a viable diversion strategy if the project team follows the European Commission Waste Framework Directive 2008/98/EC and the European Commission Waste Incineration Directive 2000/76/EC. These standards consist of performance metrics of both efficiency and emissions for different types of energy recovery systems. In addition, the facility must meet the applicable European standards based on the fuel type. See *Referenced Standards* for more information on these directives:

- EN 303-1—1999/A1—2003, Heating boilers with forced draught burners
- EN 303-2—1998/A1—2003, Heating boilers with forced draught burners
- EN 303-3—1998/AC—2006, Gas-fired central heating boilers
- EN 303-4—1999, Heating boilers with forced draught burners
- EN 303-5—2012, Heating boilers for solid fuels
- EN 303-6—2000, Heating boilers with forced draught burners
- EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner

Project teams pursuing this compliance option must demonstrate that reuse and recycling strategies were exhausted before sending material to waste-to-energy facilities.

The combustion of wood or "wood-derived fuel" is not considered waste-to-energy and is exempt from the criteria above.

SOURCE REDUCTION

Source reduction eliminates waste produced by a project in the following three ways:

- Prefabrication is a viable alternative for many wall assemblies. Because prefabrication occurs off site in a dedicated facility, the manufacturer can achieve high efficiencies in its use of equipment and materials, thereby reducing waste.
- Modular designs are likely to have a longer lifespan if they use of durable materials and permanent fastening. They are also safer to build because large assemblies are constructed in controlled environments, reducing workers' exposure to elevated work tasks.
- Designing for standard material lengths eliminates large amounts of off-cuts and scrap. If incorporated early in the design process, this strategy does not add additional cost to a project.

Under Option 2, exclude on-site reused materials. Materials reused on site are not considered waste for the purposes of calculating this option only.

CAMPUS

Group Approach

All buildings in the group may be documented as one. Multiple buildings on a campus may share waste hauling contracts and on-site collection equipment. Data aggregation is allowed, provided that each building included is pursuing the same option.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
MR Construction and Demolition Waste Management calculator or equivalent tool, tracking total and diverted waste amounts and material streams	X	
Documentation of recycling rates for commingled facilities (if applicable)	X	
Justification narrative for use of waste-to-energy strategy (if applicable)	X	
Documentation of waste-to-energy facilities adhering to relevant EN standards (if applicable)	X	
Total waste per area		X

RELATED CREDIT TIPS

MR Prerequisite Construction and Demolition Waste Management Planning. The diversion accomplished in this credit should be done according to the plan developed in the related prerequisite.

CHANGES FROM LEED 2009

- A compliance option has been added for total project waste reduction per gross floor area of the project.
- Multiple material streams must be diverted to earn the credit for waste diversion (Option 1).
- ADC has been specifically excluded from diversion calculations. In LEED 2009, it was allowed to count as diverted waste.
- Waste-to-energy may count as a diversion method if the facility meets European Union requirements for waste management and emissions into air, soil, surface water, and groundwater.

REFERENCED STANDARDS

Certification of Sustainable Recyclers: recyclingcertification.org

European Commission Waste Framework Directive 2008/98/EC:

- ec.europa.eu/environment/waste/framework/index.htm
- eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

European Commission Waste Incineration Directive 2000/76/EC:

- europa.eu/legislation_summaries/environment/waste_management/l28072_en.htm
- central2013.eu/fileadmin/user_upload/Downloads/Document_Centre/OP_Resources/Incineration_Directive_2000_76.pdf

EN 303-1—1999/A1—2003, Heating boilers with forced draught burners, Terminology, general requirements, testing and marking: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-2—1998/A1—2003, Heating boilers with forced draught burners, Special requirements for boilers with atomizing oil burners: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-3—1998/AC—2006, Gas-fired central heating boilers, Assembly comprising a boiler body and a forced draught burner: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-4—1999, Heating boilers with forced draught burners, Special requirements for boilers with forced draught oil burners with outputs up to 70 kW and a maximum operating pressure of 3 bar, Terminology, special requirements, testing and marking: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-5—2012, Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-6—2000, Heating boilers with forced draught burners, Specific requirements for the domestic hot water operation of combination boilers with atomizing oil burners of nominal heat input not exceeding 70 kW: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner of nominal heat output not exceeding 1000 kW: cen.eu/cen/Products/Search/Pages/default.aspx

EXEMPLARY PERFORMANCE

Achieve both Option 1 (either Path 1 or Path 2) and Option 2.

DEFINITIONS

alternative daily cover (**ADC**) material other than earthen material placed on the surface of the active face of a municipal solid waste landfill at the end of each operating day to control vectors, fires, odors, blowing litter, and scavenging. Generally these materials must be processed so they do not allow gaps in the exposed landfill face. (CalRecycle)

clean waste nonhazardous materials left over from construction and demolition. Clean waste excludes lead and asbestos.

commingled waste building waste streams that are combined on the project site and hauled away for sorting into recyclable streams. Also known as single-stream recycling.

land-clearing debris and soil materials that are natural (e.g., rock, soil, stone, vegetation). Materials that are man-made (e.g., concrete, brick, cement) are considered construction waste even if they were on site.

source separated construction or demolition waste materials that are sorted into separate bins on the project site (aka on-site). This waste strategy often isolates waste materials targeted for reuse, donation, or recycling programs. Typically, sorted materials on-site include m**et**als, wood, ceiling tiles, furniture, and concrete.

waste diversion a management activity that disposes of waste through methods other than incineration or landfilling. Examples include reuse and recycling.

waste-to-energy the conversion of nonrecyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery

Indoor Environmental Quality (EQ)

OVERVIEW

The Indoor Environmental Quality (EQ) category rewards decisions made by project teams about indoor air quality and thermal, visual, and acoustic comfort. Green buildings with good indoor environmental quality protect the health and comfort of building occupants. High-quality indoor environments also enhance productivity, decrease absenteeism, improve the building's value, and reduce liability for building designers and owners.[1] This category addresses the myriad design strategies and environmental factors—air quality, lighting quality, acoustic design, control over one's surroundings—that influence the way people learn, work, and live.

The relationship between the indoor environment and the health and comfort of building occupants is complex and still not fully understood. Local customs and expectations, occupants' activities, and the building's site, design, and construction are just a few of the variables that make it difficult to quantify and measure the direct effect of a building on its occupants.[2] Therefore, the EQ section balances the need for prescriptive measures with more performance-oriented credit requirements. For example, source control is addressed first, in a prerequisite, and a later credit then specifies an indoor air quality assessment to measure the actual outcome of those strategies.

The EQ category combines traditional approaches, such as ventilation and thermal control, with emerging design strategies, including a holistic, emissions-based approach (Low-Emitting Materials credit), source control and monitoring for user-determined contaminants (Enhanced Indoor Air Quality Strategies credit), requirements for lighting quality (Interior Lighting credit), and advanced lighting metrics (Daylight credit). A new credit covering acoustics is now available for all projects using a BD+C rating system.

1. *U.S. Environmental Protection Agency, Health Buildings Healthy People: A Vision for the 21st Century, epa.gov/iaq/pubs/hbhp.html (October 2001) (accessed July 25, 2013).*
2. *Mitchell, Clifford S., Junfeng Zhang, Torben Sigsgaard, Matti Jantunen, Palu J. Lioy, Robert Samson, and Meryl H. Karol, Current State of the Science: Health Effects and Indoor Environmental Quality, Environmental Health Perspectives 115(6) (June 2007).*

CROSS-CUTTING ISSUES

FLOOR AREA CALCULATIONS AND FLOOR PLANS

For many of the credits in the EQ category, compliance is based on the percentage of floor area that meets the credit requirements. In general, floor areas and space categorization should be consistent across EQ credits. Any excluded spaces or discrepancies in floor area values should be explained and highlighted in the documentation. See S*pace Categorization*, below, for additional information on which floor area should be included in which credits.

SPACE CATEGORIZATION

The EQ category focuses on the interaction between the occupants of the building and the indoor spaces in which they spend their time. For this reason, it is important to identify which spaces are used by the occupants, including any visitors (transients), and what activities they perform in each space. Depending on the space categorization, the credit requirements may or may not apply (Table 1).

Occupied versus unoccupied space

All spaces in a building must be categorized as either occupied or unoccupied. Occupied spaces are enclosed areas intended for human activities. Unoccupied spaces are places intended primarily for other purposes; they are occupied only occasionally and for short periods of time—in other words, they are inactive areas.

Examples of spaces that are typically unoccupied include the following:

- Mechanical and electrical rooms
- Egress stairway or dedicated emergency exit corridor
- Closets in a residence (but a walk-in closet is occupied)
- Data center floor area, including a raised floor area
- Inactive storage area in a warehouse or distribution center

For areas with equipment retrieval, the space is unoccupied only if the retrieval is occasional.

Regularly versus nonregularly occupied spaces

Occupied spaces are further classified as regularly occupied or nonregularly occupied, based on the duration of the occupancy. Regularly occupied spaces are enclosed areas where people normally spend time, defined as more than one hour of continuous occupancy per person per day, on average; the occupants may be seated or standing as they work, study, or perform other activities. For spaces that are not used daily, the classification should be based on the time a typical occupant spends in the space when it is in use. For example, a computer workstation may be largely vacant throughout the month, but when it is occupied, a worker spends one to five hours there. It would then be considered regularly occupied because that length of time is sufficient to affect the person's well-being, and he or she would have an expectation of thermal comfort and control over the environment.

Occupied spaces that do not meet the definition of regularly occupied are nonregularly occupied; these are areas that people pass through or areas used an average of less than one hour per person per day.

Examples of regularly occupied spaces include the following:

- Airplane hangar
- Auditorium
- Auto service bay
- Bank teller station
- Conference room
- Correctional facility cell or day room
- Data center network operations center
- Data center security operations center
- Dorm room
- Exhibition hall
- Facilities staff office
- Facilities staff workstation
- Food service facility dining area
- Food service facility kitchen area
- Gymnasium
- Hospital autopsy and morgue
- Hospital critical-care area
- Hospital dialysis and infusion area
- Hospital exam room
- Hospital operating room
- Hospital patient room
- Hospital recovery area
- Hospital staff room
- Hospital surgical suite
- Hospital waiting room
- Hospital diagnostic and treatment area
- Hospital laboratory
- Hospital nursing station
- Hospital solarium
- Hospital waiting room
- Hotel front desk
- Hotel guest room
- Hotel housekeeping area
- Hotel lobby
- Information desk
- Meeting room
- Natatorium
- Open-office workstation
- Private office
- Reception desk
- Residential bedroom
- Residential dining room
- Residential kitchen
- Residential living room
- Residential office, den, workroom
- Retail merchandise area and associated circulation
- Retail sales transaction area
- School classroom
- School media center
- School student activity room
- School study hall
- Shipping and receiving office
- Study carrel
- Warehouse materials-handling area

Examples of nonregularly occupied spaces include the following:

- Break room
- Circulation space
- Copy room
- Corridor
- Fire station apparatus bay
- Hospital linen area
- Hospital medical record area
- Hospital patient room bathroom
- Hospital short-term charting space
- Hospital prep and cleanup area in surgical suite
- Interrogation room
- Lobby (except hotel lobby)*
- Locker room
- Residential bathroom
- Residential laundry area
- Residential walk-in closet
- Restroom
- Retail fitting area
- Retail stock room
- Shooting range
- Stairway

** Hotel lobbies are considered regularly occupied because people often congregate, work on laptops, and spend more time there than they do in an office building lobby.*

Occupied space subcategories

Occupied spaces, or portions of an occupied space, are further categorized as individual or shared multioccupant, based on the number of occupants and their activities. An individual occupant space is an area where someone performs distinct tasks. A shared multioccupant space is a place of congregation or a place where people pursue overlapping or collaborative tasks. Occupied spaces that are not regularly occupied or not used for distinct or collaborative tasks are neither individual occupant nor shared multioccupant spaces.

Examples of individual occupant spaces include the following:

- Bank teller station
- Correctional facility cell or day room
- Data center staff workstation
- Hospital nursing station
- Hospital patient room
- Hotel guest room
- Medical office
- Military barracks with personal workspaces
- Open-office workstation
- Private office
- Reception desk
- Residential bedroom
- Study carrel

Examples of shared multioccupant spaces include the following:

- Active warehouse and storage
- Airplane hangar
- Auditorium
- Auto service bay
- Conference room
- Correctional facility cell or day room
- Data center network operations center
- Data center security operations center
- Exhibition hall
- Facilities staff office
- Food service facility dining area
- Food service facility kitchen area
- Gymnasium
- Hospital autopsy and morgue
- Hospital critical-care area
- Hospital dialysis and infusion area
- Hospital exam room
- Hospital operating room
- Hospital surgical suite
- Hospital waiting room
- Hospital diagnostic and treatment area
- Hospital laboratory
- Hospital solarium
- Hotel front desk
- Hotel housekeeping area
- Hotel lobby
- Meeting room
- Natatorium
- Retail merchandise area and associated circulation
- Retail sales transaction area
- School classroom
- School media center
- School student activity room
- School study hall
- Shipping and receiving office
- Warehouse materials-handling area

Occupied spaces can also be classified as densely or nondensely occupied, based on the concentration of occupants in the space. A densely occupied space has a design occupant density of 25 people or more per 1,000 square feet (93 square meters), or 40 square feet (3.7 square meters) or less per person. Occupied spaces with a lower density are nondensely occupied.

Table 1 outlines the relationship between the EQ credits and the space categorization terms. If the credit is listed, the space must meet the requirements of the credit.

TABLE 1. Space types in EQ credits

Space Category	Prerequisite or credit
Occupied space	• Minimum Indoor Air Quality Performance, ventilation rate procedure and natural ventilation procedure • Minimum Indoor Air Quality Performance, monitoring requirements • Enhanced Indoor Air Quality Strategies, Option 1 C • Enhanced Indoor Air Quality Strategies, Option 1 D • Enhanced Indoor Air Quality Strategies, Option 1 E • Enhanced Indoor Air Quality Strategies, Option 2 B • Enhanced Indoor Air Quality Strategies, Option 2 E • Indoor Air Quality Assessment, Option 2, Air Testing (sampling must be representative of all occupied spaces) • Thermal Comfort (New Construction, Schools, Retail, Hospitality), design requirements • Acoustic Performance (New Construction, Data Centers, Warehouses and Distribution Centers, Hospitality)
Regularly occupied space	• Thermal Comfort, design requirements (Data Centers) • Interior Lighting, Option 2, strategy A • Interior Lighting, Option 2, strategy D • Interior Lighting, Option 2, strategy E • Interior Lighting, Option 2, strategy G • Interior Lighting, Option 2, strategy H • Daylight • Quality Views
Individual occupant space	• Thermal Comfort, control requirements • Interior Lighting, Option 1
Shared multioccupant space	• Thermal Comfort, control requirements • Interior Lighting, Option 1
Densely occupied space	• Enhanced Indoor Air Quality Strategies, Option 2 C

Table 2 outlines the relationship between the EQ credits and the space categorization terms specific to each rating system (see *Definitions*). Unless otherwise stated, if the credit is listed, the space must meet the requirements of the credit.

TABLE 2. Rating system–specific space classifications

Rating system	Space type	Prerequisite or credit
Schools	Classroom and core learning spaces	• Minimum Acoustic Performance • Acoustic Performance (Schools)
Hospitality	Guest rooms	• Interior Lighting* • Thermal Comfort, control requirements*
Healthcare	Patient rooms	• Thermal Comfort, control requirements • Interior Lighting, Option 2, Lighting Quality
Healthcare	Staff areas	• Interior Lighting, Option 2, Lighting Quality
Healthcare	Perimeter area	• Daylight • Quality Views
Healthcare	Inpatient units	• Quality Views
Warehouses & Distribution Centers	Office areas	• Thermal Comfort, design requirements • Quality Views
Warehouses & Distribution Centers	Areas of bulk storage, sorting, and distribution	• Thermal Comfort, design requirements • Quality Views
Retail	Office and administrative areas	• Thermal Comfort, control requirements • Interior Lighting, Option 2, Lighting Quality
Retail	Sales areas	• Interior Lighting, Option 2, Lighting Quality

*Hotel guest rooms are excluded from the credit requirements.

The following credits are not affected by space classifications:

- Environmental Tobacco Smoke Control
- Enhanced Indoor Air Quality Strategies, Option 1 A
- Enhanced Indoor Air Quality Strategies, Option 1 B
- Enhanced Indoor Air Quality Strategies, Option 2 A
- Enhanced Indoor Air Quality Strategies, Option 2 D (no specific spaces; applicable spaces are determined by the project team)
- Low-Emitting Materials
- Construction Indoor Air Quality Management Plan
- Indoor Air Quality Assessment, Option 1, Flush-Out (the floor area from all spaces must be included in calculation for total air volume; the flush-out must be demonstrated at the system level.)
- Interior Lighting, Option 2, strategy B
- Interior Lighting, Option 2, strategy C
- Interior Lighting, Option 2, strategy F
- Acoustic Performance (Healthcare)

TRICKY SPACES

Pay extra attention to how the following types of spaces are classified in specific credits.

Residential

- Minimum Indoor Air Quality Performance and Environmental Tobacco Smoke have specific requirements and considerations for residential projects.

- See the *Further Explanation, Project Type Variations* sections in Thermal Comfort and Interior Lighting for guidance on providing appropriate controllability in residential buildings.

Auditoriums

- Exceptions to Daylight and Quality Views are permitted. See the *Further Explanation, Project Type Variations* sections in Daylight and Quality Views.

Gymnasiums

- See the *Further Explanation, Project Type Variations* section in Thermal Comfort for guidance on dealing with high levels of physical activity.
- Exceptions to Quality Views are permitted. See the *Further Explanation, Project Type Variations* section in Quality Views.

Transportation Terminals

- For Thermal Comfort and Interior Lighting, Option 1, Lighting Control, most of the areas in a transportation terminal can be considered shared multioccupant. Most areas in transportation terminals are also regularly occupied.

Dormitories and Military Barracks

- These spaces fall in-between a work space and residence.
- Dorm rooms or military barracks with personal workspaces are considered individual occupant spaces. Military barracks without personal workspaces are considered shared multioccupant.

Industrial Facilities

- For Thermal Comfort and Interior Lighting, Option 1, Lighting Control, most of the active warehouse and storage areas are considered multioccupant.
- Most areas in industrial facilities are also regularly occupied.

INDOOR ENVIRONMENTAL QUALITY PREREQUISITE

Minimum Indoor Air Quality Performance

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

Meet the requirements for both ventilation and monitoring.

Ventilation

Mechanically Ventilated Spaces

OPTION 1. ASHRAE STANDARD 62.1–2010

For mechanically ventilated spaces (and for mixed-mode systems when the mechanical ventilation is activated), determine the minimum outdoor air intake flow for mechanical ventilation systems using the ventilation rate procedure from ASHRAE 62.1–2010 or a local equivalent, whichever is more stringent.

Meet the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quality (with errata), or a local equivalent, whichever is more stringent.

OPTION 2. CEN STANDARDS EN 15251–2007 AND EN 13779–2007

Projects outside the U.S. may instead meet the minimum outdoor air requirements of Annex B of Comité Européen de Normalisation (CEN) Standard EN 15251–2007, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics; and meet the requirements of CEN Standard EN 13779–2007, Ventilation for nonresidential buildings, Performance requirements for ventilation and room conditioning systems, excluding Section 7.3, Thermal environment; 7.6, Acoustic environment; A.16; and A.17.

Naturally Ventilated Spaces

For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), determine the minimum outdoor air opening and space configuration requirements using the natural ventilation procedure from ASHRAE Standard 62.1–2010 or a local equivalent, whichever is more stringent. Confirm that natural ventilation is an effective strategy for the project by following the flow diagram in the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Nondomestic Buildings, Figure 2.8, and meet the requirements of ASHRAE Standard 62.1–2010, Section 4, or a local equivalent, whichever is more stringent.

All Spaces

The indoor air quality procedure defined in ASHRAE Standard 62.1–2010 may not be used to comply with this prerequisite.

Monitoring

Mechanically Ventilated Spaces

For mechanically ventilated spaces (and for mixed-mode systems when the mechanical ventilation is activated), monitor outdoor air intake flow as follows:

- For variable air volume systems, provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow. This device must measure the minimum outdoor air intake flow with an accuracy of +/–10% of the design minimum outdoor airflow rate, as defined by the ventilation requirements above. An alarm must indicate when the outdoor airflow value varies by 15% or more from the outdoor airflow setpoint.
- For constant-volume systems, balance outdoor airflow to the design minimum outdoor airflow rate defined by ASHRAE Standard 62.1–2010 (with errata), or higher. Install a current transducer on the supply fan, an airflow switch, or similar monitoring device.

Naturally Ventilated Spaces

For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), comply with at least one of the following strategies.

- Provide a direct exhaust airflow measurement device capable of measuring the exhaust airflow. This device must measure the exhaust airflow with an accuracy of +/–10% of the design minimum exhaust airflow rate. An alarm must indicate when airflow values vary by 15% or more from the exhaust airflow setpoint.
- Provide automatic indication devices on all natural ventilation openings intended to meet the minimum opening requirements. An alarm must indicate when any one of the openings is closed during occupied hours.
- Monitor carbon dioxide (CO_2) concentrations within each thermal zone. CO_2 monitors must be between 3 and 6 feet (900 and 1 800 millimeters) above the floor and within the thermal zone. CO_2 monitors must have an audible or visual indicator or alert the building automation system if the sensed CO_2 concentration exceeds the setpoint by more than 10%. Calculate appropriate CO_2 setpoints using the methods in ASHRAE 62.1–2010, Appendix C.

CORE AND SHELL ONLY

Mechanical ventilation systems installed during core and shell construction must be capable of meeting projected ventilation levels and monitoring based on the requirements of anticipated future tenants.

RESIDENTIAL ONLY

In addition to the requirements above, if the project building contains residential units, each dwelling unit must meet all of the following requirements.

- Unvented combustion appliances (e.g., decorative logs) are not allowed.
- Carbon monoxide monitors must be installed on each floor of each unit.
- All indoor fireplaces and woodstoves must have solid glass enclosures or doors that seal when closed.
- Any indoor fireplaces and woodstoves that are not closed combustion or power-vented must pass a backdraft potential test to ensure that depressurization of the combustion appliance zone is less than 5 Pa.
- Space- and water-heating equipment that involves combustion must be designed and installed with closed combustion (i.e., sealed supply air and exhaust ducting) or with power-vented exhaust, or located in a detached utility building or open-air facility.
- For projects in high-risk areas for radon, EPA Radon Zone 1 (or local equivalent for projects outside the U.S.), design and construct any dwelling unit on levels one through four above grade with radon-resistant construction techniques. Follow the techniques prescribed in EPA Building Radon Out; NFPA 5000, Chapter 49; International Residential Code, Appendix F; CABO, Appendix F; ASTM E1465; or a local equivalent, whichever is most stringent.

HEALTHCARE

Meet the following requirements for both ventilation and monitoring.

Mechanically Ventilated Spaces

For mechanically ventilated spaces (and for mixed-mode systems when the mechanical ventilation is activated), determine the minimum outdoor air intake flow for mechanical ventilations systems using the ventilation rates in ASHRAE Standard 170–2008, Section 7; the requirements of the 2010 FGI Guidelines for Design and Construction of Health Care Facilities (Table 2.1–2); or a local equivalent, whichever is most stringent. For any area not covered in 170 or the FGI guidelines, follow ASHRAE 62.1 or a local equivalent, whichever is more stringent and meet the minimum requirements of ASHRAE Standard 170–2008, Sections 6–8, Ventilation of Health Care Facilities (with errata) or a USGBC-approved equivalent standard for projects outside the U.S.

Naturally Ventilated Spaces

For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), determine the minimum outdoor air opening and space configuration requirements using the natural ventilation procedure of ASHRAE Standard 62.1–2010 (with errata) or a local equivalent, whichever is more stringent. Confirm that natural ventilation is an effective strategy for the project by following the flow diagram in Figure 2.8 of the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Nondomestic Buildings.

Mechanically Ventilated Spaces

For mechanically ventilated spaces (and for mixed-mode systems when the mechanical ventilation is activated), provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow. This device must measure the minimum outdoor air intake flow with an accuracy of +/–10% of the design minimum outdoor airflow rate defined by the ventilation requirements above. An alarm must alert staff whenever the outdoor airflow value varies by 15% or more from the outdoor airflow setpoint.

Naturally Ventilated Spaces

For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), comply with at least one of the following strategies.

- Provide a direct exhaust airflow measurement device capable of measuring the exhaust airflow with an accuracy of +/–10% of the design minimum exhaust airflow rate. An alarm must indicate when airflow values vary by 15% or more from the exhaust airflow setpoint.
- Provide automatic indication devices on all natural ventilation openings intended to meet the minimum opening requirements. An alarm must indicate when any one of the openings is closed during occupied hours.
- Monitor carbon dioxide (CO_2) concentrations within each thermal zone. CO_2 monitors must be between 3 and 6 feet (900 and 1 800 millimeters) above the floor and within the thermal zone. CO_2 monitors must have an audible or visual indicator or alert the building automation system if the sensed CO_2 concentration exceeds the setpoint by more than 10%. Calculate appropriate CO_2 setpoints by using the methods in ASHRAE 62.1–2010, Appendix C.

BEHIND THE INTENT

By diluting pollutants created by a building's occupants and other contaminant sources, ventilation contributes to the occupants' comfort and well-being. The exact connections between ventilation rates and occupants' health are still being researched, but a multidisciplinary scientific review of the current state of knowledge shows some strong associations.[1] Maintaining good indoor air quality (IAQ) depends on controlling pollutant sources, removing contaminants from outdoor air, and supplying at least some outdoor air, among other factors. The standards referenced in this prerequisite outline well-tested methods for determining the amount of outdoor air each type of space requires. These standards were chosen because they strike a balance between providing fresh air and maintaining energy efficiency.

Different kinds of occupants, activities, and equipment in a building will make for different IAQ parameters, so requirements vary both by space type in a building and by project type. For example, residential projects must meet additional prescriptive requirements that protect occupants from indoor contaminants, such as combustion byproducts and radon, and health care facilities have more stringent ventilation and space pressurization requirements to prevent cross-contamination.

Intelligent ventilation design is only the first step. Monitoring, as required by this prerequisite, helps maintain IAQ during all stages of a building's operation. Even though occupants may not notice reductions in outdoor airflow or exhaust airflow, indoor air pollutants begin to build up the moment proper ventilation ceases. The combination of intelligent ventilation design with monitoring provides confidence that occupants enjoy comfort and well-being.

STEP-BY-STEP GUIDANCE

Healthcare projects, see *Further Explanation, Rating System Variations.*

STEP 1. EVALUATE OUTDOOR AIR QUALITY

Investigate local outdoor air quality at the project location. If pursuing Option 1 for mechanically ventilated spaces, or using naturally ventilated spaces, follow ASHRAE 62.1–2010, Section 4, or a local equivalent, whichever is more stringent. If pursuing Option 2 for mechanically ventilated spaces, see Comité Européen de Normalisation (CEN) Standard EN 13779–2007, Section 6.2.3, Outdoor Air.

Use the results of this analysis to inform ventilation strategy selection and system design. For example, natural ventilation may not be appropriate in high-pollution areas, where outdoor air requires significant filtration. Outdoor air quality may affect mechanical equipment filtration specifications.

STEP 2. SELECT VENTILATION STRATEGY

Determine whether mechanical ventilation, natural ventilation, or a mixed-mode approach is appropriate for the project.

- Consider how the building's form, location, orientation, programming, and depth of the floor plate can create opportunities for low-energy, high-quality natural ventilation or mixed-mode systems. For help in determining whether natural ventilation is feasible for a building or space, see Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Non-Domestic Buildings, Figure 2.8 (flow chart).
- ASHRAE Standard 62.1–2010 requires mechanical ventilation systems in addition to natural ventilation, unless specific exceptions are met. See ASHRAE Standard 62.1–2010, Section 6.4.
- If mechanical ventilation is preferred, consider separating ventilation from thermal conditioning with a dedicated outdoor air system. These systems ensure that the correct amount of ventilation air is provided while minimizing overventilation and reducing energy consumption.
- Core and Shell, Healthcare, and residential projects: see *Further Explanation, Rating System Variations* and *Project Type Variations.*

1. *Sundell, Jan, Hal Levin, and Davor Novosel, Ventilation Rates and Health: Report of an Interdisciplinary Review of the Scientific Literature (National Center for Energy Management and Building Technologies Task 06-01, September 2006), ncembt.org/downloads/Sundell%20J_VentilationRatesAndHealthReportOfAnInterdisciplinaryReviewOfTheScientificLiterature_NCEMBT-070914.pdf (accessed June 10, 2013).*

STEP 3. CATEGORIZE SPACES

Create a table of all rooms and spaces in the project and identify the following for each:

- Ventilation strategy
- Net occupiable space, as defined in ASHRAE Standard 62.1–2010, page 4, or room floor area if using CEN Standard 15251
- Occupancy category, as listed in ASHRAE Standard 62.1–2010, Table 6-1 or CEN Standard 15251, Table B.2
- If applicable, identify whether the building is very low polluting, low polluting, or not low polluting (see CEN Standard 15251, Annex C).
- Design occupancy (see *Getting Started, Occupancy*)

It may be appropriate to group rooms or spaces into ventilation zones (see *Further Explanation, Types of Mechanical Ventilation Systems*).

STEP 4. IDENTIFY APPROPRIATE PREREQUISITE REQUIREMENTS

Follow the steps below for mechanical ventilation or natural ventilation, depending on the ventilation strategy used in each space.

For mixed-mode systems, projects must comply with mechanical ventilation requirements when the mechanical system is active, and natural ventilation requirements when the mechanical ventilation system is inactive.

Mechanically Ventilated Spaces (and Mixed-Mode Spaces When A Mechanical Ventilation Is Active)

STEP 1. DETERMINE PRELIMINARY HVAC SYSTEM CONFIGURATION

Identify the following basic mechanical system features, which will affect the calculation of outdoor air required:

- Single-zone, 100% outdoor air, or multiple-zone systems
- Underfloor, overhead, or side air distribution and location of return grilles
- Supply air temperature: cooling only or heating and cooling
- Variable air volume (VAV) or constant volume (CV) supply

STEP 2. CALCULATE REQUIRED OUTDOOR AIRFLOW UNDER OPTION 1

Complete the ventilation rate procedure in ASHRAE Standard 62.1–2010, Section 6.2, to determine the minimum amount of outdoor air that must be supplied by each ventilation system.

- Complete a separate ventilation rate procedure calculation for each ventilation system.
- Account for all occupied spaces in the calculation. Perform ventilation rate procedure calculations for worst-case conditions, which typically occur in the heating mode when supply airflows are lowest or supply air temperature is highest. From Table 6-2 of the standard, select the zone air distribution effectiveness (Ez) value that corresponds to the air distribution configuration of the worst-case conditions. Ez is typically less than 1.0 when the system is in heating mode. If Ez is greater than 1.0, see EA Prerequisite Minimum Energy Performance, *Further Explanation, Common Issues with Energy Modeling, Ventilation (zone air distribution effectiveness).*
- As applicable, evaluate and document assumptions for all variables required for the ventilation rate procedure calculation. These variables include the percentage of total design airflow rate at condition analyzed (Ds), the primary air fraction of supply air at condition analyzed (Ep), the system ventilation efficiency (Ev), and the fraction of local recirculated air that is representative of system return air (Er).
- For special conditions that apply to systems designed to respond to varying operating conditions, such as with demand-controlled ventilation, see *Further Explanation, Considerations for Variable Operating Conditions.*

Ensure that the appropriate method is selected for each system in the project. The ventilation rate procedure calculation differs for single-zone, 100% outdoor air, and multiple-zone systems. Suggested methods are as follows:

- For single-zone systems or 100% outdoor air systems, use the calculator provided by USGBC or a user-generated spreadsheet. The 62MZCalc spreadsheet is not applicable to these systems and should not be used to perform the ventilation calculations.

- For multiple-zone systems, use the calculator provided by USGBC or ASHRAE's 62MZCalc Spreadsheet. This includes VAV and CV systems in which one or more air handlers supply a mixture of outdoor air and recirculated air to more than one ventilation zone (see *Further Explanation, Calculations for Multiple-Zone Systems*).

Energy modeling software may also be used to perform ventilation rate procedure calculations for all three system types. Direct outputs from the programs are acceptable, provided they include sufficient information about the values used for all variables in the calculation.

If the local code is more stringent than ASHRAE 62.1–2010, see *Further Explanation, Local Equivalent to ASHRAE 62.1–2010.*

ALTERNATIVE STEP 2. CALCULATE REQUIRED OUTDOOR AIRFLOW UNDER OPTION 2

Follow the calculations outlined in CEN Standard 15251–2007, Annex B, to determine the minimum amount of outdoor air that must be supplied by each ventilation system.

STEP 3. REVISE DESIGN TO MEET OUTDOOR AIR REQUIREMENTS, IF NECESSARY

If the ventilation calculations in Step 2 indicate that the preliminary design does not provide enough outdoor air to meet the selected reference standard, revise the design and recalculate the minimum amount of outdoor air to confirm compliance.

For single-zone and 100% outdoor air systems, increase the amount of outdoor air supplied by the system. For multiple-zone systems, increase supply airflow to the critical zone or increase the amount of outdoor air supplied by the system.

In the final calculations, ensure that the net occupiable space, design occupancy, number of air handlers, and outdoor air volume are consistent with the project's mechanical schedules and documentation provided for other LEED credits. Create a summary table that lists the required outdoor air intake flow and design outdoor air intake flow for each ventilation system.

STEP 4. MEET MINIMUM REQUIREMENTS

Option 1. ASHRAE Standard 62.1–2010

- Confirm compliance with Sections 4 through 7.
- Indicate whether the project is in a nonattainment area for fine particulate matter (PM2.5), and if so, confirm that filters with minimum efficiency reporting values (MERV) of 11 or higher have been or will be installed.
- Indicate whether the project is in an area where ozone exceeds the most recent three-year average, annual fourth-highest daily maximum eight-hour average ozone concentration of 0.107 ppm, and if so, confirm that the project has or will have air-cleaning devices for ozone.
- If using a local code instead of ASHRAE 62.1–2010, see *Further Explanation, Local Equivalent to ASHRAE 62.1–2010.*

Option 2. CEN Standards EN 15251–2007 and EN 13779–2007

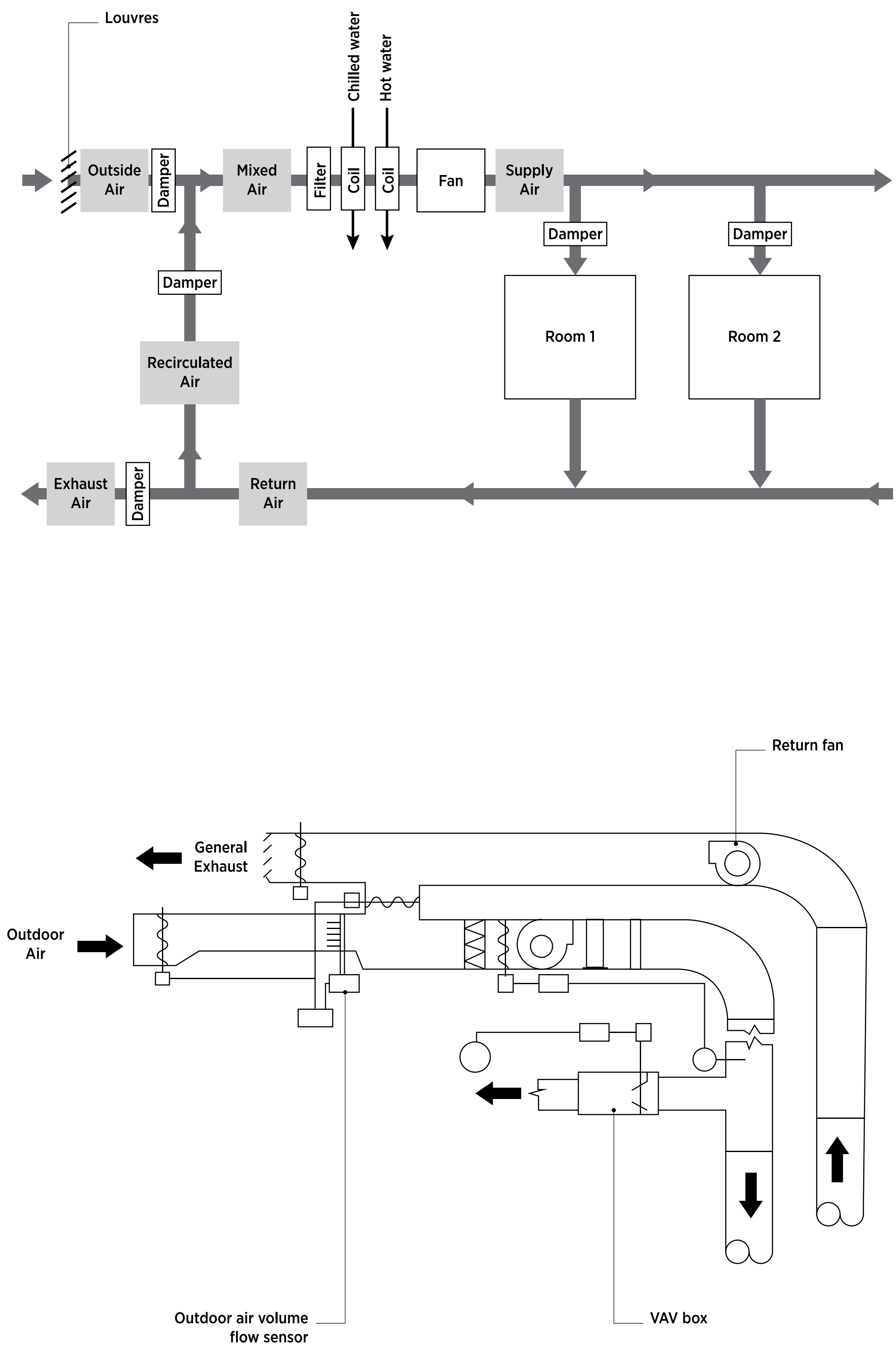
- Confirm compliance with the requirements in CEN Standard 13770–2007, excluding Section 7.3 Thermal environment, 7.6 Acoustic environment, A.16, and A.17.

STEP 5. IMPLEMENT AIRFLOW MONITORING

Incorporate airflow monitoring equipment into the HVAC system design. The technique for monitoring outdoor air depends on the HVAC system. For VAV systems—for example, a 100% outdoor air energy recovery unit with demand-controlled ventilation, or any system that provides a variable amount of supply or outdoor air—a direct outdoor airflow measurement device must measure the intake flow rate (Figure 1).

- Indirect measurements, such temperature or current transducers, cannot directly measure the airflow rate and thus are not allowed for VAV systems.
- If a 100% outdoor air system provides ventilation air to the return of downstream terminal devices (e.g., fan coil units, heat pumps), the measurement device needs to measure the outdoor airflow rate at the 100% outdoor air unit only, not at each terminal device. The ventilation rate procedure must still be calculated for each terminal device.
- For device requirements, see the specific language in the prerequisite requirements.

Figure 1. Example schematic for outdoor air sensor location



For constant volume systems, balancing ensures that the correct amount of outdoor air is being supplied to the building.

- Once the system has been balanced, a current transducer on the supply fan, airflow switch, pressure transducer, or similar monitoring device must be installed.
- If a 100% outdoor air system provides ventilation air to the return of downstream terminal devices (e.g., fan coil units, heat pumps), the measurement device needs to be installed at the 100% outdoor air system only, not at each terminal device. The ventilation rate procedure must still be calculated to each terminal device.

For all systems, retain equipment cut sheets showing the accuracy of the monitoring device(s), copies of control sequences and diagrams, and test and balance reports that show airflow setpoints for each ventilation system.

Naturally Ventilated Spaces (and Mixed-Mode Systems When Mechanical Ventilation Is Inactivated)

STEP 1. CONFIRM NATURAL VENTILATION EFFECTIVENESS

Use Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, Natural Ventilation in Non-Domestic Buildings, Figure 2.8 (flow chart), to confirm that natural ventilation is appropriate. Retain a copy of the flow chart path for the project.

STEP 2. IDENTIFY CEILING HEIGHTS AND NATURAL VENTILATION OPENINGS

Collect the following information for each naturally ventilated space and add to the table of rooms and spaces:

- Minimum ceiling height in the space
- Location of natural ventilation openings (on one side, two opposite sides, or two adjacent sides)
- Size of the natural ventilation openings (openable area)

STEP 3. PERFORM NATURAL VENTILATION PROCEDURE

Use the natural ventilation procedure in ASHRAE 62.1–2010, Section 6.4, to determine the size of openings required in each space and the maximum distance from the openings that can be considered naturally ventilated.

- Compare the calculation results with the design and revise, if necessary, to ensure that all spaces meet the requirements of the standard.
- If the project includes an engineered natural ventilation system approved by the authority having jurisdiction, the requirements of Section 6.4 do not apply (see *Further Explanation, Authority Having Jurisdiction Exception*).
- Confirm compliance with the exhaust ventilation requirements of ASHRAE Standard 62.1–2010, Section 6.5.

STEP 4. CONFIRM MECHANICAL SYSTEM EXCEPTION OR COMPLIANCE

If the project qualifies for an exception to the mechanical ventilation requirement in ASHRAE 62.1–2010, Section 6.4, prepare an explanatory narrative.

If the project does not qualify for exception, follow the step-by-step instructions for mechanical ventilation systems to demonstrate compliance with ASHRAE 62.1–2010 when mechanical ventilation is active (see *Further Explanation, Natural Ventilation Exceptions*).

STEP 5. IMPLEMENT MONITORING SYSTEM

Incorporate airflow monitoring equipment into the natural ventilation system design through one of the following three monitoring strategies.

Direct exhaust airflow measurement device

- Incorporate exhaust airflow monitoring equipment that has an accuracy of +/–10% of the design minimum exhaust airflow rate.
- Naturally ventilated systems induce passive air movement from openings to the point of exhaust, requiring that airflow measurement devices be placed at the exhaust location.
- Configure the exhaust airflow monitoring equipment to generate an alarm when airflow values vary by 15% or more from the exhaust airflow setpoint.
- Retain equipment cutsheets for the monitors, plans indicating sensor locations, and copies of control sequences and diagrams.

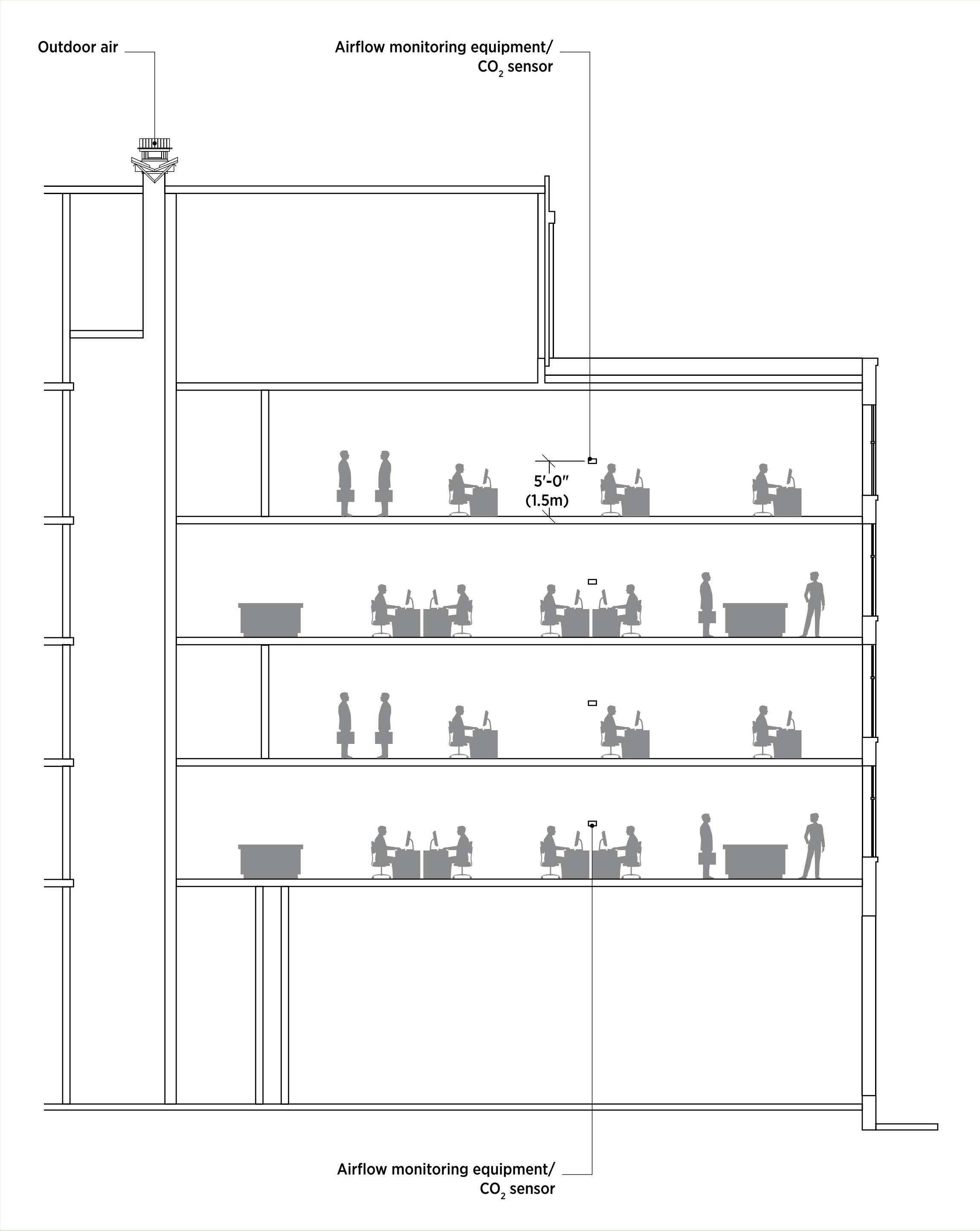
Alarmed openings for naturally ventilated spaces

- Identify all windows, louvers, and trickle vents used for natural ventilation.
- Each opening counted as a natural ventilation intake for this prerequisite must have an alarm under this strategy. For example, an office with two windows intended to provide natural ventilation must have alarms installed on both windows. However, if only one window is counted as a natural ventilation intake, only one window is required to have an alarm.

Carbon dioxide (CO_2) monitors

- Install a CO_2 sensor in each thermal zone.
- CO_2 sensors must be located in the breathing zone, as defined in the prerequisite requirements (Figure 2). CO_2 sensors installed in return air ducts cannot be used to meet the requirements.
- Determine CO_2 concentration setpoint(s) using the methods in ASHRAE 62.1–2010, Appendix C. See *ASHRAE 62.1–2010 User's Manual, Appendix A*, for calculations and examples. Configure the CO_2 monitoring system to generate an audible or visual alarm to the system operator if the differential CO_2 concentration exceeds the setpoint by more than 10%.

Figure 2. Example CO_2 sensor locations



FURTHER EXPLANATION

CALCULATIONS

For mechanical ventilation, Option 1, see ASHRAE 62.1–2010, Section 6.2, and ASHRAE 62.1–2010 User's Manual, Chapter 6.2. Refer to *ASHRAE Journal* articles[2] for additional information on the calculations.

For mechanical ventilation, Option 2, see CEN Standards EN 15251–2007 and EN 13779–2007.

For natural ventilation, see ASHRAE 62.1–2010, Section 6.4, and ASHRAE 62.1–2010 User's Manual, Chapter 6.4.

NATURAL VENTILATION EXCEPTIONS

ASHRAE Standard 62.1–2010, Section 6.4, requires naturally ventilated spaces to include a mechanical ventilation system unless one of the following exceptions applies:

- Ventilation openings comply with Section 6.4 and are permanently open.
- Ventilation openings comply with Section 6.4 and have controls that prevent them from being closed during times of expected occupancy.
- The naturally ventilated zone is not served by heating or cooling equipment.
- The system is an engineered natural ventilation system approved by the authority having jurisdiction (see *Further Explanation, Authority Having Jurisdiction Exception*).

TYPES OF MECHANICAL VENTILATION SYSTEMS

ASHRAE 62.1–2010 defines a ventilation zone as any area with similar occupancy categories, occupant density, zone air distribution effectiveness, and zone primary airflow per unit area. This differs from the definition of a thermal zone.

There are three main types of mechanical ventilation systems.

Single-zone system
This system delivers a mixture of outdoor air and recirculated air to only one ventilation zone. For example, a single rooftop unit that provides ventilation and conditioned air to three separate offices may be considered a single-zone system, provided the offices are similar, as defined above.

Alternatively, a single rooftop unit that provides ventilation and conditioned air to an office and a conference room would not be considered a single-zone system, since these two spaces differ in occupancy category and occupant density, even though the unit itself is often considered "single-zone" because it only has one thermal zone. In this case, the unit must be analyzed using the method for multiple-zone recirculating systems.

A separate ventilation rate procedure calculation must be made for each single-zone system serving the building.

100% outdoor air system
This type of system delivers only outdoor air directly to one or more ventilation zones. The ventilation air cannot contain any recirculated air. For example, an energy recovery unit that provides 100% outdoor ventilation air to each space via a separate distribution system and mixes this air with air from only the same zone would be considered a 100% outdoor air system.

Alternatively, an energy recovery unit that provides 100% outdoor ventilation air to zone-level fan coil units that mix outdoor air with return air from other ventilation zones before delivering it to the space would not be considered a 100% outdoor air system. In this case, each fan coil unit must be analyzed as either a single-zone or a multiple-zone recirculating system.

A separate ventilation rate procedure calculation must be made for each 100% outdoor air system serving the building.

2. *Stanke, Dennis, "Single-Zone & Dedicated-OA Systems," ASHRAE Journal (October 2004); "Single-Path Multiple-Zone System Design," ASHRAE Journal (January 2005); "Designing Dual-Path Multiple-Zone Systems," ASHRAE Journal (May 2005).*

Multiple-zone recirculating system
This type of system delivers a mixture of outdoor air and recirculated air to more than one ventilation zone. Typical examples include a constant volume rooftop unit that serves more than one ventilation zone or a VAV system that serves an entire building.

A separate ventilation rate procedure calculation must be made for each multiple-zone recirculating system serving the building (see *Further Explanation, Calculations for Multiple-Zone Recirculating Systems*).

CALCULATIONS FOR MULTIPLE-ZONE RECIRCULATING SYSTEMS

Because of the complexity of the calculations for multiple-zone recirculating systems, project teams must use the calculator provided by USGBC, ASHRAE's 62MZCalc spreadsheet, or energy modeling software to perform the ventilation rate procedure calculations and determine the amount of outdoor air required at the system level.

System ventilation efficiency
Multiple-zone system calculations need to account for the inefficiency that occurs when the zones have different ratios of outdoor ventilation air to supply the air required for thermal conditioning. The calculations account for this through system ventilation efficiency (Ev) and by determining the critical zone.

The critical zone is the zone with the highest proportion of required outdoor air to provided supply air. Critical zones are often densely occupied spaces, such as conference rooms. If using the calculator provided by USGBC or ASHRAE's 62MZCalc spreadsheet, when all zones are entered, the critical zone for the system is determined automatically.

For large projects, it may not be feasible to enter each individual zone. In these cases, the mechanical engineer can determine the outdoor air required for the system simply by identifying the potentially critical zone(s). For a detailed discussion of identifying critical zones, see ASHRAE Standard 62.1–2010, Appendix A–A3.1, Selecting Zones for Calculation, and ASHRAE 62.1–2010 User's Manual, Example 6-L.

Diversity factor
Alternatively, the multiple-zone system calculations may include a diversity factor to account for the movement of occupants between spaces, per ASHRAE Standard 62.1–2010, Section 6.2.5.3.1. For example, in a school, it is reasonable to assume that not all rooms are occupied simultaneously, because students and staff would not be in a classroom if they are eating lunch in the cafeteria. In this case, diversity can be applied, provided the classroom and cafeteria are served by the same ventilation system.

Diversity may not be applied to either single-zone or 100% outdoor air systems. If applying diversity, all calculations and assumptions must be included with the documentation.

If preliminary calculations indicate that a multiple-zone system does not comply with ASHRAE 62.1–2010 outdoor air requirements, consider the following before increasing outdoor air at the air-handling unit(s):

- Increase the amount of supply air (e.g., zone primary airflow, Vpz) to the critical zone. This has the effect of decreasing the primary outdoor air fraction, Zpz, which will increase system efficiency and reduce the total amount of outdoor air required.
- For systems with VAV terminal units, increase the minimum terminal unit flow rate setting for the critical zone. This has the same effect described above.

CONSIDERATIONS FOR VARIABLE OPERATING CONDITIONS

ASHRAE 62.1–2010 permits ventilation systems to reflect or respond to changes in zone occupancy in two ways, time-average population and dynamic reset. These two strategies cannot be applied simultaneously, however.

Time-average population. In spaces where peak occupancy occurs over only a short period, a time-average design population may be used, per ASHRAE 62.1–2010, Section 6.2.6.2 (see ASHRAE 62.1–2010 User's Manual, Examples 6-W, 6-X, 6-Y, 6-Z, and 6-AA). Project teams must include all calculations and assumptions used when submitting the ventilation rate procedure calculations for time-average population.

Dynamic reset. The system varies the flow of outdoor air as operating conditions change, thereby reducing the amount of energy needed to condition outdoor air. Demand-controlled ventilation is one of the most common reset strategies. Refer to ASHRAE 62.1–2010, Section 6.2.7, for dynamic reset requirements, some of which include the following:

- A minimum level of outdoor air, based on the area outdoor air rate, must be provided to each ventilation zone at all times when dynamic reset is implemented. Refer to the ASHRAE standard's Section 6.2.7.1.2.
- The ventilation system must be controlled to provide the required amount of outdoor air in each zone, based on current occupancy. For a multiple-zone recirculating system, a single CO_2 sensor mounted in the return duct does not meet the requirements of ASHRAE 62.1–2010, since it does not guarantee that the appropriate amount of outdoor air will be provided to the critical zones. Refer to ASHRAE 62.1–2010 User's Manual, Appendix A, and the *ASHRAE Journal*[3] for demand-controlled ventilation approaches for multiple-zone systems and for CO_2 setpoint calculations.

LOCAL EQUIVALENT TO ASHRAE STANDARD 62.1–2010

If local code is more stringent than ASHRAE 62.1–2010 for the system design, use the local code.

For mechanically ventilated spaces, prepare the following documentation:

- A detailed summary comparing the two standards' requirements
- A comparison demonstrating that outdoor air requirements established by the local code for occupants and for floor area are at least as stringent as the ASHRAE standard
- Evidence that the local code incorporates the zone- and system-level efficiency of the ventilation systems in an equivalent or more stringent way than the ASHRAE ventilation rate procedure

For naturally ventilated spaces, prepare the following documentation:

- A detailed summary comparing the two standards' requirements for fenestration opening area, distance from window, and ceiling height
- A description of the engineered ventilation modeling approach, and documentation of approval by the local code authority

AUTHORITY HAVING JURISDICTION EXCEPTION

In some situations, compliance with this prerequisite is acceptable through an authority having jurisdiction exception. With this exception, the local code authority (the authority having jurisdiction) approves the plans and specifications used for the building's engineered natural ventilation approach. There are three possible situations for this exception: (1) the local code is ASHRAE Standard 62.1–2010, (2) the ventilation code governing the project is any code other than ASHRAE Standard 62.1–2010, and (3) USGBC is serving as the authority having jurisdiction for the purposes of LEED certification.

If USGBC is the authority having jurisdiction, a ventilation strategy that meets the intent of ASHRAE 62.1–2010 but does not meet the requirements of the ventilation rate procedure may be approved. It is highly recommended that project teams contact USGBC for approval of the engineered natural ventilation approach as early as possible, rather than waiting until the system has been fully designed.

If the local code is ASHRAE Standard 62.1–2010, provide the following documentation:

- Evidence that ASHRAE Standard 62.1–2010 (or a later version) is required for local building code compliance
- A description of the engineered ventilation modeling approach
- Documentation of plan approval by the local code authority

If the ventilation code governing the project is other than ASHRAE Standard 62.1–2010, provide the following:

- Evidence that the alternate code is at least as stringent as ASHRAE 62.1–2010 in its entirety (see *Further Explanation, Local Equivalent to ASHRAE Standard 62.1–2010*).

3. *Stanke, Dennis, "Dynamic Reset for Multiple-Zone Systems," ASHRAE Journal (March 2010).*

- A description of the engineered ventilation modeling approach
- Documentation of plan approval by the local code authority

If USGBC is serving as the authority having jurisdiction for the purposes of LEED certification, provide the following:

- A description of the engineered ventilation modeling approach
- Drawings and calculations or airflow analyses
- Evidence that the project's engineered natural ventilation system meets the intent of ASHRAE 62.1–2010. This documentation must clearly identify how the project does not meet the standard's natural ventilation requirements, and how the ventilation design has been engineered to meet the intent of the standard.

OCCUPIED VERSUS OCCUPIABLE

ASHRAE Standard 62.1–2010 requires occupiable spaces to be ventilated. For consistency with other LEED credits, this prerequisite uses the term *occupied*. Spaces classified as occupiable per Standard 62 are considered occupied for the purposes of LEED certification (see *Definitions*).

EXAMPLES

For mechanical ventilation, see ASHRAE 62.1–2010 User's Manual, Examples 6-F through 6-V.

For natural ventilation, see ASHRAE 62.1–2010 User's Manual, Examples 6-AC through 6-AF.

RATING SYSTEM VARIATIONS

Core and Shell

If the scope of the core-and-shell project includes mechanical systems, the project team must comply with both the ventilation and monitoring requirements. Make reasonable assumptions about the distribution of spaces and ensure that air handlers are capable of providing enough outdoor air for anticipated occupants and space types. For example, a typical buildout by an office tenant will include office spaces, corridors, and conference rooms. If these spaces are all served by the air handling unit, the system-level outdoor air must be sufficient to meet the outdoor air requirements of all three space types. If the occupancy is unknown, see *Getting Started, Occupancy*.

If the scope of the core-and-shell project does not include mechanical systems, the project is exempt from the ventilation and monitoring requirements. See *EQ Overview*.

Healthcare

Review Steps 1–3 in *Step-by-Step Guidance*. For mechanically ventilated spaces and mixed-mode spaces when mechanical ventilation is active, evaluate whether the spaces are ventilated according to ASHRAE Standard 170–2008, Section 7; the 2010 Facility Guidelines Institute (FGI) Guidelines for Design and Construction of Health Care Facilities (Table 2.1–2); or a local equivalent, whichever is most stringent. For any space type not covered by these standards, use ASHRAE Standard 62.1–2010 or a local equivalent, whichever is more stringent, and follow Steps 2, 3, and 5 in *Step-by-Step Guidance* for mechanically ventilated spaces and mixed-mode spaces when mechanical ventilation is active. Ensure that the design meets the minimum requirements of ASHRAE Standard 170–2008, Sections 6–8, or a local equivalent, whichever is more stringent.

For naturally ventilated spaces, follow *Step-by-Step Guidance* for naturally ventilated spaces and mixed-mode systems when mechanical ventilation is inactivated.

Data Centers

All occupied spaces in data centers, including offices and control rooms, must meet ventilation requirements.

Warehouses and Distribution Centers

Both warehouses and distribution centers (e.g., shipping and receiving) are listed as an occupancy category in Table 6-1 of ASHRAE 62.1–2010. Therefore, these spaces must meet either the mechanical or natural ventilation requirements. If ventilation cannot be provided to these spaces due to extenuating circumstances, contact USGBC.

PROJECT TYPE VARIATIONS

Residential

Residential projects and units must comply with the ventilation requirements outlined above as well as all requirements for combustion appliances and radon-resistance listed in the residential only credit language in the rating system. Gas ranges must have hoods that exhaust air directly to the outdoors. No pressure testing is required if closed-combustion or power-vented fireplaces and stoves are used.

To minimize the infiltration and concentration of radon gas, the National Building Code, NFPA 5000, Chapter 49 has incorporated several building techniques, including sealing, home pressurization, soil depressurization, and ventilation.

Provide outdoor air to each unit directly from the outdoors. Do not use systems that rely on transfer air from pressurized hallways or corridors, adjacent dwelling units, attics, or elsewhere.

Apparatus Bays in Fire Stations

Typically, these spaces are not designed for human occupancy and would not be required to meet the prerequisite requirements. If these spaces will be occupied, however, then they must be ventilated according to the applicable reference standard for this prerequisite.

Vehicle Repair Facilities and Maintenance Bays

These space types include military buildings where trucks, tanks, aircraft, and other vehicles are being serviced. Because these are occupied spaces, they must meet the prerequisite requirements.

CAMPUS

Group Approach

Submit separate documentation for each building.

Campus Approach

Ineligible. Each LEED project must pursue the prerequisite individually.

REQUIRED DOCUMENTATION

New Construction, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality				
Documentation	**Option 1**	**Option 2**	**Naturally ventilated**	**Mixed Mode**
Confirmation that project meets minimum requirements of ASHRAE 62.1–2010, Sections 4–7, or CEN Standard 13779–2007	X	X		X
Confirmation that project has MERV 11 or higher filters (if project is in nonattainment area for PM2.5)	X	X		X
Ventilation rate procedure or CEN calculations and documentation of assumptions for calculation variables	X	X		X
Confirmation that project meets minimum requirements of ASHRAE Standard 62.1–2010, Section 7, and exhaust ventilation requirements of Section 6.5			X	X
Documentation of CIBSE flow diagram process for project			X	X
Natural ventilation procedure calculations and ventilation opening information			X	X
Any natural ventilation exception from mechanical ventilation system (ASHRAE 62.1–2010, Section 6.4)			X	X
Any exception from authority having jurisdiction			X	X
Controls drawing showing monitoring devices (outdoor airflow measuring device, current transducer, airflow switch, or similar monitor, automatic indication device, CO_2 sensor)	X	X	X	X

Healthcare			
Documentation	**Mechanically ventilated**	**Naturally ventilated**	**Mixed mode**
Confirmation that project meets minimum requirements of ASHRAE Standard 170-2008, Sections 6-8	X		X
If applicable, air balance summary table to demonstrate that the minimum OA changes, min total air changes, and space pressurization relationships provided are consistent with the FGI or ASHRAE Standard 170	X		X
If applicable, ventilation rate procedure calculations and documentation of assumptions for calculation variables	X		X
Documentation of CIBSE flow diagram process for project		X	X
Natural ventilation procedure calculations and ventilation opening information		X	X
Any natural ventilation exception from mechanical ventilation system (ASHRAE 62.1–2010, Section 6.4)		X	X
Any exception from authority having jurisdiction		X	X
Controls drawing showing monitoring devices (outdoor airflow measuring device, current transducer, airflow switch, or similar monitor, automatic indication device, CO_2 sensor)	X	X	X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. Outdoor air can increase the amount of energy needed to heat and cool the building. Dynamic reset, such as demand-controlled ventilation, can reduce energy use.

EQ Credit Enhanced Indoor Air Quality Strategies. Airflow monitoring and increased ventilation addressed by this prerequisite will assist in earning the related credit.

EQ Credit Indoor Air Quality Assessment. The building's minimum outdoor air ventilation rate may affect the duration of the flush-out required for Option 2, Occupied Flush-Out, of the related credit.

CHANGES FROM LEED 2009

- ASHRAE Standard 62.1 has been updated to version 2010 from version 2007.
- ASHRAE 62.1–2010 natural ventilation calculations now consider window configuration and ceiling height.
- ASHRAE 62.1–2010 now requires supplementary mechanical ventilation systems for naturally ventilated spaces in some cases.
- Project teams are required to confirm the appropriate application of natural ventilation through CIBSE AM10, Figure 2.8 (flow chart).
- Projects outside the U.S. are now allowed to demonstrate achievement via CEN requirements (rather than ASHRAE 62.1–2010).
- This prerequisite now includes the monitoring requirements previously included in Indoor Environmental Quality Credit 1, Outdoor Air Delivery Monitoring. Additionally, the monitoring requirements now distinguish between variable air volume and constant volume systems.
- This prerequisite now includes specific requirements for residential projects. These requirements are mostly taken from LEED for Homes, Indoor Environmental Quality Credit 2, Combustion Venting.

REFERENCED STANDARDS

ASHRAE 62.1–2010: ashrae.org

ASHRAE Standard 170–2008: ashrae.org

2010 FGI Guidelines for Design and Construction of Health Care Facilities: fgiguidelines.org

CEN Standard EN 15251–2007: cen.eu

CEN Standard EN 13779–2007: cen.eu

CIBSE Applications Manual AM10, March 2005: cibse.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

occupiable space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are occupied only occasionally and for short periods of time (ASHRAE 62.1–2010)

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

unoccupied space an area designed for equipment, machinery, or storage rather than for human activities. An equipment area is considered unoccupied only if retrieval of equipment is occasional.

INDOOR ENVIRONMENTAL QUALITY PREREQUISITE

Environmental Tobacco Smoke Control

This prerequisite applies to:

New Construction
Core and Shell
Schools
Retail
Data Centers
Warehouses and Distribution Centers
Hospitality
Healthcare

INTENT

To prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, RETAIL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY, HEALTHCARE

Prohibit smoking inside the building.

Prohibit smoking outside the building except in designated smoking areas located at least 25 feet (7.5 meters) from all entries, outdoor air intakes, and operable windows. Also prohibit smoking outside the property line in spaces used for business purposes.

If the requirement to prohibit smoking within 25 feet (7.5 meters) cannot be implemented because of code, provide documentation of these regulations.

Signage must be posted within 10 feet (3 meters) of all building entrances indicating the no-smoking policy.

RESIDENTIAL ONLY

OPTION 1. NO SMOKING

Meet the requirements above.

OR

OPTION 2. COMPARTMENTALIZATION OF SMOKING AREAS

Prohibit smoking inside all common areas of the building. The prohibition must be communicated in building rental or lease agreements or condo or coop association covenants and restrictions. Make provisions for enforcement.

Prohibit smoking outside the building except in designated smoking areas located at least 25 feet (7.5 meters) from all entries, outdoor air intakes, and operable windows. The no-smoking policy also applies to spaces outside the property line used for business purposes.

If the requirement to prohibit smoking within 25 feet (7.5 meters) cannot be implemented because of code, provide documentation of these regulations.

Signage must be posted within 10 feet (3 meters) of all building entrances indicating the no-smoking policy.

Each unit must be compartmentalized to prevent excessive leakage between units:

- Weather-strip all exterior doors and operable windows in the residential units to minimize leakage from outdoors.
- Weather-strip all doors leading from residential units into common hallways.
- Minimize uncontrolled pathways for the transfer of smoke and other indoor air pollutants between residential units by sealing penetrations in the walls, ceilings, and floors and by sealing vertical chases (including utility chases, garbage chutes, mail drops, and elevator shafts) adjacent to the units.
- Demonstrate a maximum leakage of 0.23 cubic feet per minute per square foot (1.17 liters per second per square meter) at 50 Pa of enclosure (i.e., all surfaces enclosing the apartment, including exterior and party walls, floors, and ceilings).

SCHOOLS

Prohibit smoking on site.

Signage must be posted at the property line indicating the no-smoking policy.

BEHIND THE INTENT

Tobacco use kills more than five million people worldwide every year.[1] Smoking also puts nonsmokers at risk by exposing them to environmental tobacco smoke (ETS), often called secondhand smoke. In 2006, nearly half of all nonsmoking Americans were regularly exposed to secondhand smoke.[2] ETS exposure at home or in the workplace increases nonsmokers' risk of developing lung cancer, heart disease, and other serious health problems.[3]

Prohibiting indoor smoking is the only way to fully eliminate the health risks associated with ETS.[4] For this reason, designated indoor smoking rooms are not allowed in LEED-certified buildings. Only residential projects are excepted, because of legal ownership issues. The prerequisite also prohibits smoking in outdoor areas used for business purposes. A business that uses a public sidewalk or courtyard for seating or kiosks still maintains control over those areas, even though they are typically outside the property boundary line. They are included under this prerequisite because the business owner still has control over the smoking policy in these areas.

Restricting the introduction of ETS into the building interior not only benefits human health, it also improves the longevity of building surfaces, air distribution systems, furniture, and furnishings when compared with those in buildings that allow smoking.[5]

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE SMOKE-FREE LOCATIONS

Obtain confirmation from the owner that smoking is prohibited inside the building. Residential projects may allow smoking in specific units, with specific requirements for ensuring that those units are adequately isolated (see *Further Explanation, Project Type Variations*).

- Identify the location of building openings, including entries, outdoor air intakes, and operable windows. Identify the property line and the location of outdoor areas used for business purposes, both inside and outside the property line. Indicate these elements on a site plan, map, or sketch.
- Emergency exits do not qualify as building openings if the doors are alarmed, because alarmed doors will not be opened. Emergency exits without alarms qualify as building openings.

STEP 2. DESIGNATE LOCATIONS OF EXTERIOR SMOKING AREAS

Determine whether the project has or will have designated outdoor smoking areas. Locate any area designated for smoking at least 25 feet (7.5 meters) from smoke-free areas, based on the information gathered in Step 1. The 25-foot (7.5-meter) distance is a straight-line calculation.

- Consider design strategies that may encourage people to use the designated smoking area, such as covered seating.
- Educate occupants on the smoking policy and encourage them to self-police. This is particularly important in retail situations.
- Ashtrays signal that smoking is allowed in a particular area. Be sure these are placed outside the 25-foot (7.5-meter) perimeter.

STEP 3. CONFIRM THAT SMOKING IS PROHIBITED IN NONDESIGNATED AREAS

Provide confirmation from the owner that smoking outside designated areas is prohibited in any space used by the building for business purposes, even if the space falls outside the property line. Examples of spaces used for business purposes include sidewalk seating, kiosks, and courtyards.

- Smoking must be prohibited in areas within 25 feet (7.5 meters) from building openings.

1. *World Health Organization, WHO Report on the Global Tobacco Smoke Epidemic (Geneva, Switzerland, 2009), who.int/tobacco/mpower/2009/gtcr_download/en/index.html (accessed June 10, 2013).*
2. *U.S. Department of Health and Human Services, The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General (Atlanta, Georgia, 2006). surgeongeneral.gov/library/reports/secondhandsmoke/report-index.html (accessed June 10, 2013).*
3. *Ibid.*
4. *Ibid.*
5. *Mudarri, D.H., The Costs and Benefits of Smoking Restrictions: An Assessment of the Smoke-Free Environment Act of 1993 (H.R.3434) (Washington, DC: Environmental Protection Agency, Office of Radiation and Indoor Air, Indoor Air Division, 1994), tobaccodocuments.org/landman/89268337-8360.html (accessed June 10, 2013).*

- If smoking cannot be prohibited for the full 25-foot (7.5-meter) distance because of code restrictions, provide documentation of the regulation (see *Further Explanation, Code Limitations and Restrictions*).
- Smoking in the prohibited area is not allowed, even when the 25-foot (7.5-meter) distance extends beyond the property line. The boundary of the space for business purposes, other than a building opening, indicates the end of a nonsmoking area (see *Further Explanation, Property Line LessThan 25 Feet from the Building*).

STEP 4. DETERMINE LOCATIONS OF NO-SMOKING SIGNAGE

Post signage within 10 feet (3 meters) of all building entrances indicating that smoking is not allowed.

- School projects must post signage at the property line adjacent to all pedestrian and vehicular entrances indicating the no-smoking policy for the school site.
- Language on the signage is up to the project team. Two examples of successful language include “No smoking allowed within 25 feet” and “Smoking is allowed in designated smoking areas only.”
- It may be helpful to stripe sidewalks to show the no-smoking boundary.

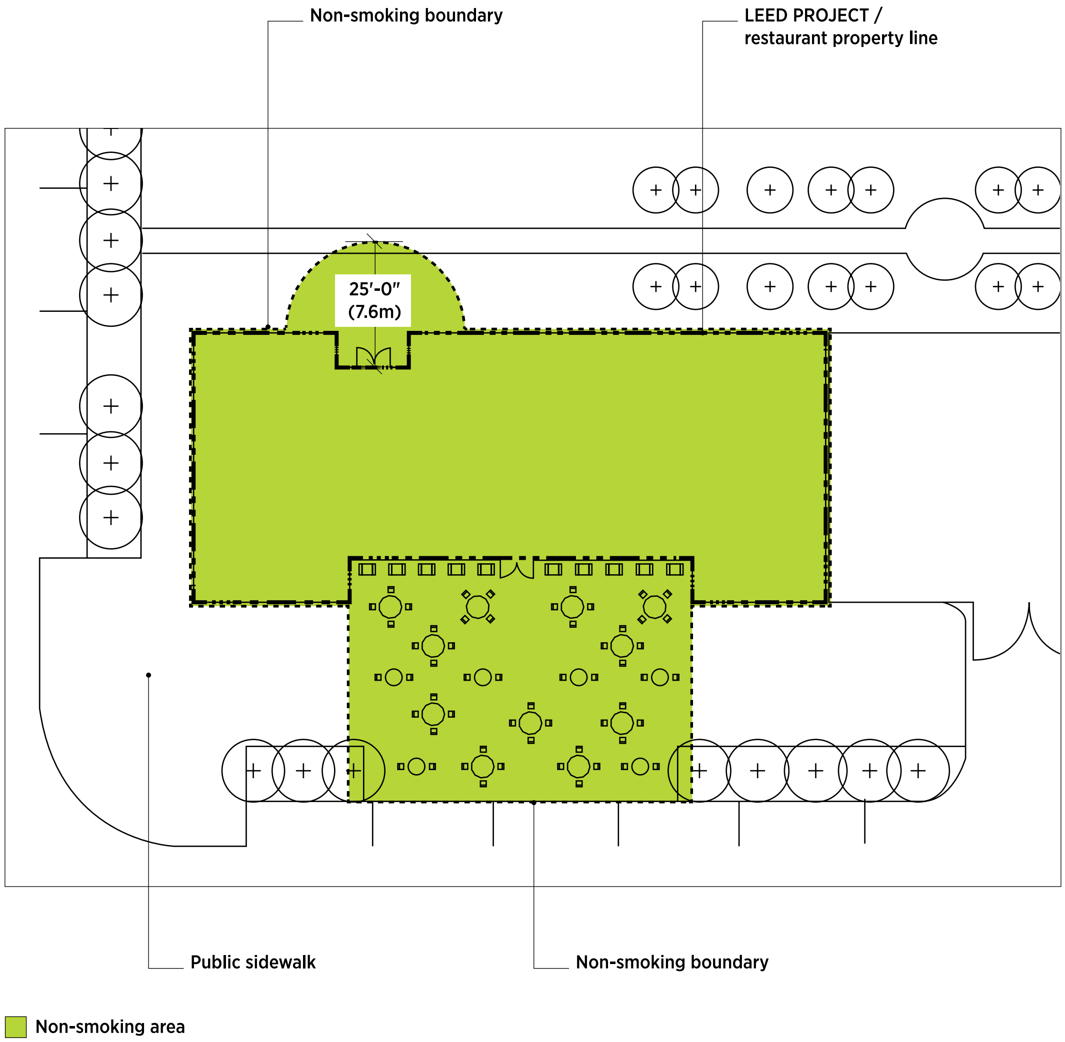
FURTHER EXPLANATION

PROPERTY LINE LESS THAN 25 FEET (7.5 METERS) FROM THE BUILDING

Projects with a property line less than 25 feet (7.5 meters) from the building must consider space usage when determining the outdoor smoking policy. The no-smoking requirement still applies to spaces outside the property line used for business purposes. Public sidewalks are not considered used for business purposes, but smoking must still be prohibited on sidewalks within 25 feet (7.5 meters) of openings. Building staff should be educated about this policy so that they can direct smokers to designated smoking areas and away from entrances or windows.

Examples of common business activities that would require the smoking prohibition include outdoor seating, outdoor stadium areas, courtyards, and banking kiosks.

FIGURE 1. Example site plan with no smoking areas



CODE LIMITATIONS AND RESTRICTIONS

Many local governments ban smoking in the workplace and in public spaces. These regulations do not always meet the 25-foot (7.5-meter) distance for exterior smoking required by this prerequisite. In most cases, LEED projects can extend the smoking ban to the required 25 feet (7.5 meters), regardless of existing code. However, if existing code explicitly prohibits this, building owners may still achieve the prerequisite by providing documentation of the code.

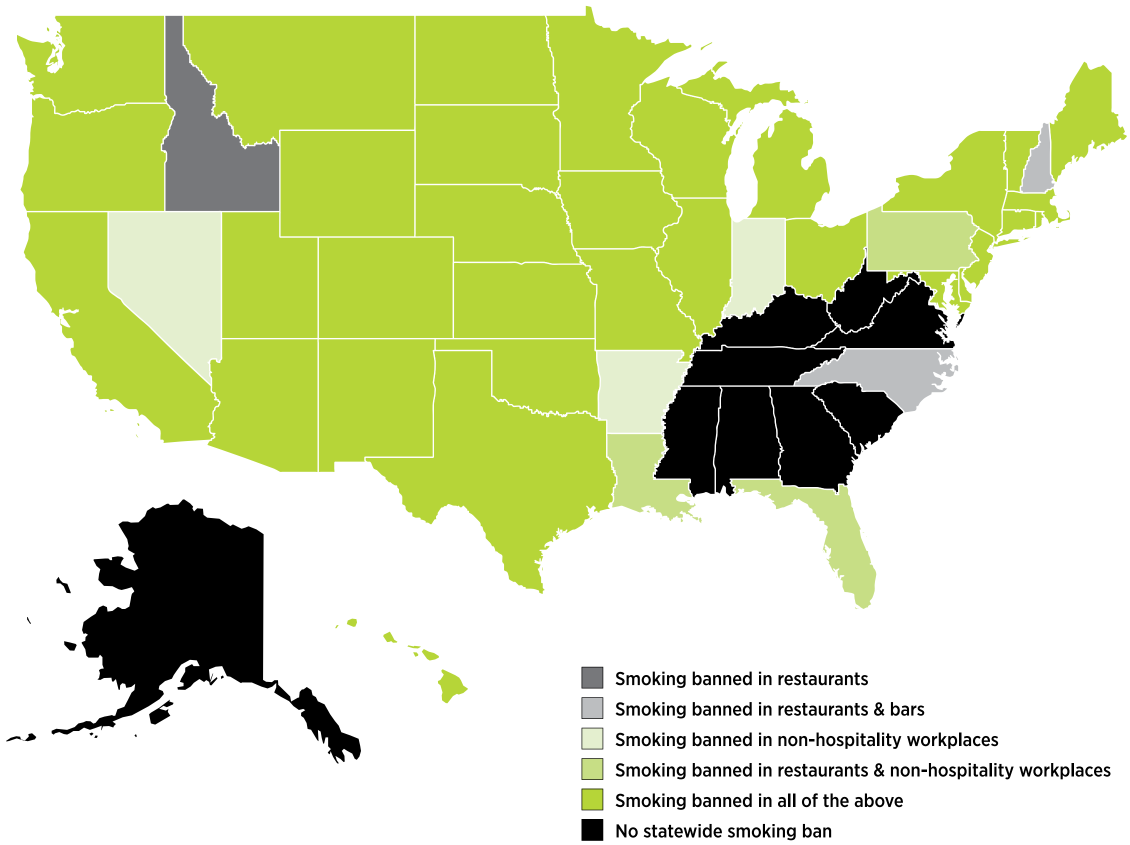


Figure 2. Smoking bans by state

RATING SYSTEM VARIATIONS

Healthcare

The residential-only Option 2 Compartmentalization of Smoking Areas is available to Healthcare projects that have a clinical need to permit residents to smoke.

PROJECT TYPE VARIATIONS

Multitenant

Owners and property management teams for multitenant buildings may find it useful to communicate the interior and exterior smoking policy in tenant guidelines, handbooks, or similar documents.

Residential Healthcare

Residential health care projects, such as long-term care facilities, may allow smoking inside residential units if there is a clinical need to permit residents to smoke. Examples of clinical needs include medical treatments for substance abuse and psychiatric programs.

Residential

Residential projects are the only project type that may choose to allow smoking indoors in specific units. If smoking is permitted in residential projects, leakage from smoking units to other areas of the building must be prevented. Confirm the following requirements:

- All applicable doors and windows are weather-stripped.
- All residential units are sealed in applicable places.
- Testing results demonstrate compliance with the identified leakage rate requirements (see *Referenced Standards*).

Smoking must be prohibited in all building common areas. This prohibition must be communicated through rental or lease agreements, or condo or co-op association covenants and restrictions.

Prohibiting smoking on private residential balconies is a best practice for protecting nearby nonsmoking units and balconies from ETS infiltration. Consider prohibiting smoking on balconies in lease agreements.

All units must be compartmentalized because of potential tenant turnover. The following strategies are recommended to achieve proper air sealing:

- Use caulk for cracks and smaller gaps.
- Use expanding foam sealant for larger openings.
- Use mastic to seal all ducts.
- Use high-quality, durable, exterior-grade weatherstrip on all exterior doors, operable windows, and doors leading from residential units into common hallways.
- Confirm that all recessed can lights in insulated ceilings are airtight and IC-rated.
- Block stud cavities at changes in ceiling height and joist cavities under attic kneewall.
- Use sealed exterior sheathing and/or netting for dense insulation at attic kneewall.

Seal the following areas:

- Bottom plate to subfloor
- Penetrations in the top plate
- Drywall to framing
- Window and door rough openings with expanding foam
- Gaps in exterior wall sheathing
- Exterior walls of fireplace chase
- Shower and tub drains
- Cantilevered floor above supporting wall
- Seams in band joist between conditioned floors
- Electrical and communication boxes

Properly seal all penetrations in unit walls, ceilings, and floors, including the following:

- Perimeter doors, windows, and baseboards
- Plumbing and electrical penetrations, including outlets and switches, through insulated floors, ceilings, and walls
- Recessed lights and fans in insulated ceilings
- Dropped ceilings and cantilevered floors
- Exhaust vent penetrations
- Sheathing, including exterior light fixtures
- Band joist, including exhaust ducts
- Through drywall in attached garage
- Insulated subfloor, including HVAC boots

Properly seal airpath connections to all vertical chases adjacent to smoking units:

- Utility chases
- Garbage chutes
- Mail drops
- Elevator shafts
- All other adjacent vertical chases

Compartmentalization is achieved when individual residential units are adequately isolated from adjacent units and spaces. This must be demonstrated for all units. The most common way to meet this requirement is to conduct a blower door test that follows either the RESNET standards, Energy Star Multifamily Testing Protocol, ASTM E779-03, or ASTM E1827-11 (see *Referenced Standards*).

Consider having a building performance technician visit the job site to explain proper air-sealing techniques before insulation and drywall are installed. Perform blower door testing after drywall is installed and before painting. Testing a single representative unit first can help identify any leakages and pinpoint areas where additional sealing is likely to be required in other units. Use the test results to improve the construction process so that the remaining units pass the test.

A sampling rate of at least one in seven smoking units can be used, per the Residential Manual for Compliance with California's 2001 Energy Efficiency Standards, Chapter 4.

The results must demonstrate a maximum leakage of 0.23 cubic feet per minute per square foot (1.17 liters per second per square meter) at 50 Pa of enclosure.

Teams may use another air leakage test, such as tracer gas testing, provided that the same performance results as a blower door test can be documented. Testing must follow CEN Standard EN 1779 or CEN Standard EN 13185 with EN 13192.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Eligible. Projects can demonstrate compliance with a campus-wide no-smoking policy in lieu of building signage. The policy must be widely communicated to all occupants (including transients and visitors) through ongoing methods such as site signage and other media (brochures, websites, etc.).

REQUIRED DOCUMENTATION

Documentation	All projects where smoking is prohibited	Residential projects where smoking is permitted
Description of project's no-smoking policy, including information on how policy is communicated to building occupants and enforced	X	X
Copy of no-smoking policy, signed letter from owner describing project's no-smoking policy and enforcement, or copy of any legally binding covenants or restrictions to verify status of residential units as nonsmoking	X	
Door schedule demonstrating weather-stripping at exterior unit doors and doors leading from units to common hallways		X
Differential air pressure test report for units in project building		X
Scaled site plan or map showing the location of designated outdoor smoking and no-smoking areas, location of property line, and site boundary and indicating 25-foot (7.5-meter) distance from building openings	X	X
Drawings, photos, or other evidence of signage communicating no-smoking policy	X	X
Any code restrictions that prevent establishment of no-smoking requirements	X	X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

- Designated interior smoking rooms are no longer permitted, with the exception of residential spaces. This change recognizes the overwhelming evidence and broad consensus that exposure to ETS harms human health, and it supports higher indoor air quality in LEED projects.
- The no-smoking policy has been expanded to apply to spaces outside the property line if the space is used for business purposes and is within 25 feet (7.5 meters) of building openings or outdoor air intakes.
- A specific requirement for the location of exterior posted signs has been added.
- The acceptable procedure for demonstrating compliance with air leakage requirements in residential projects has been expanded. This change allows teams to use testing procedures other than blower door testing.

REFERENCED STANDARDS

Standard Test Method for Determining Air Leakage Rate by Fan Pressurization, ASTM E779-03: astm.org

Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door, ASTM E1827-11: astm.org

Nondestructive testing, Leak testing—Criteria for method and technique selection, CEN Standard EN 1779—1999: cen.eu

Nondestructive testing, Leak testing, Tracer gas method, CEN Standard EN 13185—2001: cen.eu

Nondestructive testing, Leak testing, Calibration of reference leaks for gases, CEN Standard EN 13192—2001: cen.eu

RESNET Standards: resnet.us/standards

ENERGY STAR Multifamily Testing Protocol: energystar.gov/ia/partners/bldrs_lenders_raters

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

INDOOR ENVIRONMENTAL QUALITY PREREQUISITE

Minimum Acoustic Performance

This prerequisite applies to: **Schools**

INTENT

To provide classrooms that facilitate teacher-to-student and student-to-student communication through effective acoustic design.

REQUIREMENTS

HVAC Background Noise

Achieve a maximum background noise level of 40 dBA from heating, ventilating, and air-conditioning (HVAC) systems in classrooms and other core learning spaces. Follow the recommended methodologies and best practices for mechanical system noise control in ANSI Standard S12.60–2010, Part 1, Annex A.1; the 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control (with errata); AHRI Standard 885–2008; or a local equivalent for projects outside the U.S.

Exterior Noise

For high-noise sites (peak-hour Leq above 60 dBA during school hours), implement acoustic treatment and other measures to minimize noise intrusion from exterior sources and control sound transmission between classrooms and other core learning spaces. Projects at least one-half mile (800 meters) from any significant noise source (e.g., aircraft overflights, highways, trains, industry) are exempt.

Reverberation Time

Adhere to the following reverberation time requirements.

Classroms and Core Learning Spaces < 20,000 Cubic Feet (566 Cubic Meters)

Design classrooms and other core learning spaces to include sufficient sound-absorptive finishes for compliance with the reverberation time requirements specified in ANSI Standard S12.60–2010, Part 1, Acoustical Performance Criteria, Design Requirements and Guidelines for Schools, or a local equivalent for projects outside the U.S.

OPTION 1

For each room, confirm that the total surface area of acoustic wall panels, ceiling finishes, and other sound-absorbent finishes equals or exceeds the total ceiling area of the room (excluding lights, diffusers, and grilles). Materials must have an NRC of 0.70 or higher to be included in the calculation.

OR

OPTION 2

Confirm through calculations described in ANSI Standard S12.60-2010 that rooms are designed to meet reverberation time requirements as specified in that standard.

Classrooms and Core Learning Spaces ≥ 20,000 Cubic Feet (566 Cubic Meters)

Meet the recommended reverberation times for classrooms and core learning spaces described in the NRC-CNRC Construction Technology Update No. 51, Acoustical Design of Rooms for Speech (2002), or a local equivalent for projects outside the U.S.

Exceptions

Exceptions to the requirements because of a limited scope of work or to observe historic preservation requirements will be considered.

BEHIND THE INTENT

Acoustic performance is important to consider when designing classrooms and other core learning spaces because it can affect students' learning and performance. Background noise and reverberation can distract and confuse children, whose ability to distinguish sounds is not fully developed.[1] Background noises compete with the primary sound source—teachers or fellow students—and reverberation often reduces speech intelligibility and clarity of sound. Students of any age who are distracted by extraneous sounds have difficulty retaining information and staying engaged in learning.[2] Figure 1 shows the typical sources of noise that impinge on concentration in core learning spaces.

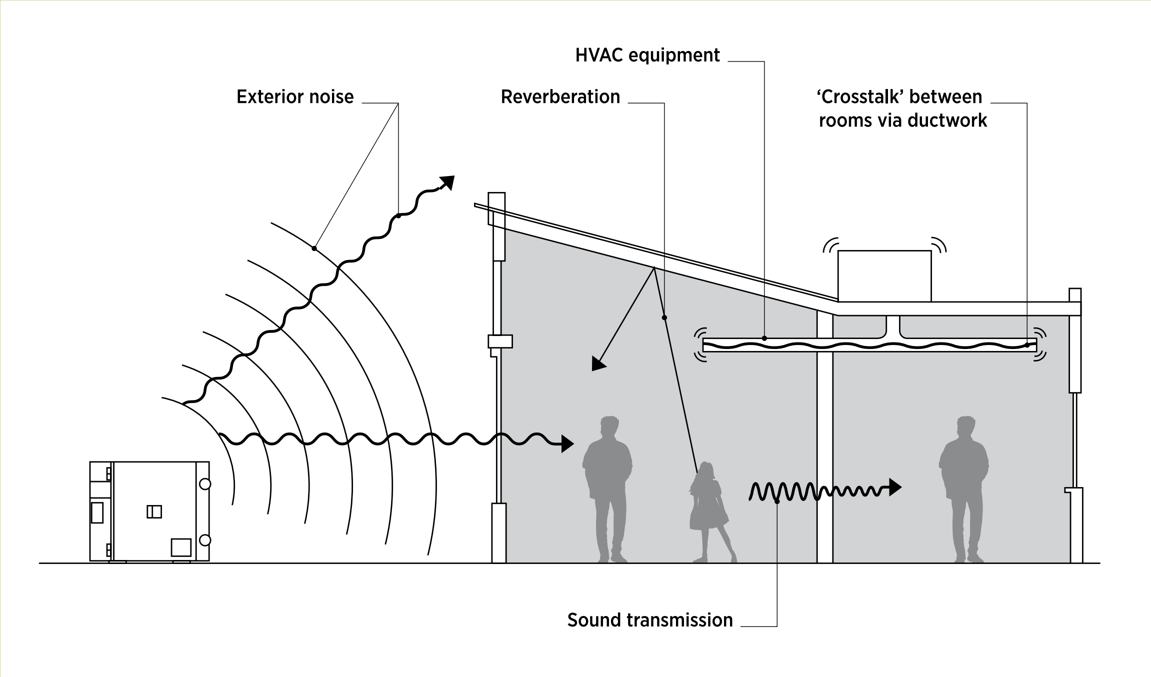


Figure 1. Sources of noise (from left): exterior noise, reverberation, HVAC equipment, sound transmission, and "crosstalk" between rooms via ductwork

For children with temporary or permanent hearing loss or cochlear implants and children who are nonnative speakers, poor acoustics in schools erect needless additional educational barriers. Assistive technologies such as hearing aids amplify both wanted and unwanted sound across a variety of frequencies; these technologies can do little to improve student-to-teacher or student-to-student communication in spaces with poor acoustics. According to the Centers for Disease Control and Prevention, children with temporary hearing loss—some 15% of the school-age population—are especially affected, as are children with speech impairments or learning disabilities.

This prerequisite's reference standards and documentation options allow a project team with even a limited knowledge of acoustics to demonstrate compliance and become aware of school-appropriate acoustic standards. The prerequisite thresholds were specifically chosen to avoid mandating top-tier design practices for high-performance spaces, which would be difficult or impractical to implement within school budgets. Teams that consider acoustics early in the design process (when thinking about programming, site layout, and room layouts) will be best positioned to meet the prerequisite's intent.

1. *Acoustical Society of America, American National Standard: Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools* (2007).
2. *Centers for Disease Control, National Workshop on Mild and Unilateral Hearing Loss* (2005). *cdc.gov/ncbddd/hearingloss/conference.html* (accessed June 10, 2013).

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY ALL CLASSROOMS AND OTHER CORE LEARNING SPACES

Determine which rooms and spaces are covered by this prerequisite (see *EQ Overview* for a list of space types that are considered classrooms and other core learning spaces, and see *Further Explanation, Excluded Space Types* and *Further Explanation, Project Type Variations, Schools*).

STEP 2. REVIEW ACOUSTIC CRITERIA

Evaluate how the three acoustic performance areas addressed by this prerequisite affect each applicable space:

- **HVAC background noise**. Engineers or acoustic experts will need to analyze A-weighted sound pressure levels resulting from HVAC equipment.
- **Exterior noise**. Engineers and designers will need to minimize exterior noise intrusion through design strategies that reduce noise source level.
- **Reverberation time**. Designers will need to specify sound-absorbing treatments and/or revisit room size to address reverberation time.

Prepare a log or spreadsheet to record the pertinent acoustic information for each space.

Determine how the acoustic requirements fit into the design process so that each can be addressed by the responsible party at the appropriate time.

STEP 3. ADDRESS HVAC BACKGROUND NOISE

Identify equipment and air distribution elements that could contribute to HVAC background noise in core learning spaces.

- When selecting and designing HVAC systems, consider basic acoustic design techniques from 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control, page 48.8.
- Consider specific source design considerations from 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control, pages 48.8–48.30.
- Compile acoustic performance data at the specific operating points from the HVAC equipment manufacturer's data.
- Consider source-receiver paths when locating core learning spaces, and HVAC equipment. For example, noise-generating HVAC equipment could be placed above a corridor rather than above a classroom.

STEP 4. VERIFY HVAC BACKGROUND NOISE

Determine A-weighted sound pressure levels for each core learning space through one or more of the following methods. Consider sound pressure levels from HVAC equipment only; plumbing, lighting, and electrical may be excluded.

- Calculate sound pressure levels per 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control. Follow the steps in the HVAC Noise-Reduction Design Procedures section of the handbook (pages 48.38–48.41). The dBA method and a 40-dBA sound pressure limit may be used instead of the referenced noise criteria method. Calculations may be done in the design phase.
- Calculate sound pressure levels per AHRI Standard 885–2008, Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets. Follow the steps outlined in Section 6, Calculation Procedures for Estimating Sound Levels in Occupied Spaces (pages 11–26). A sound pressure limit of 40 dBA may be used in lieu of the dBA and dBC levels shown in Table 15 of the standard. Calculations may be done in the design phase.
- Measure sound pressure levels per ANSI S12.60–2010, Part 1, American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Annex A.1. A sound pressure limit of 40 dBA may be used in lieu of the dBA and dBC levels shown in Tables 1 and 2 of the standard. The measurements must be performed during postconstruction in furnished spaces with HVAC systems operating in typical conditions and while no occupants are present. Noises from sources other than HVAC systems should be minimized or turned off during testing.
- Measure sound pressure levels per 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control. Follow field measurement guidelines from the Determining Compliance section. Follow guidelines from the Room Noise Measurements section. A sound pressure limit of 40 dBA may be used in lieu of the dBA and dBC levels shown in Table 1 of the handbook. The measurements must

be performed during postconstruction in furnished spaces with HVAC systems operating in typical conditions and while no occupants are present. Noises from sources other than HVAC systems should be minimized or turned off during testing.

A local standard, procedure, or handbook that is equivalent to one of the above methods may also be used. Additionally, a sound rating method other than the standard weighted decibel method (dBA method), such as the noise criteria (NC), room criteria (RC), room criteria neutral (RCN), balanced noise criteria (NCB), A-room criteria (RC Mark II), or dBC methods, may be used.

Prepare a narrative that describes the methods followed and a summary report with measurements or calculations.

STEP 5. DETERMINE PRESENCE OF EXTERIOR NOISE SOURCES

Assess the project site for exterior noise sources. Sources of exterior noise can often be readily identified through a site visit during normal school hours. Predicted noise sources may also be identified through study of neighborhood maps or aerial photography that show adjacent site uses. If the site is in the flyover area of an airport, L_{dn} data are typically available online in noise exposure maps (NEMs).

- Identify significant noise sources within ½ mile (800 meters) of the face of the building. Examples of significant sources are major transit corridors, industrial or manufacturing facilities, outdoor concert or sports venues, rail lines, and air traffic lanes. If there are no significant noise sources, skip the exterior L_{eq} measurement, and skip Step 6.
- Conduct acoustic readings on the project site using a sound meter that can measure equivalent continuous noise levels (L_{eq}) measured in A-weighted decibels (dBA) (see *Further Explanation, Understanding Peak-Hour L_{eq}*). Measure exterior noise during the normal period of school hours and repeat as necessary to capture intermittent noise sources such as train and airplane traffic. Record site observations, noting the source, direction, and intensity of the exterior noise, so that the project team can develop design strategies for noise mitigation. If applicable, data from the NEM may be used in lieu of taking measurements.
- If peak-hour L_{eq} measurements exceed 60 dBA, the project is considered a high-noise site and the team must implement noise reduction measures (Step 6). If the peak-hour L_{eq} measurements are below 60 dBA, the team may skip Step 6.
- It is acceptable to forgo measuring L_{eq} if it is already known that the project is on a high-noise site.

STEP 6. FOR HIGH-NOISE SITES, IMPLEMENT MEASURES TO MINIMIZE EXTERIOR NOISE INTRUSION

Minimize the amount of exterior noise in core learning spaces.

- Explore strategies that reduce the source or occurrence of noise, if collaboration with the noise-generating property owner is possible.
- Define the path(s) of noise on the site, and identify how each measure implemented creates a barrier or dampening effect between the source and the receiving core learning space. Include acoustic treatments as appropriate.
- Refer to 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control, Sound Control for Outdoor Equipment (pages 48.33–34), for additional design guidance.

The appropriate combination of strategies depends on the type and regularity of noise sources. Example strategies include the following:

- Site barriers, such as earth berms and site walls
- Architectural barriers, such as other building spaces and courtyards
- Architectural material barriers, such as dense wall construction and offset studs
- Construction best practices, such as sound sealants and window and door gaskets

STEP 7. DESIGN FOR OPTIMUM REVERBERATION TIMES

Use sound-absorptive materials or other strategies to limit reverberation time in core learning spaces.

- Sound absorptive materials can be applied to any planar surface in the space. While applying treatment to the walls is typically the most effective way forward, a sound absorptive ceiling is generally the most cost effective for a classroom. Consider using absorptive wall surfaces or treatments in spaces that primarily require hard surfaces, such as teaching laboratories.
- For spaces that will accommodate seating, consider soft or upholstered backs and seats.
- Refer to ANSI 12.60–2010, Annex C, for additional design guidance.

- Determine sound absorption properties (sound absorption coefficients at 500 Hz, 1000 Hz and 2,000 Hz and/or noise reduction coefficients) for absorptive materials. Use manufacturers' documentation or Table 1 for common materials and pay attention to the mounting condition employed for any values determined from laboratory tests (see ANSI 12.60–2010, Section C.2.1).

TABLE 1. Sound absorption coefficients for common materials

	Coefficient (α)				Coefficient (α)		
Material	**500HZ**	**1000HZ**	**2000HZ**	**Material**	**500Hz**	**1000Hz**	**2000HZ**
Walls				**Floor**			
Brick, unglazed	.03	.04	.05	Concrete or Terrazzo	.015	.02	.02
Brick, unglazed, painted	.02	.02	.02	Linoleum, asphalt, rubber, or cork tile on concrete	.03	.03	.03
Plaster, gypsum, or lime, smooth finish on tile or brick	.02	.03	.04	Wood	.10	.07	.06
Plaster, gypsum, or lime, rough or smooth finish on lath	.06	.05	.04	Wood parquet in asphalt on concrete	.07	.06	.06
Concrete block, light, porous	.31	.29	.39	Carpet, heavy, on concrete	.14	.37	.60
Concrete block, dense, painted	.06	.07	.09	Same, on 40 oz hairfelt or foam rubber	.57	.69	.71
Gypsum boards. 1/2-inch nailed to 2x4s, 16 inches o.c.	.05	.04	.07	Same, with impermeable latex backing on 40 oz hairfelt or foam rubber	.39	.34	.48
Plywood paneling, 3/8-inch thick	.17	.09	.10	Marble or glaze tile	.01	.01	.02
Large panes of heavy plate glass	.04	.03	.02	**Fabrics**			
Ordinary window glass	.18	.12	.07	Light velour, 10 oz per sq yd, hung straight, in contact with walll	.11	.17	.24
Misc				Medium velour, 14 oz per sq yd, draped to half area	.49	.75	.70
Chairs, metal or wood seats, each, unoccupied	.22	.39	.38	Heavy velour, 18 oz per sq yd, draped to half area	.55	.72	.70

STEP 8. CALCULATE ROOM VOLUME

Determine the room volume of each core learning space in the project. Use the room volume to determine whether the reverberation time requirements are defined by the ANSI or NRC-CNRC standard.

STEP 9. SELECT OPTION FOR CLASSROOMS AND CORE LEARNING SPACES LESS THAN 20,000 CUBIC FEET (566 CUBIC METERS)

Determine the acoustic design approach option that is appropriate for each space:

- Option 1 is for simple spaces with regular shapes and parallel surfaces.
- Option 2 is for more complex spaces or for project teams that want a tailored solution to handle unique conditions.

For spaces with a volume between 13,500 cubic feet (382 cubic meters) and 20,000 cubic feet (566 cubic meters), Option 2 is strongly encouraged. Although such spaces are eligible to demonstrate compliance using Option 1, consideration of noise reduction coefficients (NRCs) alone may be insufficient if the space features irregular shapes and nonparallel surfaces; these configurations may need acoustic panels on both ceilings and walls to reduce reverberation.

Option 1. Total Compliant Acoustic Finish Area Exceeds Ceiling Area

Calculate the total ceiling area for the core learning space, excluding diffusers, grilles, and light fixtures. If the ceiling is sloped, consider the ceiling area to be the total area of that sloped surface (minus grilles and light fixtures). If the ceiling has multiple surfaces or levels, use the entire ceiling surface (minus grilles and light fixtures). Include vertical and sloped ceiling elements in the ceiling area calculation.

The total area of compliant sound absorbing treatment must equal or exceed the total ceiling area calculated in the previous step. Sound absorbing treatments may be applied to the ceiling or wall, or may be free hanging acoustic features.

Collect manufacturers' documentation to verify the NRC of each acoustic finish material is 0.7 or higher. Record the area of each acoustic finish material for credit documentation (see *Further Explanation, Examples*).

Option 2. ANSI Standard S12.60–2010 Compliance

Follow the procedures described in ANSI Standard S12.60–2010, Annex A.4, to confirm that the reverberation time for each space complies with the maximum permitted reverberation times in Table 1 of the standard (footnote e of the table may be excluded). Reverberation times are 0.6 seconds or 0.7 seconds, based on space volume.

Reverberation time must be verified at 500, 1000, and 2000 Hz. Calculation and measurement options are available. Retain calculations or measurements for credit documentation. For detailed reverberation time calculations, see EQ Credit Acoustic Performance, *Further Explanation*.

STEP 10. CONFIRM APPROPRIATE REVERBERATION TIMES FOR SPACES 20,000 CUBIC FEET (566 CUBIC METERS) AND LARGER

Follow the procedures described in NRC-CNRC Construction Technology Update No. 51, Acoustical Design of Rooms for Speech (2002), to confirm that the reverberation time for each space complies with Figure 3 of the standard. Reverberation times vary from approximately 0.45 seconds to 1.23 seconds, based on space volume, use, and type.

Reverberation time must be verified at 500, 1000, and 2000 Hz using calculations or measurements. Retain calculations or measurement logs for credit documentation. For detailed reverberation time calculations, see EQ Credit Acoustic Performance, *Further Explanation*.

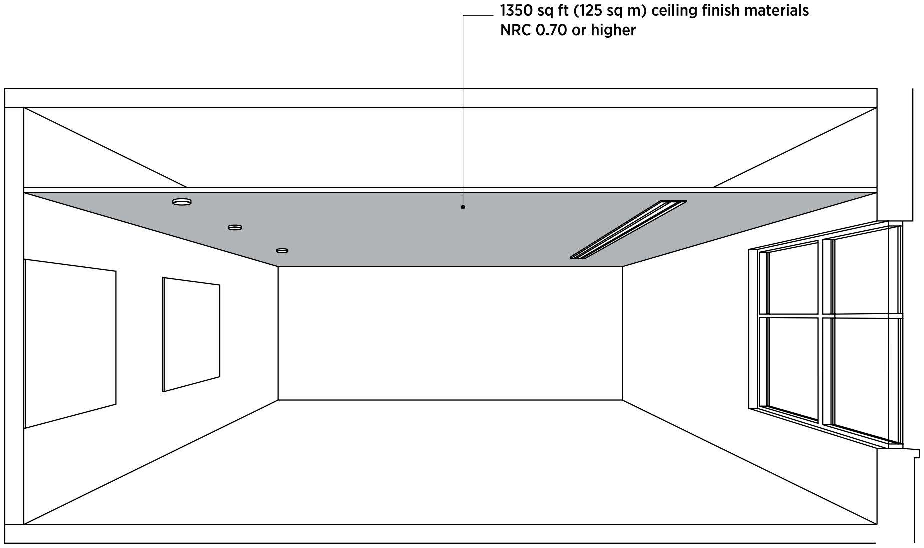
FURTHER EXPLANATION

EXAMPLES

Example 1. 100% acoustic ceiling treatment (Option 1)

A project team has calculated the area of the diffusers and recessed lighting and subtracted it from the total area of the ceiling. The remaining area, 1,350 square feet (125 square meters), has been specified with an acoustic ceiling material rated 0.70 NRC; the rating is documented with testing data supplied by the manufacturer. Because the ceiling material is compliant and covers the entire adjusted ceiling area, the project meets the requirements.

Figure 2. Example of 100% acoustic ceiling treatment

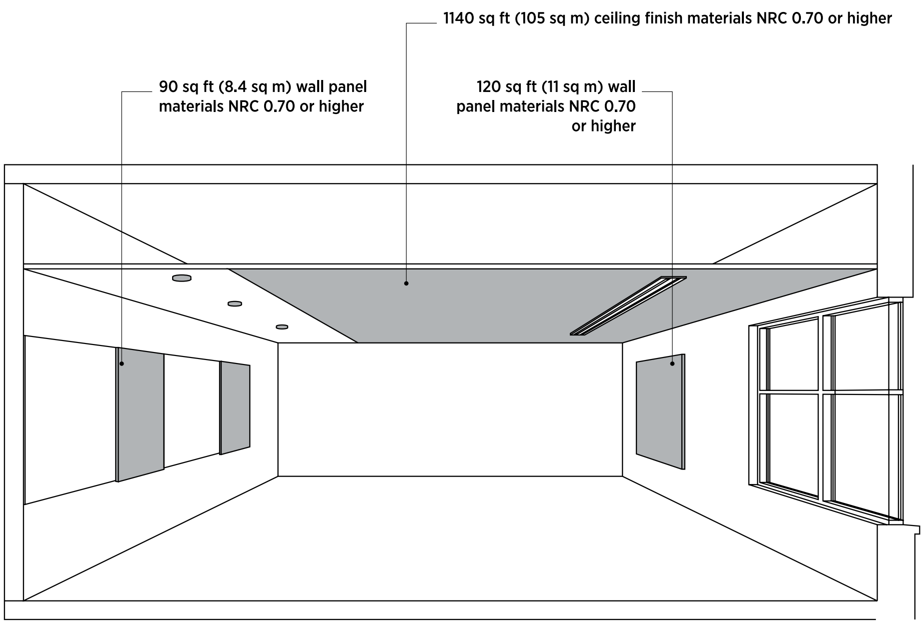


100% of ceiling area finished with NRC of 0.70 or higher

Example 2. Total acoustic finish area (Option 1)

A project team has calculated the area of the diffusers and the recessed lighting and subtracted it from the total area of the ceiling. The remaining area, 1,350 square feet (125 square meters), dictates the total amount of acoustic treatment needed. This team has elected to use 1,140 square feet (105 square meters) of acoustic ceiling tile and added three wall panels of acoustic treatment that totals 210 square feet (20 square meters). For both the ceiling tile and the wall material, the team specifies material that exceeds the credit minimum rating of 0.70 NRC, a rating that is verified by manufacturer-supplied testing data. Because the total area with compliant acoustic finish equals the adjusted ceiling area, the project achieves the prerequisite.

Figure 3. Example of total acoustic finish area



Total area finished with NRC of 0.70 or higher equals ceiling area

EXCLUDED SPACE TYPES

Prerequisite requirements do not apply to natatoriums, auditoriums, music performance spaces, teleconferencing rooms, or special education rooms, such as those for severely acoustically challenged students. These spaces require special acoustical design and treatment that are not within the scope of this prerequisite or the referenced standards.

UNDERSTANDING PEAK-HOUR L_{EQ}

Peak-hour L_{eq} is the equivalent continuous noise level (L_{eq}) for the peak hour. In lay terms, L_{eq} is an energy-average of the noise level over a specified sample time. Most modern sound meters can measure L_{eq}. Teams should follow common industry practice for determining L_{eq}, and source the methodology for their calculations.

PROJECT TYPE VARIATIONS

Schools

Schools projects with limited scope or historical preservation restrictions may still be able to achieve the prerequisite if the team implements as many measures as feasible for each requirement and proposes alternative means to meet the intent.

Strategies may extend to technological, behavioral, or other unconstructed methods of providing acceptable acoustic conditions for classrooms and core learning spaces. For example, a project may not be allowed to change exterior and interior finishes or replace windows and doors of designated historical structures, but the project may be able to modify the exterior landscape, install suspended acoustic treatments, and specify soft seating to meet the intent of the prerequisite.

Provide a detailed narrative about what is and is not under the project team's control. Document and describe all acoustic mitigation strategies undertaken to meet the intent.

INTERNATIONAL TIPS

Local equivalents to ANSI Standard S12.60–2010, Part 1, and NRC-CNRC Construction Technology Update No. 51, Acoustical Design of Rooms for Speech (2002), are acceptable.

CAMPUS

Group Approach

Submit separate documentation for each building.

Campus Approach

Ineligible. Each LEED project must pursue the prerequisite individually. For exterior noise, the L_{eq} measurements and measures to minimize noise intrusion may be appropriate for the entire campus.

REQUIRED DOCUMENTATION

Spaces with identical size and material treatments may be documented together. To reduce documentation burden, calculations and measurements can also be based on acoustically critical spaces or room types or worst-case combinations of room assemblies.

Documentation		All projects
Background noise	Summary report of measurements and calculations documenting compliance with selected reference standard	X
Exterior noise	Description of exterior noise sources (or lack thereof) within ½-mile (800-meter) radius	X
	L_{eq} calculations and narrative describing when measurements were taken (if required)	X
	Description or drawings of measures and strategies implemented to minimize exterior noise (if required)	X
Reverberation time, spaces less than 20,000 ft² (1 860 m²)	Option 1, documentation showing materials with NRC of 0.70 or higher	X
	Option 2, calculations or measurements showing that reverberation times meet the ANSI S12.60-2010 requirements.	X
Reverberation time, spaces 20,000 ft² (1 860 m²) or larger	Calculations or measurements showing that reverberation times meet NRC-CNRC Construction Technology Update No. 51 requirements	X

RELATED CREDIT TIPS

EQ Credit Acoustic Performance. This related credit defines additional acoustic performance criteria that build on the fundamentals of this prerequisite.

CHANGES FROM LEED 2009

- The maximum allowable background noise has been revised from 45 dBA to 40 dBA.
- An exterior noise requirement has been added to minimize exterior noise intrusion into classrooms and core learning spaces.
- The ANSI referenced standard has been updated to ANSI S12.60–2010.
- The ASHRAE referenced standard has been updated to 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control.
- For spaces 20,000 cubic feet (566 cubic meters) or larger, the referenced standard for reverberation time has changed to NRC-CNRC Construction Technology Update No. 51. This standard specifies variable reverberation time and total sound absorption values depending on the size of the space.
- Exceptions for projects with limited renovation scopes or strict historic preservation requirements have been added.

REFERENCED STANDARDS

AHRI Standard 885–2008, Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets: ahrinet.org

American National Standards Institute (ANSI)/ASHRAE Standard S12.60–2010, Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools: asastore.aip.org

2011 HVAC Applications, ASHRAE Handbook, Chapter 48, Noise and Vibration Control: ashrae.org

NRC-CNRC Construction Technology Update No. 51, Acoustic Design of Rooms for Speech, 2002: nrc-cnrc.gc.ca

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

classroom or core learning space a space that is regularly occupied and used for educational activities. In such space, the primary functions are teaching and learning, and good speech communication is critical to students' academic achievement. (Adapted from ANSI S12.60)

INDOOR ENVIRONMENTAL QUALITY CREDIT

Enhanced Indoor Air Quality Strategies

This credit applies to:

New Construction (1–2 points)
Core and Shell (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To promote occupants' comfort, well-being, and productivity by improving indoor air quality.

REQUIREMENTS

OPTION 1. ENHANCED IAQ STRATEGIES (1 POINT)

Comply with the following requirements, as applicable.

Mechanically ventilated spaces:

A. entryway systems;
B. interior cross-contamination prevention; and
C. filtration.

Naturally ventilated spaces:

A. entryway systems; and
D. natural ventilation design calculations.

Mixed-mode systems:

A. entryway systems;
B. interior cross-contamination prevention;
C. filtration;
D. natural ventilation design calculations; and
E. mixed-mode design calculations.

A. Entryway Systems
Install permanent entryway systems at least 10 feet (3 meters) long in the primary direction of travel to capture dirt and particulates entering the building at regularly used exterior entrances. Acceptable entryway systems include permanently installed grates, grilles, slotted systems that allow for cleaning underneath, rollout mats, and any other materials manufactured as entryway systems with equivalent or better performance. Maintain all on a weekly basis.

WAREHOUSES AND DISTRIBUTION CENTERS ONLY

Entryway systems are not required at doors leading from the exterior to the loading dock or garage but must be installed between these spaces and adjacent office areas.

HEALTHCARE ONLY

In addition to the entryway system, provide pressurized entryway vestibules at high-volume building entrances.

B. Interior Cross-Contamination Prevention
Sufficiently exhaust each space where hazardous gases or chemicals may be present or used (e.g., garages, housekeeping and laundry areas, copying and printing rooms), using the exhaust rates determined in EQ Prerequisite Minimum Indoor Air Quality Performance or a minimum of 0.50 cfm per square foot (2.54 l/s per square meter), to create negative pressure with respect to adjacent spaces when the doors to the room are closed. For each of these spaces, provide self-closing doors and deck-to-deck partitions or a hard-lid ceiling.

C. Filtration
Each ventilation system that supplies outdoor air to occupied spaces must have particle filters or air-cleaning devices that meet one of the following filtration media requirements:

- minimum efficiency reporting value (MERV) of 13 or higher, in accordance with ASHRAE Standard 52.2–2007; or
- Class F7 or higher as defined by CEN Standard EN 779–2002, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance.

Replace all air filtration media after completion of construction and before occupancy.

DATA CENTERS ONLY

The above filtration media requirements are required only for ventilation systems serving regularly occupied spaces.

D. Natural Ventilation Design Calculations
Demonstrate that the system design for occupied spaces employs the appropriate strategies in Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Non-Domestic Buildings, Section 2.4.

E. Mixed-Mode Design Calculations
Demonstrate that the system design for occupied spaces complies with CIBSE Applications Manual 13–2000, Mixed Mode Ventilation.

OPTION 2. ADDITIONAL ENHANCED IAQ STRATEGIES (1 POINT)

Comply with the following requirements, as applicable.

Mechanically ventilated spaces (select one):

A. exterior contamination prevention;
B. increased ventilation;
C. carbon dioxide monitoring; or
D. additional source control and monitoring.

Naturally ventilated spaces (select one):

A. exterior contamination prevention;
D. additional source control and monitoring; or
E. natural ventilation room by room calculations.

Mixed-mode systems (select one):

A. exterior contamination prevention;
B. increased ventilation;
D. additional source control and monitoring; or
E. natural ventilation room-by-room calculations.

A. Exterior Contamination Prevention
Design the project to minimize and control the entry of pollutants into the building. Ensure through the results of computational fluid dynamics modeling, Gaussian dispersion analyses, wind tunnel modeling, or tracer gas modeling that outdoor air contaminant concentrations at outdoor air intakes are below the thresholds listed in Table 1 (or local equivalent for projects outside the U.S., whichever is more stringent).

TABLE 1. Maximum concentrations of pollutants at outdoor air intakes

Pollutants	Maximum concentration	Standard
Those regulated by National Ambient Air Quality Standards (NAAQS)	Allowable annual average **OR** 8-hour or 24-hour average where an annual standard does not exist **OR** Rolling 3-month average	National Ambient Air Quality Standards (NAAQS)

B. Increased Ventilation
Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates as determined in EQ Prerequisite Minimum Indoor Air Quality Performance.

C. Carbon Dioxide Monitoring
Monitor CO_2 concentrations within all densely occupied spaces. CO_2 monitors must be between 3 and 6 feet (900 and 1 800 millimeters) above the floor. CO_2 monitors must have an audible or visual indicator or alert the building automation system if the sensed CO_2 concentration exceeds the setpoint by more than 10%. Calculate appropriate CO_2 setpoints using methods in ASHRAE 62.1–2010, Appendix C.

D. Additional Source Control and Monitoring
For spaces where air contaminants are likely, evaluate potential sources of additional air contaminants besides CO_2. Develop and implement a materials-handling plan to reduce the likelihood of contaminant release. Install monitoring systems with sensors designed to detect the specific contaminants. An alarm must indicate any unusual or unsafe conditions.

E. Natural Ventilation Room-by-Room Calculations
Follow CIBSE AM10, Section 4, Design Calculations, to predict that room-by-room airflows will provide effective natural ventilation.

BEHIND THE INTENT

Indoor pollutants and particulates are brought indoors by occupants, through ventilation system intakes or building openings, and from activities conducted within the building. Designing for effective indoor air quality (IAQ) can help produce a comfortable indoor environment for building occupants and prevent the human health problems associated with poor indoor air quality.

This credit identifies IAQ strategies that extend beyond the outdoor air requirements of EQ Prerequisite Minimum Indoor Air Quality Performance. Design strategies include the installation of entryway systems to prevent contaminants from being brought inside by occupants, use of enhanced filtration media, increased ventilation, and monitoring strategies for ventilation systems. Each strategy alone is beneficial, but a combination of multiple strategies is encouraged.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE HOW PROJECT IS VENTILATED

Determine whether the project will use mechanical ventilation, natural ventilation, or a mixed-mode approach (see EQ Prerequisite Minimum Indoor Air Quality Performance).

STEP 2. SELECT ONE OR BOTH OPTIONS

Determine which option(s) and strategies the project will pursue, based on the information in Table 2 and the credit requirements.

- Option 1 requires implementing all strategies applicable to the project's ventilation system type.
- Option 2 requires implementing one strategy applicable to the project's ventilation system type. If multiple ventilation system types are used (i.e., mixed mode), only one strategy needs to be attempted. For example, if a space is both naturally and mechanically ventilated, the project team could select carbon dioxide monitoring and implement this strategy by installing monitors that operate whenever the space is operating in mechanical ventilation mode. Similarly, if the project has both naturally and mechanically ventilated spaces, it could also select carbon dioxide monitoring and implement this strategy by installing monitors in all mechanically ventilated spaces.

<table>
<tr><th colspan="6">TABLE 2. Ventilation systems and credit requirements</th></tr>
<tr><td colspan="6">Option 1. Enhanced IAQ strategies</td></tr>
<tr><td></td><td>Entryway systems</td><td>Interior cross-contamination prevention</td><td>Filtration</td><td>Natural ventilation design calculations</td><td>Mixed-mode design calculations</td></tr>
<tr><td>Mechanically ventilated space</td><td>Required</td><td>Required</td><td>Required</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Naturally ventilated space</td><td>Required</td><td>N/A</td><td>N/A</td><td>Required</td><td>N/A</td></tr>
<tr><td>Mixed-mode system</td><td>Required</td><td>Required</td><td>Required</td><td>Required</td><td>Required</td></tr>
<tr><td colspan="6">Option 2. Additional enhanced IAQ strategies</td></tr>
<tr><td></td><td>Exterior contamination prevention</td><td>Increased ventilation</td><td>Carbon dioxide monitoring</td><td>Additional source control and monitoring</td><td>Natural ventilation room-by-room calculations</td></tr>
<tr><td>Mechanically ventilated space</td><td colspan="4">Select 1 of 4</td><td>N/A</td></tr>
<tr><td>Naturally ventilated space</td><td>Select 1 of 3</td><td>N/A</td><td>N/A</td><td colspan="2">Select 1 of 3</td></tr>
<tr><td>Mixed-mode system</td><td colspan="2">Select 1 of 4</td><td>N/A</td><td colspan="2">Select 1 of 4</td></tr>
</table>

STEP 3. COMPLY WITH APPROPRIATE STRATEGY REQUIREMENTS

For each strategy required for a given space's ventilation system, follow the appropriate set of steps. Prepare a narrative indicating the system type and strategies pursued, detailing how compliance was achieved.

Option 1. Enhanced IAQ Strategies

ENTRYWAY SYSTEMS

STEP 1. IDENTIFY APPLICABLE ENTRIES

Identify all regularly used exterior entrances to the building (see *Further Explanation, Regularly Used Exterior Entrances, Rating System Variations,* and *Project Type Variations*).

STEP 2. INCORPORATE PERMANENT ENTRYWAY SYSTEMS INTO DESIGN

Determine which type of permanent entryway system will be installed and incorporate into the project drawings and specifications (see *Further Explanation, Selecting a Permanent Entryway System*). Indicate the compliant entryways on project plans.

STEP 3. IMPLEMENT MAINTENANCE STRATEGY

Determine how the entryway systems will be maintained on a weekly basis. Consider modifying standard operating procedures, cleaning programs, and vendor requirements to include entryway maintenance.

INTERIOR CROSS-CONTAMINATION PREVENTION

STEP 1. IDENTIFY ALL SPACES NEEDING INTERIOR CROSS-CONTAMINATION PREVENTION

Identify spaces where hazardous gases or chemicals may be handled or used, as indicated in the credit requirements.

- Open garages are exempt from this requirement.
- Include housekeeping and laundry areas even if green cleaning policies are adopted.
- Copying and printing rooms with convenience printers and copiers only may be excluded. The definition of convenience printers and copiers is left to the discretion of the design team; convenience machines are generally small units shared by many office personnel for short printing and copying jobs.

STEP 2. DEVELOP CONTAMINANT CONTROL DESIGN

Work with the architect and mechanical designer to develop a contaminant control design for all spaces needing interior cross-contamination prevention and incorporate strategies into the project drawings and specifications.

- Include self-closing doors and either deck-to-deck partitions or a hard-lid ceiling for each space, as indicated in the credit requirements.
- Design the exhaust system such that each space has negative pressure, as indicated in the credit requirements. Use the exhaust rates from EQ Prerequisite Minimum Indoor Air Quality Performance or 0.50 cfm per square foot, whichever is greater (see *Further Explanation, Exhaust Rates for Interior Cross-Contamination Prevention*).
- Additional ductwork and exhaust fans may be needed to provide the required ventilation. Possible strategies to achieve the necessary ventilation economically include stacking all high-pollutant source areas and locating rooms with hazardous material adjacent to outside walls and each other.

FILTRATION MEDIA

STEP 1. SPECIFY COMPLIANT FILTRATION MEDIA

Identify all HVAC equipment that supplies outdoor air to occupied spaces and specify outdoor air filtration media that meet the credit requirements for minimum efficiency reporting value (MERV) ratings or filtration class. All outdoor air supplied to occupied spaces must be filtered.

- Ensure that specified air-handling equipment is designed to accommodate the required filter media. Otherwise, customization—resizing ductwork, increasing fan capacity to maintain air delivery despite the added resistance of MERV 13 (F7) filtration, or other modifications to system design—may be required.

- Mixed return and outdoor air can also be filtered with MERV 13 (F7) or higher, but this is not required.
- If the project design includes a dedicated outdoor air system with local distribution systems, the filtration requirement applies only to the dedicated outdoor air system.

STEP 2. REPLACE FILTRATION BEFORE OCCUPANCY

Replace all filters after completion of construction but before occupancy. For Data Center projects, see *Further Explanation, Rating System Variations*.

NATURAL VENTILATION DESIGN CALCULATIONS

STEP 1. REVIEW STANDARD

Review the basic forms of ventilation strategy presented in Chartered Institution of Building Service Engineers Applications (CIBSE) Manual AM10, Natural Ventilation in Non-Domestic Buildings, Section 2.4: single-sided ventilation, single opening, double opening, cross-ventilation, stack ventilation, double-skin facade ventilation, mechanically assisted strategies, and night ventilation. Identify which ventilation strategies apply to the project.

STEP 2. CONFIRM RULES OF THUMB FOR ESTIMATING EFFECTIVENESS OF NATURAL VENTILATION

Use the rules of thumb or guidance from CIBSE AM10 as applicable to the project. Prepare diagrams and narratives to explain how each applicable rule of thumb or guidance was considered. The documentation should supplement the natural ventilation calculations for EQ Prerequisite Minimum Indoor Air Quality Performance.

Room-by-room calculations found in CIBSE AM10, Section 4, are not required for this option.

MIXED-MODE VENTILATION DESIGN CALCULATIONS

STEP 1. REVIEW STANDARD

Review the mixed-mode design strategies presented in Chartered Institution of Building Service Engineers (CIBSE) Applications Manual AM13, Mixed-Mode Ventilation, Section 2.1: contingency design, complementary design, and zone design. Identify which mixed-mode strategy applies to the project. If the complementary design is selected, also identify the operational strategy based on CIBSE AM13, Section 2.2.

Use CIBSE AM13, Figure 2.1, as the iteration strategy to optimize the mixed mode system.

STEP 2. CONFIRM THAT DESIGN FOLLOWS APPROPRIATE MIXED-MODE STRATEGIES

Use the guidance and strategies from CIBSE AM13 (Section 2.1, Section 2.2, and Figure 2.1) as applicable to the project. Prepare diagrams and narratives to explain how the guidance was considered. The documentation should supplement that prepared for EQ Prerequisite Minimum Indoor Air Quality Performance and requirement D (natural ventilation design calculations) in this credit.

Option 2. Additional Enhanced IAQ Strategies

Determine which strategy the project will implement, based on Table 2.

EXTERIOR CONTAMINATION PREVENTION

STEP 1. DESIGN OUTDOOR AIR INTAKES TO MINIMIZE AND CONTROL ENTRY OF POLLUTANTS

Consider locating outdoor air intakes away from nearby sources of pollutants. Air intakes located one-third of the way up the side of the building tend to work best.[1] Locate air intakes away from loading docks and roadways. Also avoid below-grade locations in areaways and locations near roof-mounted exhausts.[2] ASHRAE 62.1–2010, Table 5-1, lists minimum separation distances for air intakes (see *Further Explanation, International Tips*).

1. *Spengler, J.D., J.M. Samet, and J.F. McCarthy, Indoor Air Quality Handbook (New York: McGraw-Hill, 2001).*
2. *Ibid.*

STEP 2. SELECT MODELING TOOL

Determine which modeling tool, of the list in the credit requirements, will be used to verify compliance with pollution concentration requirements. Consider whether the software can accurately capture expected meteorological conditions, potential pollutant plumes, and contaminant concentrations at the project's outdoor air intakes.

STEP 3. COMPLETE LEVEL 1 SCREENING

Model contaminant travel at worst-case meteorological conditions. Worst-case conditions should be based on the wind speed and direction, with a direct line of sight from each pollutant source to the project building.

Once worst-case conditions have been identified, perform a simulation to determine whether concentrations for the pollutants regulated by National Ambient Air Quality Standards (NAAQS) at outdoor air intakes are below the allowable annual average, eight-hour or 24-hour average where an annual standard does not exist, or the rolling three-month average. If all pollutant concentrations are well below the required thresholds, no further modeling is required.

STEP 4. COMPLETE LEVEL 2 SCREENING

If the Level 1 screening indicates that pollutant concentrations are barely compliant or noncompliant, perform a Level 2 screening to reassess pollutant concentrations. Use more detailed inputs pertaining to atmospheric processes, building geometry, and emissions concentrations. If the precise composition of chemical exhaust from a source is unpublished, document how the team arrived at its components and concentrations.

The Level 2 screening should confirm one of the following outcomes:

- The concentrations for the pollutants regulated by NAAQS at outdoor air intakes are below the allowable annual average, eight-hour or 24-hour average where an annual standard does not exist, or the rolling three-month average.
- The indoor concentrations for the pollutants regulated by NAAQS are below 2.5% of the allowable annual average, eight-hour or 24-hour average where an annual standard does not exist, or the rolling three-month average. Indoor analyses may require a different modeling technique than that used in the Level 1 dispersion analysis. If the Level 2 screening indicates that pollutant concentrations are noncompliant, consider modifying air filtration or the locations of the outdoor air intakes.

INCREASED VENTILATION

STEP 1. DETERMINE VOLUME OF OUTDOOR AIR REQUIRED

Use the ventilation standard or code and the calculation methodology selected for EQ Prerequisite Minimum Indoor Air Quality Performance to determine the 30% increase.

- Follow the prerequisite's steps for mechanical ventilation systems to determine the amount of outdoor air that must be supplied by each ventilation system. To meet the credit requirements, the system must deliver 30% more outdoor air to the occupied spaces at all times the space is occupied. For multiple-zone recirculating systems, this will likely increase the required outdoor air intake for the system by more than 30%.
- For projects that use ASHRAE 62.1–2010, see *Further Explanation, Determining Increased Ventilation Rate*.
- Exhaust rates are excluded from the credit requirements.

STEP 2. REVISE DESIGN TO MEET OUTDOOR AIR REQUIREMENTS, IF NECESSARY

See EQ Prerequisite Minimum Indoor Air Quality Performance for recommended modifications for specific mechanical ventilation system types.

CARBON DIOXIDE (CO_2) MONITORING

STEP 1. IDENTIFY DENSELY OCCUPIED SPACES

Review ventilation calculations developed for EQ Prerequisite Minimum Indoor Air Quality Performance or the project's furniture plans to identify all spaces with an occupant density greater than 25 people per 1,000 square feet (93 square meters).

STEP 2. DESIGN CO_2 MONITORING SYSTEM

Incorporate CO_2 sensors into the design for each densely occupied space.

- CO_2 sensors must be located in the breathing zone, as defined in the credit requirements. CO_2 sensors installed in return air ducts cannot be used to meet the requirements.

- Determine CO_2 concentration setpoint(s) using the methods in ASHRAE 62.1–2010, Appendix C. See *ASHRAE 62.1–2010 User's Manual, Appendix A*, for calculations and examples.
- Configure the CO_2 monitoring system to generate an alarm if the differential CO_2 concentration exceeds the setpoint by more than 10%. Alarms may be audible or visual indicators to space occupants or building automation system alerts. CO_2 sensors may be incorporated into the HVAC control system, for example, to open zone VAV dampers when the setpoint is exceeded. However, this is not required.

STEP 3. INSTALL AND COMMISSION CO_2 SENSORS

During construction, install CO_2 sensors per the design. Include CO_2 sensors in the commissioning process for EA Prerequisite Fundamental Commissioning and Verification.

ADDITIONAL SOURCE CONTROL AND MONITORING

STEP 1. DETERMINE POTENTIAL CONTAMINANT SOURCES

List potential indoor air contaminants that may be present in the project spaces. Consider typical substances found in the particular building type, and review activities and processes that will occur. Substances might include cleaning supplies, laboratory chemicals, or materials required for manufacturing.

STEP 2. IDENTIFY PRIORITY CONTAMINANTS AND EXPOSURE LIMITS

From the list of potential sources, identify the priority contaminants—those that pose the greatest risk to occupants' health. For each priority contaminant, identify a reference standard and an exposure limit.

STEP 3. DESIGN AND INSTALL MONITORING SYSTEM

Install a permanent monitoring system to continuously monitor concentrations of priority contaminants. Configure the system to generate an alarm when unusual or unsafe concentrations occur.

- Retain documentation that describes how alarm setpoints were established.
- Include the contaminant monitoring system in the commissioning process for EA Prerequisite Fundamental Commissioning and Verification.

STEP 4. DEVELOP AND IMPLEMENT MATERIALS HANDLING PLAN

Develop a materials handling plan to limit human exposure to priority contaminants and ensure that the monitoring system is effective. For example, a materials handling plan may require that a particular solvent be stored and used in a single room that is properly ventilated and equipped with sensors connected to an alarm.

NATURAL VENTILATION ROOM-BY-ROOM CALCULATIONS

STEP 1. DETERMINE REQUIRED FLOW RATES

Follow CIBSE AM10, Section 4.1, to determine the desired airflow rates.

STEP 2. DETERMINE OPENING SIZES

Follow CIBSE AM10, Sections 4.1.2, 4.1.3, 4.1.4, 4.2, and 4.3, as applicable, to determine whether the design will produce sufficient airflow rates and to optimize opening sizes, locations, and characteristics. These sections offer many calculation options. All options are acceptable, provided inputs and results are justified and reasonable.

STEP 3. CONFIRM COMPLIANCE

Create a table of all naturally ventilated spaces in the project, opening characteristics, desired flow rates, and calculated flow rates. Indicate how seasonal conditions and different wind conditions were considered.

Determine the free area of natural ventilation openings and the required opening area. Confirm that natural ventilation openings meet or exceed the sizes calculated for all spaces. The documentation should supplement that developed for EQ Prerequisite Minimum Indoor Air Quality Performance and Option 1, requirement D (natural ventilation design calculations) in this credit.

Note, if you comply with these natural ventilation room-by-room calculations, you automatically comply with the ventilation requirements for naturally ventilated spaces in the Minimum Indoor Air Quality Performance prerequisite. The monitoring requirements in the prerequisite must still be met.

FURTHER EXPLANATION

CALCULATIONS

See the referenced standards for all calculations.

REGULARLY USED EXTERIOR ENTRANCES

See *Definitions* to help in identifying regularly used entrances.

For renovation or additions where the scope of the project does not include an exterior entrance, entryway systems do not need to be installed. However, if the project scope includes an entrance that would qualify as regularly used exterior entrance, then the team must ensure that appropriate entryway systems are also installed.

See *Rating System Variations* for considerations for Warehouses and Distribution Centers and Healthcare.

SELECTING A PERMANENT ENTRYWAY SYSTEM

Permanent entryway systems must catch and hold dirt particles and prevent contamination of the building interior. Acceptable permanent entryway systems include the following:

- Permanently installed grates
- Grilles
- Slotted systems that allow for cleaning underneath
- Rollout mats
- Carpet tile specifically designed for entryway system or similar use
- Other materials manufactured for use as an entryway system or similar that performs at least as well as the above systems

Typical building carpeting is not an acceptable permanent entryway system.

Consider permanent entryway systems that have solid backings. A nonporous backing captures dirt and moisture and helps prevent contaminants from collecting underneath. Consider permanent entryway systems made with mold- and mildew- resistant materials.

The permanent entryway system should be at least 10 feet (3 meters) long. Exceptions to the 10-foot (3-meter) distance are allowed if the team submits documentation verifying that the proposed entryway system performs at least as well as a full-length system. The selected product should be appropriate for the project's climate. Areas with high precipitation, for example, may need to install more absorbent mats to prevent occupants from slipping.

Evaluate maintenance requirements when selecting the permanent entryway system. All permanent entryway systems must be maintained on a weekly basis.

EXHAUST RATES FOR INTERIOR CROSS-CONTAMINATION PREVENTION

In general, exhaust rates are prescribed by the ventilation standard or code used in EQ Prerequisite Minimum Indoor Air Quality Performance. However, if this standard or code does not set a requirement for a particular space type, a minimum exhaust rate of 0.5 cubic feet per minute (cfm) per square foot (2.54 liters per second, l/s, per square meter) must be used.

ASHRAE 62.1–2010, Table 6-4, lists numerous spaces whose exhaust requirements exceed the 0.5 cfm per square foot (2.54 l/s per square meter) rate. Exhaust rates for these spaces must be maintained at all times, even when the building is not occupied.

If supply air is being provided to the room, the exhaust rate must be sufficient to create a negative pressure with respect to adjacent spaces when the doors to the room are closed.

No recirculation of the air from these rooms is permitted.

DETERMINING INCREASED VENTILATION RATES

When using ASHRAE 62.1–2010, use the following process to determine the 30% increase in ventilation for the breathing zone:

Single-zone or 100% outdoor air system. Calculate the required outdoor intake flow using the ventilation rate procedure and multiple the result by 1.3.

Multiple-zone recirculating system. At the system level, multiply the uncorrected outdoor air requirements for the system, V_{ou}, by 1.3. Multiply the outdoor airflow (V_{bz}) in the critical zone's breathing zone by 1.3. Recalculate the system ventilation efficiency, Ev, based on the revised values for Vou and critical zone V_{bz}. This will likely increase the required outdoor air intake for the system (V_{ot}) by more than 30%.

RATING SYSTEM VARIATIONS

Warehouses and Distribution Centers
For Option 1 Entryway Systems, exterior entrances to loading docks and garages are not required to have entryway systems. Regularly used entrances from these areas into adjacent spaces in the building (typically office areas of the building) must have entryway systems.

Healthcare
For Option 1 Entryway Systems, in addition to the entryway system, provide pressurized entryway vestibules at high-volume building entrances.

Data Centers
For Option 1 Filtration, the requirements apply only to ventilation systems serving regularly occupied spaces (see *EQ Overview*).

PROJECT TYPE VARIATIONS

Residential Projects
For Option 1 Entryway Systems, the systems are required only at the ground level, for each residential entrance from the outdoors.

INTERNATIONAL TIPS

For Option 2 Exterior Contamination Prevention, local guidelines for maximum concentrations of pollutants at air intakes may be followed, provided they are at least as stringent as the U.S. EPA guideline.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Entryway systems: scaled floor plans showing locations and measurements	X	
Interior cross-contamination prevention: list of rooms, areas, exhaust rate, separation method	X	
Filtration: mechanical schedules highlighting MERV or class ratings for all units that supply outdoor air	X	
Natural ventilation design: calculations and narrative demonstrating appropriate strategies per referenced standard	X	
Mixed mode design: calculations and narrative demonstrating appropriate strategies per referenced standard	X	
Exterior contamination prevention: narrative describing type of modeling; model output reports highlighting contaminant levels and required thresholds		X
Increased ventilation: confirmation (calculations are documented under EQ Prerequisite Minimum Indoor Air Quality Performance)		X
Carbon dioxide monitoring: list of densely occupied spaces, space type, design CO_2 concentrations, floor plan showing sensor locations, narrative describing CO_2 setpoints		X
Additional source control and monitoring: description of likely air contaminants and how they were identified, description of materials handling plan, plans showing installed monitoring system		X
Natural ventilation: room-by-room calculations, narrative, and diagrams demonstrating effective natural ventilation per referenced standard		X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. Increased filtration and increased ventilation affect energy consumption. Consider incorporating energy efficiency measures, such as dedicated outdoor air systems, economizers, and demand-controlled ventilation, to reduce or eliminate potential energy penalties.

EQ Prerequisite Minimum Indoor Air Quality Performance. The ventilation system referenced in the related prerequisite must be consistent with this credit.

CHANGES FROM LEED 2009

- Portions of IEQ Credit 1 Outdoor Air Delivery Monitoring, IEQ Credit 2 Increased Ventilation, and IEQ Credit 5 Indoor Chemical and Pollutant Source Control have been combined into a single credit.
- Meeting the requirements of interior cross-contamination prevention no longer requires a calculation of a minimum pressure differential. However, the exhaust rates from the ventilation standard in EQ Prerequisite Minimum Indoor Air Quality Performance must be used. For spaces that do not have a requirement from this standard, a minimum exhaust rate of 0.5 cubic feet per minute per square foot (2.54 liters per second per square meter) must be used.
- Additional options regarding naturally ventilated spaces have been included.
- Additional guidance has been incorporated for warehouses, distribution centers, health care facilities, data centers, and residential projects.
- An option for filtration media requirements, CEN Standard EN 779–2002, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance, has been added.

REFERENCED STANDARDS

ASHRAE Standard 52.2–2007: ashrae.org

CEN Standard EN 779–2002: cen.eu

ASHRAE Standard 62.1—2010: ashrae.org

Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005: cibse.org

Chartered Institution of Building Services Engineers (CIBSE) Applications Manual 13, 2000: cibse.org

National Ambient Air Quality Standards (NAAQS): epa.gov/air/criteria.html

EXEMPLARY PERFORMANCE

Achieve both Option 1 and Option 2 and incorporate an additional Option 2 strategy.

DEFINITIONS

densely occupied space an area with a design occupant density of 25 people or more per 1,000 square feet (93 square meters)

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

regularly occupied space an area where one or more individuals normally spend time (more than one hour per person per day on average) seated or standing as they work, study, or perform other focused activities inside a building. The one-hour timeframe is continuous and should be based on the time a typical occupant uses the space. For spaces that are not used daily, the one-hour timeframe should be based on the time a typical occupant spends in the space when it is in use.

regularly used exterior entrance a frequently used means of gaining access to a building. Examples include the main building entrance as well as any building entryways attached to parking structures, underground parking garages, underground pathways, or outside spaces. Atypical entrances, emergency exits, atriums, connections between concourses, and interior spaces are not included.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Low-Emitting Materials

This credit applies to:

New Construction (1–3 points)
Core and Shell (1–3 points)
Schools (1–3 points)
Retail (1–3 points)
Data Centers (1–3 points)
Warehouses and Distribution Centers (1–3 points)
Hospitality (1–3 points)
Healthcare (1–3 points)

INTENT

To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment.

REQUIREMENTS

This credit includes requirements for product manufacturing as well as project teams. It covers volatile organic compound (VOC) emissions in the indoor air and the VOC content of materials, as well as the testing methods by which indoor VOC emissions are determined. Different materials must meet different requirements to be considered compliant for this credit. The building interior and exterior are organized in seven categories, each with different thresholds of compliance. The building interior is defined as everything within the waterproofing membrane. The building exterior is defined as everything outside and inclusive of the primary and secondary weatherproofing system, such as waterproofing membranes and air- and water-resistive barrier materials.

OPTION 1. PRODUCT CATEGORY CALCULATIONS

Achieve the threshold level of compliance with emissions and content standards for the number of product categories listed in Table 2.

TABLE 1. Thresholds of compliance with emissions and content standards for 7 categories of materials

Category	Threshold	Emissions and content requirements
Interior paints and coatings applied on site	At least 90%, by volume, for emissions; 100% for VOC content	• General Emissions Evaluation for paints and coatings applied to walls, floors, and ceilings • VOC content requirements for wet applied products
Interior adhesives and sealants applied on site (including flooring adhesive)	At least 90%, by volume, for emissions; 100% for VOC content	• General Emissions Evaluation • VOC content requirements for wet applied products
Flooring	100%	General Emissions Evaluation
Composite wood	100% not covered by other categories	Composite Wood Evaluation
Ceilings, walls, thermal, and acoustic insulation	100%	• General Emissions Evaluation • **Healthcare, Schools only** Additional insulation requirements
Furniture (include in calculations if part of scope of work)	At least 90%, by cost	Furniture Evaluation
Healthcare and Schools Projects only: Exterior applied products	At least 90%, by volume	Exterior Applied Products

TABLE 2. Points for number of compliant categories of products

Compliant categories	Points
New Construction, Core and Shell, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality projects without furniture	
2	1
4	2
5	3
New Construction, Core and Shell, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality projects with furniture	
3	1
5	2
6	3
Schools, Healthcare without furniture	
3	1
5	2
6	3
Schools, Healthcare with furniture	
4	1
6	2
7	3

OPTION 2. BUDGET CALCULATION METHOD

If some products in a category do not meet the criteria, project teams may use the budget calculation method (Table 3).

TABLE 3. Points for percentage compliance, under budget calculation method

Percentage of total	Points
≥ 50% and < 70%	1
≥ 70% and < 90%	2
≥ 90%	3

The budget method organizes the building interior into six assemblies:

- flooring;
- ceilings;
- walls;
- thermal and acoustic insulation;
- furniture; and
- **Healthcare, Schools only:** exterior applied products.

Include furniture in the calculations if it is part of the scope of work. Walls, ceilings, and flooring are defined as building interior products; each layer of the assembly, including paints, coatings, adhesives, and sealants, must be evaluated for compliance. Insulation is tracked separately.

Determine the total percentage of compliant materials according to Equation 1.

EQUATION 1. Total percentage compliance

$$\text{Total \% compliant for projects without furniture} = \left\{ \frac{(\text{\% compliant walls} + \text{\% compliant ceilings} + \text{\% compliant flooring} + \text{\% compliant insulation})}{4} \right\}$$

$$\text{Total \% compliant for projects without furniture} = \left\{ \frac{(\text{\% compliant walls} + \text{\% compliant ceilings} + \text{\% compliant flooring} + \text{\% compliant insulation}) + (\text{\% compliant furniture})}{5} \right\}$$

EQUATION 2. System percentage compliant

$$\text{Flooring, walls, ceilings, insulation \% compliant} = \left\{ \frac{\left(\text{compliant surface area of layer 1} + \text{compliant surface area of layer 2} + \text{compliant surface area of layer 3} + \ldots\right)}{\left(\text{total surface area of layer 1} + \text{total surface area of layer 2} + \text{total surface area of layer 3} + \ldots\right)} \right\} \times 100$$

EQUATION 3. Furniture systems compliant, using ANSI/BIFMA evaluation

$$\text{\% compliant for furniture} = \left\{ \frac{0.5 \times \text{cost compliant with §7.6.1 of ANSI/BIFMA e3-2011} + \text{cost compliant with §7.6.2 of ANSI/BIFMA e3-2011}}{\text{total furniture cost}} \right\} \times 100$$

Calculate surface area of assembly layers based on the manufacturer's documentation for application.

If 90% of an assembly meets the criteria, the system counts as 100% compliant. If less than 50% of an assembly meets the criteria, the assembly counts as 0% compliant.

Manufacturers' claims. Both first-party and third-party statements of product compliance must follow the guidelines in CDPH SM V1.1–2010, Section 8. Organizations that certify manufacturers' claims must be accredited under ISO Guide 65.

Laboratory requirements. Laboratories that conduct the tests specified in this credit must be accredited under ISO/IEC 17025 for the test methods they use.

Emissions and Content Requirements

To demonstrate compliance, a product or layer must meet all of the following requirements, as applicable.

Inherently nonemitting sources. Products that are inherently nonemitting sources of VOCs (stone, ceramic, powder-coated metals, plated or anodized metal, glass, concrete, clay brick, and unfinished or untreated solid wood) are considered fully compliant without any VOC emissions testing if they do not include integral organic-based surface coatings, binders, or sealants.

General emissions evaluation. Building products must be tested and determined compliant in accordance with California Department of Public Health (CDPH) Standard Method v1.1–2010, using the applicable exposure scenario. The default scenario is the private office scenario. The manufacturer's or third-party certification must state the exposure scenario used to determine compliance. Claims of compliance for wet-applied products must state the amount applied in mass per surface area.

Manufacturers' claims of compliance with the above requirements must also state the range of total VOCs after 14 days (336 hours), measured as specified in the CDPH Standard Method v1.1:

- 0.5 mg/m^3 or less;
- between 0.5 and 5.0 mg/m^3; or
- 5.0 mg/m^3 or more.

Projects outside the U.S. may use products tested and deemed compliant in accordance with either (1) the CDPH standard method (2010) or (2) the German AgBB Testing and Evaluation Scheme (2010). Test products either with (1) the CDPH Standard Method (2010), (2) the German AgBB Testing and Evaluation Scheme (2010), (3) ISO 16000-3: 2010, ISO 16000-6: 2011, ISO 16000-9: 2006, ISO 16000-11:2006 either in conjunction with AgBB, or with French legislation on VOC emission class labeling, or (4) the DIBt testing method (2010). If the applied testing method does not specify testing details for a product group for which the CDPH standard method does provide details, use the specifications in the CDPH standard method. U.S. projects must follow the CDPH standard method.

Additional VOC content requirements for wet-applied products. In addition to meeting the general requirements for VOC emissions (above), on-site wet-applied products must not contain excessive levels of VOCs, for the health of the installers and other tradesworkers who are exposed to these products. To demonstrate compliance, a product or layer must meet the following requirements, as applicable. Disclosure of VOC content must be made by the manufacturer. Any testing must follow the test method specified in the applicable regulation.

- All paints and coatings wet-applied on site must meet the applicable VOC limits of the California Air Resources Board (CARB) 2007, Suggested Control Measure (SCM) for Architectural Coatings, or the South Coast Air Quality Management District (SCAQMD) Rule 1113, effective June 3, 2011.

- All adhesives and sealants wet-applied on site must meet the applicable chemical content requirements of SCAQMD Rule 1168, July 1, 2005, Adhesive and Sealant Applications, as analyzed by the methods specified in Rule 1168. The provisions of SCAQMD Rule 1168 do not apply to adhesives and sealants subject to state or federal consumer product VOC regulations.
- For projects outside the U.S., all paints, coatings, adhesives, and sealants wet-applied on site must either meet the technical requirements of the above regulations, or comply with applicable national VOC control regulations, such as the European Decopaint Directive (2004/42/EC), the Canadian VOC Concentration Limits for Architectural Coatings, or the Hong Kong Air Pollution Control (VOC) Regulation.
- If the applicable regulation requires subtraction of exempt compounds, any content of intentionally added exempt compounds larger than 1% weight by mass (total exempt compounds) must be disclosed.
- If a product cannot reasonably be tested as specified above, testing of VOC content must comply with ASTM D2369-10; ISO 11890, part 1; ASTM D6886-03; or ISO 11890-2.
- For projects in North America, methylene chloride and perchloroethylene may not be intentionally added in paints, coatings, adhesives, or sealants.

Composite Wood Evaluation. Composite wood, as defined by the California Air Resources Board, Airborne Toxic Measure to Reduce Formaldehyde Emissions from Composite Wood Products Regulation, must be documented to have low formaldehyde emissions that meet the California Air Resources Board ATCM for formaldehyde requirements for ultra-low-emitting formaldehyde (ULEF) resins or no added formaldehyde resins. For projects outside the U.S., composite wood must be documented not to exceed a concentration limit of 0.05 ppm of formaldehyde (0.06 mg/m2-h when expressed as emission rate) as tested either following EN-717-1:2004, following ISO 16000-3: 2010, ISO 16000-6: 2011, ISO 16000-9: 2006, ISO 16000-11:2006, or following CEN/TS 16516: 2013 either in conjunction with AgBB or with Belgian or French legislation on VOC emission class labeling.

Salvaged and reused architectural millwork more than one year old at the time of occupancy is considered compliant, provided it meets the requirements for any site-applied paints, coatings, adhesives, and sealants.

Furniture evaluation. New furniture and furnishing items must be tested in accordance with ANSI/BIFMA Standard Method M7.1–2011. Comply with ANSI/BIFMA e3-2011 Furniture Sustainability Standard, Sections 7.6.1 (for half credit, by cost) OR 7.6.2 (for full credit, by cost), using either the concentration modeling approach or the emissions factor approach. Model the test results using the open plan, private office, or seating scenario in ANSI/BIFMA M7.1, as appropriate. USGBC-approved equivalent testing methodologies and contaminant thresholds are also acceptable. For classroom furniture, use the standard school classroom model in CDPH Standard Method v1.1. Documentation submitted for furniture must indicate the modeling scenario used to determine compliance.

Salvaged and reused furniture more than one year old at the time of use is considered compliant, provided it meets the requirements for any site-applied paints, coatings, adhesives, and sealants.

HEALTHCARE, SCHOOLS ONLY

Additional insulation requirements. Batt insulation products may contain no added formaldehyde, including urea formaldehyde, phenol formaldehyde, and urea-extended phenol formaldehyde.

Exterior applied products. Adhesives, sealants, coatings, roofing, and waterproofing materials applied on site must meet the VOC limits of California Air Resources Board (CARB) 2007 Suggested Control Measure (SCM) for Architectural Coatings, and South Coast Air Quality Management District (SCAQMD), Rule 1168, effective July 1, 2005. Small containers of adhesives and sealants subject to state or federal consumer product VOC regulations are exempt.

Projects outside North America may use either the jurisdictional VOC content requirements or comply with the European Decopaint Directive (2004/42/EC, to be updated to most current version when available) Phase II, for water-borne coatings, as analyzed according to ISO 11890 parts 1 and 2, instead of the CARB and SCAQMD regulatory standards.

Two materials are prohibited and do not count toward total percentage compliance: hot-mopped asphalt for roofing, and coal tar sealants for parking lots and other paved surfaces.

BEHIND THE INTENT

Many types of chemicals, both engineered and naturally occurring, are present everywhere. Volatile organic compounds (VOCs) are chemicals that are released into the air from numerous materials—some of them natural, humanmade, plant-based, and from animals, including people. Prolonged exposure to high concentrations of some VOCs has been linked to a wide range of chronic health problems such as asthma, chronic obstructive pulmonary disease, and cancer. Short-term exposure to VOCs can also cause acute reactions, such as eye, nose, and throat irritation.

Some VOCs are present in the natural environment; however, higher concentrations of VOCs are typically found indoors, where reduced air ventilation and numerous sources of VOCs may exist. Although completely eliminating exposure to all VOCs is impossible, specifying low-emitting and nonemitting products will significantly reduce the strength and quantity of VOC exposure indoors.

Project teams should specify products that meet the compliance thresholds established by recognized standards, or choose products classified as inherently nonemitting (see *Further Explanation, About the Referenced Standards*). Ideally, all interior building materials—from furniture and furnishings to thermal and acoustic insulation and the interior finishes of all floors, walls, and ceilings—would be compliant. This credit, however, uses a holistic systems approach that rewards teams for partial compliance, recognizing compliance of product assemblies even if some of their elements do not meet the applicable standard.

This credit addresses each layer of wall, flooring, and ceiling interior finish—a methodology that is conservatively protective of occupants, given that the emissions from layers that are not directly exposed to air are tested separately.

Air concentration measurements from chamber testing are a much better predictor of emissions over time than VOC content limits. However, chamber emissions testing is generally more expensive, less widely adopted for wet-applied products, and unable to evaluate emissions generated at the time of application. The credit still limits VOC for on-site wet-applied products, in part to avoid environmental damage (e.g., smog formulation) and in part to protect the people who apply these products or are exposed to them during installation.

STEP-BY-STEP GUIDANCE

STEP 1. RESEARCH AND SPECIFY LOW- OR NONEMITTING FINISHES AND FURNITURE

Review project documents to identify all applicable products and specify them as low- or nonemitting.

Research products that meet the requirements by having one or more of the following characteristics:

- The product is inherently nonemitting. Examples of nonemitting products are stone, ceramic, powder-coated metals, plated or anodized metal, glass, concrete, clay brick, and unfinished or untreated solid wood flooring, provided they do not include integral organic-based surface coatings, binders, or sealants (see *Further Explanation, Inherently Nonemitting Materials*).
- The manufacturer has self-declared the product's compliance and provides appropriate documentation, as outlined in the credit requirements.
- The product has third-party certification of compliance.

In most cases, turning to third-party certification to recognized guidelines, such as California Department of Public Health (CDPH) Standard Method v1.1, is the easiest way to find and specify products; in other cases, self-declared compliance to a standard, such as South Coast Air Quality Management District (SCAQMD) Rule 1113, is widespread and sufficient. Check that the appropriate version of the testing method was used to test the product. Check the USGBC website for an up-to-date listing of certification programs that test to the referenced standards. (see *Further Explanation,Testing Standards*).

Provide the contractor with detailed specifications to ensure that the team has the information needed to meet the credit requirements. The design team should specifically call out products that have been researched and confirm that they meet the credit requirements.

Request the specific documentation that will be required for the certification review, such as material safety data sheets (MSDS), third-party certificates, and test reports from subcontractors; this will help in procuring compliant products. Certificates must state the testing methodology and the model as appropriate. The units must be stated and be consistent with those as required. For wet-applied products, the manufacturer must state each product's classification and application according to the referenced standard's definitions or be otherwise justified; how it's used in the project does not count as justification. For example, a defined roof coating is not a carpet adhesive simply because it was used this way on the project. If the product is classified as a roof coating under SCAQMD, it must meet the appropriate limit for roof coatings.

Specifying only compliant products is the easiest way to ensure that the credit requirements are met and the building will have the lowest possible emissions. But Option 2 allows project teams to substitute a noncompliant product if necessary.

For the options that apply to interior applied products, the credit requirements need to be met for all products and materials installed within the waterproofing membrane (see *Further Explanation, Definitions of Building Interior and Exterior*).

STEP 2. PERFORM CONSTRUCTION SUBMITTAL REVIEWS

During construction, coordinate a review of the construction submittals to ensure that selected products meet the credit requirements and do not exceed the allocated VOC emissions.

- Because meeting these credit requirements is not typical for all construction teams and suppliers, conducting a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance will aid in successful product procurement.
- Any product substitutions should be carefully reviewed by the design team and contractor for compliance with credit requirements. Some manufacturers have a list of LEED compliant products on their websites. Such lists are good resources for design teams and contractors to consult when sourcing products that may meet the requirements of this credit.

STEP 3. SELECT ONE OPTION

Based on the research performed and products purchased in each category identified in the credit requirements, determine which option is more appropriate for the project.

- Option 1 is simpler but less flexible, since partial credit (i.e., less than the minimum percentage compliance required) in one category cannot be combined with partial credit in another category. If the minimum percentage compliance cannot be attained in a category, project teams must use Option 2.
- Option 2 offers a budget calculation method that categorizes building interior products and materials into six "assemblies." If at least 50% of an assembly is compliant, partial credit for that assembly can be combined with partial credit from another assembly to earn points, which ensures that teams can receive partial credit for specifying compliant low-emitting products or materials in each assembly category if full compliance is not readily achievable.
- Option 2 may also allow the project to achieve more points and demonstrate higher overall compliance, even if the Option 1 requirements are also feasible.

Option 1. Product Category Calculations

STEP 1. IDENTIFY ALL APPLICABLE PRODUCTS

List all specified interior paints, coatings, adhesives, sealants, flooring, composite wood, ceilings, walls, thermal and acoustic insulation, and furniture, as applicable to the project's scope of work.

- During the construction submittal review process, obtain manufacturer documentation confirming compliance for each product category. All products must comply with each applicable threshold requirement. If two requirements exist, the product must comply with both requirements.
- The most effective way to track this credit is for one team member to keep a running list of products and their compliance information (e.g., VOC content, emissions testing, emissions percentage by volume), with manufacturers' documentation.
- Healthcare and Schools projects have an additional category, exterior products, that they may choose to pursue.
- Adhesives, sealants, paints, and coatings used on site with flooring products are considered interior adhesives and sealants or interior paints and coatings, as appropriate. The flooring itself must meet the requirements of the flooring product category.
- For wet-applied product categories, 90% of products must meet emissions criteria and 100% must meet VOC content criteria.

- To demonstrate the project's overall attainment of 100% of the VOC content criteria, compare the baseline case and the design case in a VOC content budget. If the design (or actual) level is less than the baseline, the credit requirement is satisfied. The values used in the comparison calculation are the g/L of VOCs contained in the product. To determine the budget, multiply the volume of the product used by the threshold VOC level for the baseline case from the appropriate referenced standard; use the actual product VOC level for the design case. If a product with high VOC levels is applied unintentionally, use the VOC budget approach to determine whether compliance can nevertheless be attained.
- Example. SCAQMD Rule 1113 sets the allowable VOC content limit for faux finishing coatings—trowel-applied coatings at 350 g/L. A subcontractor mistakenly used 50 liters of a faux finish coating with 450 g/L VOC content. The project team must now create a budget for all paints and coatings installed in the project to offset this product, which does not meet the Rule 1113 limits.

TABLE 4. SCAQMD Rule 1113

Regulation	Product type	General emissions criteria met?	Volume installed (l)	Allowable VOC content	Actual VOC content	VOC budget	
						Baseline case (g)	Design case (g)
SCAQMD Rule 1113	Faux finishing coatings—trowel-applied coatings	YES	50	350	450	17,500	22,500
SCAQMD Rule 1113	Clear wood finishes—sanding sealers	YES	55	275	150	15,125	8,250
						VOC budget baseline case total (g)	**32,625**
						VOC budget design case total (g)	**30,750**

STEP 2. PERFORM BUDGET CALCULATION METHOD (AS NECESSARY)

A different budget may be used if threshold requirements cannot be achieved for the material categories specified in the credit requirements. That is, if 100% of the product category does not meet the requirements, use the budget calculation method in Option 2.

Option 2. Budget Calculation Method

STEP 1. IDENTIFY ASSEMBLIES

Break out assembly components for each category (flooring, ceilings, walls, insulation, and if applicable, furniture and exterior applied products).

- For each product in an assembly, calculate the surface area for typical wall, ceiling, and floor areas (see *Further Explanation, Building Products and Systems*).
- Identify products that are full-spread, such as paint or carpet adhesive, according to the manufacturer's documentation for application.

STEP 2. CALCULATE TOTAL PERCENTAGE COMPLIANCE

Use Equation 1 in the credit requirements to calculate the total percentage compliance. Generate take-offs and review estimates from subcontractors to calculate the surface area for each product. Equations 2 and 3 may be required to generate values for Equation 1.

For assemblies, use the following guidelines:

- If all layers of an assembly are compliant, the entire surface area (square footage or square meters) counts. Not-full-spread, wet-applied products are included in the definition of interior finish if they are installed on site.
- If some layers of an assembly are noncompliant, calculate the weighted average using Equation 2.

- At least 50% of an assembly must be compliant to contribute to credit compliance: if less than 50% of the assembly is compliant, it counts as 0%; if 90% of the assembly meets the criteria, it counts as 100% compliant.

If some furniture is noncompliant, calculate the percentage of compliance using Equation 3.

For **Healthcare and Schools** projects, see *Further Explanation, Rating System Variations*.

FURTHER EXPLANATION

CALCULATIONS

See calculations in the credit requirements.

ABOUT THE REFERENCED STANDARDS

As VOC emissions test methods and related criteria have advanced, the choices in standards have significantly improved. In the very early days of LEED, only proprietary criteria and incomplete standards were available, which did not promote competition between laboratories or provide consistent comparisons between products. However, after much research and work in this area, qualified laboratories, manufacturers, and third-party certification organizations are now available to support the choice of safe interior materials (see *Further Explanation, Testing Standards*).

The science behind these credit criteria is complex. Compliance with the credit requires testing agencies to measure millionths of a gram of a chemical compound in a cubic meter of air under tightly controlled laboratory conditions, and then equate these measurements to standard building conditions to correlate the results with real-world conditions.

Selection of the referenced standards included consideration of the following factors:

- Leadership and scientific basis of target criteria (necessary for market transformation)
- Rigor of the standards (specificity, consistency, repeatability across competing assessors)
- Standard development process (proprietary business interest, open balanced consensus)
- Market adoption (balanced with other factors but high enough to ensure credit success)
- Harmonization with best practices (necessary for efficiency and economical application)

When multiple, competing criteria exist, purchasers find it difficult to make meaningful comparisons among products and materials. If compliance with all cited standards were required, manufacturers (and ultimately customers) would pay for duplicative tests and evaluations, wasting precious time and resources. Thus, harmonization on baseline standards is essential for market clarity and efficiency.

INHERENTLY NONEMITTING MATERIALS

Naturally occurring materials and products that are made from inorganic materials (e.g., granite) emit either very low or no VOCs. USGBC recognizes that such products do not need to undergo testing to prove they do not emit VOCs. For the purposes of this credit, untreated and unfinished solid wood (not engineered wood) can also be considered nonemitting even though such materials will likely emit some amount of formaldehyde naturally.

TESTING STANDARDS

CDPH Standard Method v1.1

This credit uses the California Department of Public Health (CDPH) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers, v. 1.1–2010, for the emissions testing and requirements of all products and materials except furniture. The method, widely recognized as a leadership standard for its stringent scientific criteria and detailed specificity, was developed through an open, consensus process. It uses the chronic reference exposure levels established by the California Office of Environmental Health Hazard Assessment, which include some of the most stringent criteria in use. It also adopted and incorporated the first edition of the ANSI/BIFMA M7.1 standard test method for furniture.

There is no total volatile organic compound (TVOC) pass-fail requirement in the CDPH standard, which focuses on measuring and limiting individual VOCs. However, this credit requires manufacturers using the CDPH standard to also disclose the range of TVOC for each product, a requirement intended to provide greater transparency for project teams, especially when they are comparing similar materials. Though TVOC alone is a crude measurement not suitable for health-based determinations of acceptability, it is useful as a general indicator in combination with individual VOC measurements, since higher TVOC may suggest the need for additional investigation.

CARB ATCM composite wood formaldehyde regulation

This credit uses the California Air Resources Board (CARB) 93120 Airborne Toxic Control Measure (ATCM) for formaldehyde emissions from composite wood products. It provides a way to determine the compliance of composite wood materials used in products not covered by full VOC testing in other categories. CARB 93120 ATCM is required in California but widely used internationally.

This credit uses not the minimum requirements of the CARB 93120 ATCM but the more stringent requirements for ultra-low-emitting formaldehyde (ULEF) resins or no added formaldehyde based resins, as defined in the CARB ATCM. These criteria are some of the strongest available for formaldehyde emissions from composite wood.

Although composite wood compliance with the CARB formaldehyde criteria is beneficial, chamber testing for a broader range of individual VOCs emitted from assembled products that include composite wood in combination with other components can provide a better determination of a product's potential effect on indoor air quality. Therefore, the composite wood criteria of this credit do not apply to composite wood covered by the full VOC testing of other categories.

ANSI/BIFMA standards

This credit requires that all furniture VOC emissions testing be conducted in accordance with the ANSI/BIFMA M7.1–2011 Standard Test Method for Determining VOC Emissions from Office Furniture Systems, Components and Seating. The second edition of this standard incorporates important advances that include defining an emissions factor approach for compliance, refining the mathematical estimation procedures for nonmeasured time points, and adding specific, highly detailed surface area calculation requirements to ensure consistency.

This credit also requires furniture to comply with the low-emitting requirements in the ANSI/BIFMA e3–2011 Furniture Sustainability Standard. This standard includes both the historical VOC emissions requirements for furniture from earlier versions of LEED and the health-based requirements from the 2010 version of the CDPH standard, both as concentration limits and as maximum emissions factors. These emissions factor limits effectively increase the stringency of the standard and make it easier for furniture component suppliers to modify their products for compliance.

International standards

Recognizing the need for additional compliance options for projects outside the U.S., this credit also references select international standards, which can be used only under specific conditions because of the complicated nature of air quality standards.

The German AgBB Testing and Evaluation Scheme (2010) is a leading industry standard that can be used for this credit, with some limitations. The AgBB standard does not represent a European consensus but does share common attributes with several European counterparts. It addresses six times more individual VOC requirements than the CDPH standard, and it specifies TVOC and total semivolatile organic compound (TSVOC) limits for all nonregulated substances. However, the standard has limitations, including the following:

- The formaldehyde limit value of 10 $\mu g/m^3$ at 28 days must also be met when using the AgBB alternative, as specified for class A+ in French compulsory VOC emissions class labeling.
- The AgBB requirements use different exposure scenario conditions than CDPH. Because VOC emissions from building materials generally decrease over time, the point in time for determining compliance is critical. The more time there is for off-gassing to occur, the easier it may be to meet the standard, even though in many cases the difference is minor (most emissions decay within the first week). CDPH requires compliance at 14 days; the full AgBB requirements apply at three or 28 days, which this credit does not take into account.

Similarly, this credit allows the use of the ISO 16000 series standards when combined with the AgBB standard, the cited French legislation (Decree no 2011-321 and arrêté of 19 April 2011), or the DIBT method (German Institute for Building Technology, *Principles of Health Assessment of Construction Products in Indoor Environments*, 2010 dibt.de/de/data/Aktuelles_Ref_II_4_6.pdf). The ISO 16000 series standards do not contain enough detail to be cited alone for testing in this credit. The same requirements for formaldehyde also apply in each of these cases.

For composite wood, this credit allows the use of EN-717-1, CEN/TS 16516 and the ISO 16000 series provided that a formaldehyde limit of 0.05 ppm (0.06 mg/m2-h when expressed as emission rate) is met. This is the same limit required to meet CARB ATCM requirements for ultra-low-emitting formaldehyde resins (ULEF). EN 717-1 was established by the Comité Européen de Normalisation (CEN) as a consistent standard for determining formaldehyde emissions from wood-based panels and is used primarily for assigning E1 and E2 classifications to wood products.

Referenced mass VOC regulatory standards

The U.S. regulatory system for adhesives and sealants captures a limited range of listed product categories and excludes small packages intended for consumer use. The leading CARB and SCAQMD regulations are well ahead of other state and national regulations. Historically, CARB has developed the suggested control measure (SCM) coatings regulatory framework later adopted by some U.S. states and Canada. SCAQMD created a widely cited regulatory system for sealants and adhesives packaged and designed for commercial applications.

This credit includes requirements for all product categories found in the referenced standards. Product categories that are not listed do not need to be tracked. The credit incorporates various district, state, and national regulations limiting the overall VOC content in coatings, sealants, and adhesives. These regulatory limits serve as a minimum requirement, in addition to emissions testing standards listed in the general emissions requirements.

Because of divergent regulatory development processes, the coatings categories, category definitions, and VOC limits vary between CARB SCM and SCAQMD Rule 1113. Suppliers should provide information on the proper categorization of their materials consistent with definitions in the referenced regulations.

For projects outside the U.S., existing national VOC regulations may serve as the credit requirement. The Canadian VOC Concentration Limits for Architectural Coatings and the Hong Kong Air Pollution Control (VOC) Regulation are examples of local regulations deemed equivalent to the CARB SCM and SCAQMD Rule 1113. Project teams should contact USGBC to determine additional equivalent regulations. Establishing parity or a direct comparison with cited U.S. regulations is difficult, given varying definitions of product categories, the VOC status of specific solvents, and varying applications of the less-water and exempt-solvent approaches.

Information on any VOC compounds exempt from regulation is required for credit compliance. Cited regulatory limits do not include the VOC content of colorants added to coatings at the point of sale. Pretinted flat, nonflat, industrial maintenance coatings and stains include the VOC content of all ingredients, including colorants.

BUILDING PRODUCTS AND SYSTEMS

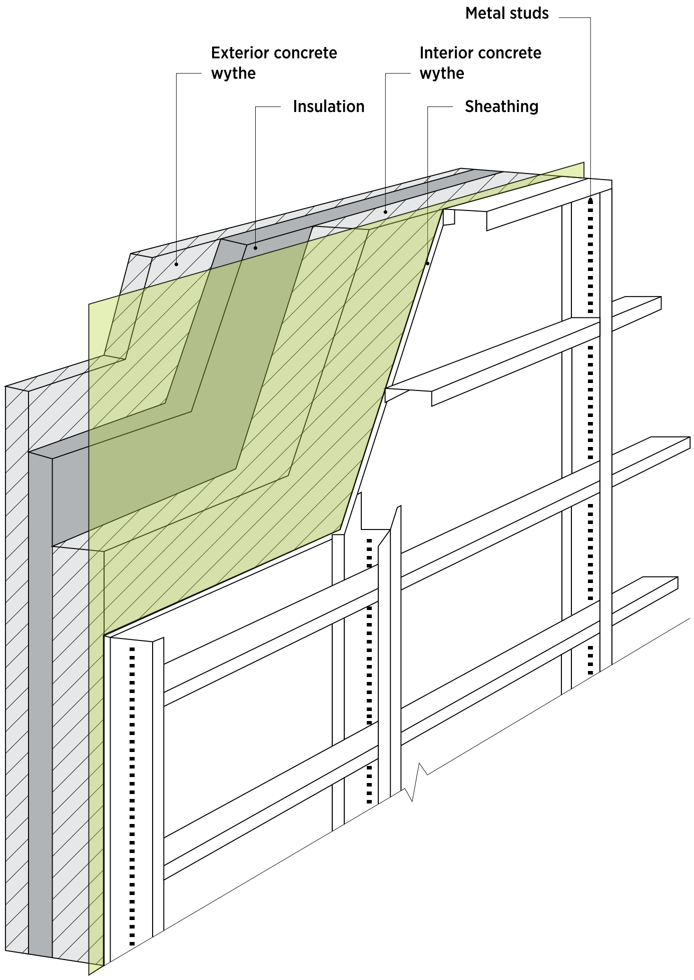
Use Table 5 to calculate the surface area for each layer in a building system. For all building systems listed in the table, salvaged and reused items more than one year old at the time of occupancy do not require testing.

TABLE 5. Building products and systems

Building system	Includes	Exceptions	Calculations
Insulation (thermal and acoustic)	Includes the following, if inside the building waterproofing membrane: • Thermal and acoustical boards, batts, rolls, blankets • Sound attenuation fire blankets • Loose fill insulation • Spray foam insulation (open and closed cell)	Insulation on interior or exterior of HVAC ductwork and insulation on any piping may be excluded (because of lack of modeling scenarios).	Total area of insulation is based on installed planar areas of each insulation type. Total area of insulation for project is sum of planar areas of all types of insulation in defined scope. Percentage of compliant insulation is calculated based on percentage of compliant insulation surface area. If insulation system comprises more than one component, all components identified in spreadsheet matrix must be compliant for system to qualify for full credit. Otherwise, use Equation 2 to determine credit percentage. Example of multicomponent insulation system is insulation board bonded to structural components with adhesive.
Flooring	Includes all finished flooring: • Subflooring • Fluid and trowel-applied adhesives and grout (full spread only) • Engineered wood • Resilient flooring • Carpeting • Mineral-based tile	Testing not required: • Mineral-based finished flooring without integral organic-based modifiers, or topically applied film-forming or penetrating coatings such as tile, terrazzo, and masonry • Associated site-applied adhesives, grouts, and sealers must be meet requirements for adhesives and sealants. • Untreated and unfinished solid wood flooring	Total finished floor area for project is sum of areas of all flooring. Percentage of compliant flooring is calculated based on percentage of compliant floor area. If flooring system comprises more than one component, all components identified in spreadsheet matrix must be compliant for system to qualify for full credit. Flooring systems generally comprise multiple components; identify all components in spreadsheet matrix. This includes all site-applied products and materials such as adhesives, underlays, grouting, stains, and sealers. Examples of multicomponent flooring systems are carpet with cushion, resilient flooring with site-applied sealer, tile with adhesive and grout, and concrete finish consisting of stain, sealer and top coat.
Walls	• Generally vertical structural elements (exposed, finished, unfinished) • All finish wall treatments • Interior columns • Exterior and interior wall glazing • Doors • Partial-height vertical surfaces (e.g., transoms, bulkheads, pony walls, knee walls, and similar structures normally constructed and finished on-site) • Architectural woodwork applied to walls • Built-in cabinetry • Floor-to-ceiling, moveable. demountable wall systems and partitions • When it is unclear what is wall versus ceiling, project teams may classify elements either way, as they deem appropriate.	• Office furniture system partitions (e.g., partial-height or floor-to-ceiling cubicle panels that are manufactured off-site) are addressed under Furniture and furnishings Testing not required: • Bare concrete or metal structural elements; tile, masonry and cut stone without integral organic-based coatings and sealants; factory-finished metal wall products; and glazing. • Plaster and stucco without >1% organic additives • Wall systems considered to be architectural woodwork must comply with prescriptive material requirements specified for built-in cabinetry (see below) • Salvaged and reused architectural woodwork is available for credit without any requirements other than those associated with site-applied paints, coatings, adhesives, sealants	Total wall area for project is total interior surface area of all elements within scope of wall systems category. Because of potential complexity of area calculations for large projects, wall surface areas may be estimated as for painting. Percentage of compliant wall systems is calculated based on percentage of compliant wall area. If wall system is comprises more than one component, all components identified in spreadsheet matrix must be compliant for system to qualify for full credit. Examples of multicomponent wall systems are drywall panel and acoustic panel applied with adhesive, drywall panel with primer and finish paint coats, and movable wall system with wood frame, wood door, and fabric-covered acoustic panels.

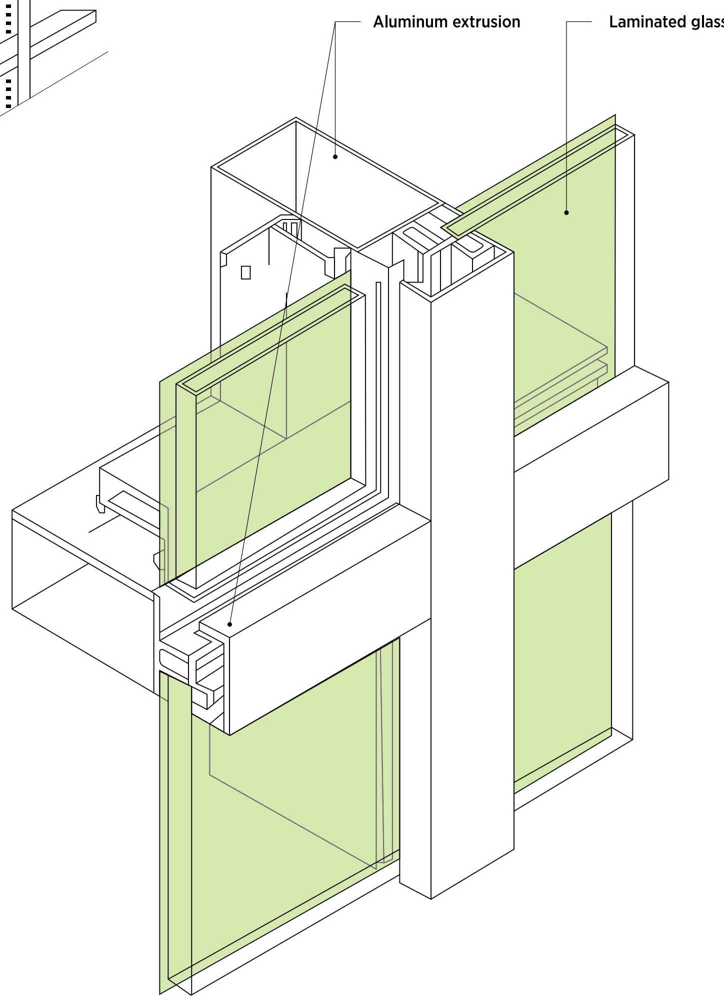
TABLE 5. (CONTINUED) Building products and systems

Building system	Includes	Exceptions	Calculations
Ceilings	• Overhead structural elements (exposed, finished, unfinished) • Direct-applied ceiling systems • Suspended systems (including canopies and clouds) • Glazed skylights • Examples include painted drywall and plaster, acoustical suspension systems, specialty systems (plastic, metal, wood), and painted or otherwise finished structural elements • When it is unclear what is wall versus ceiling, project teams may classify elements either way, as they deem appropriate	Testing not required: • Exposed concrete • Exposed metal structural elements • Factory-finished metal ceiling products • Glazing • Ceiling systems considered architectural woodwork must comply with prescriptive material requirements specified for built-in cabinetry • Bare concrete or metal structural elements; tile, masonry and cut stone without integral organic-based coatings and sealants; transition strips	Total ceiling area for project is ceiling plan area for project plus areas of additional finished ceiling planes. Percentage of compliant ceiling is calculated based on percentage of compliant ceiling area. If ceiling system comprises more than one component, all components identified in USGBC's low-emitting materials calculator must be compliant for system to qualify for full credit. Examples of multicomponent ceiling systems are drywall panel with skim coat, primer and finish paint; manufactured wood coffer applied with adhesive; and any ceiling surface with site-applied paint or coating.
Built-in cabinetry (subcategory of wall systems in Option 2)	Includes all furniture-like items built on site that are typically procured by general contractor at earlier stage than furniture and furnishings • Examples: cabinets, other storage units, shelving, product-display units, integrated or built-in reception desks and seating		Total emitting surface area of built-in cabinetry is the area exposed to interior For built-in cabinetry, compliance is determined based on following prescriptive construction criteria intended to limit sources of indoor VOC contaminants: • Products with composite woods constituting all or portion of product (e.g., countertops, cabinetry with composite wood cores and internal components) must be constructed with composite wood documented to have low formaldehyde emissions (compliant to CARB ATCM limits for no added formaldehyde or ultra-low formaldehyde emitting or its equivalent). Materials with no defined category under ATCM must follow requirements for particleboard. Built-in cabinetry constructed of inherently nonemitting materials (e.g., metal with factory-applied powder coating or plating) are eligible for credit without testing. • Site-applied finishes must comply with VOC content limits and VOC emissions limits for paints and coatings. • Site-applied adhesives must comply with VOC content limits for adhesives and sealants.
Furniture and Furnishings	All stand-alone furniture items purchased for project • Examples: individual and group seating; open-plan and private office workstations; desks and tables of all types; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted, visual display products (e.g., markerboards and tackboards, excluding electronic display products); and miscellaneous items (e.g., easels, mobile carts, freestanding screens, and movable partitions) • Movable partitions include office furniture system cubicle panels that are typically integrated with work surfaces, desks, and storage furniture. • Hospitality and Healthcare furniture is included as applicable.	• Salvaged and reused furniture more than one year old at time of occupancy is available for credit without any IAQ testing • Office accessories (e.g., desk-top blotters, trays, tape dispensers, waste baskets, work tools normally hung on office cubicle panels, monitor arms, and all electrical items such as desk lamps and small appliances) are excluded	Total amount of stand-alone furniture for project and the relative contributions of these products is based on purchase costs (i.e., excluding labor for installation). To achieve full credit, 50% or more of total stand-alone furniture costs must be compliant for project to earn credit for this category. Product compliance of 90% or more is treated as 100%. Furniture and furnishing items must be tested following ANSI/BIFMA Standard Method M7.1–2011. Use either a concentration modeling approach or emission factor approach. Furniture compliant with Section 7.6.1 of BIFMA e3-2011 counts for half credit, by cost and furniture compliant with Section 7.6.2 of BIFMA e3–2011 counts for full credit, by cost. Furniture compliant with both sections is eligible for full credit, by cost, not to exceed 100% of the furniture cost. Model test results using open plan, private office, or seating scenario in ANSI/BIFMA M7.1 as appropriate. USGBC-approved equivalent testing methodologies and contaminant thresholds are also acceptable. For classroom furniture, use standard school classroom model in CDPH Standard Method v1.1. Documentation submitted for furniture must indicate modeling scenario used to determine compliance. To be compliant, furniture must comply with Section 7.6.1 or Section 7.6.2 of BIFMA e3–2011.



Insulation
Concrete
Plane dividing interior and exterior

Figure 1. Insulated concrete panel



Plane dividing interior and exterior

Figure 2. Curtain wall assembly

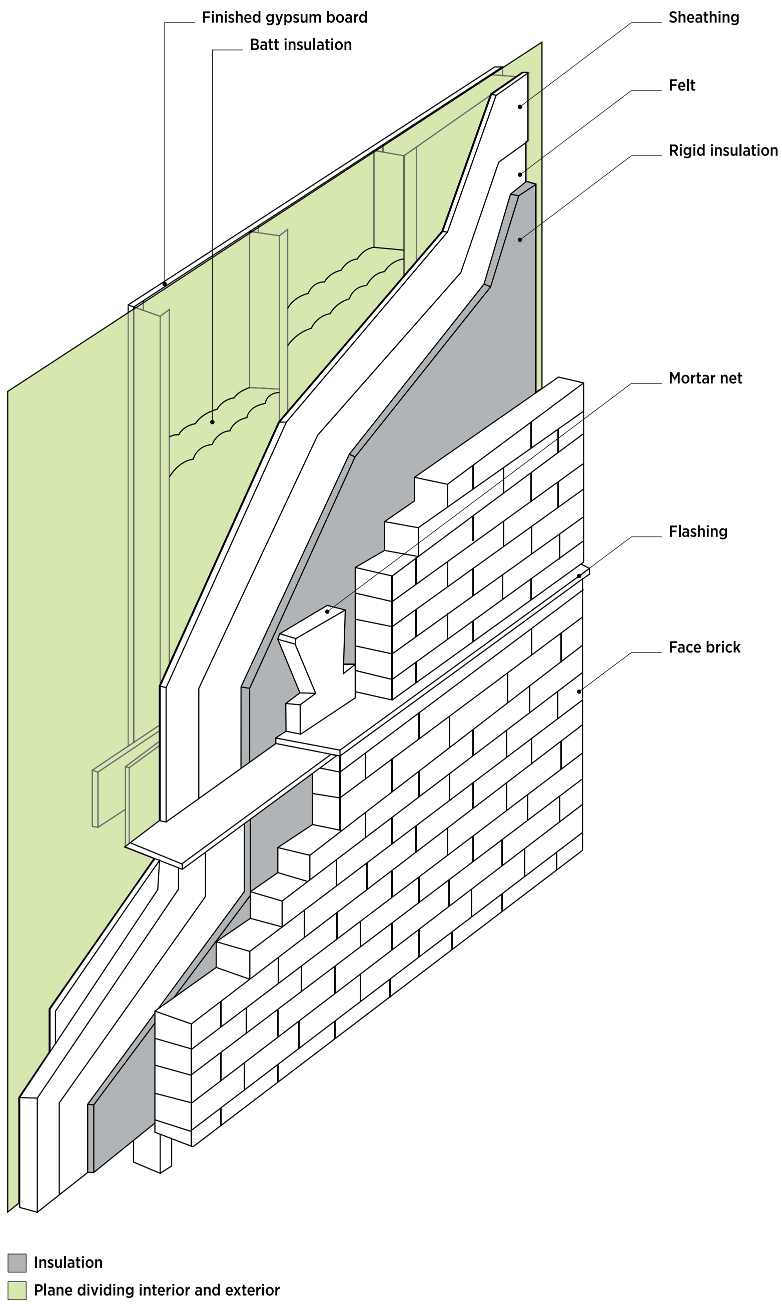


Figure 3. Metal stud masonry wall

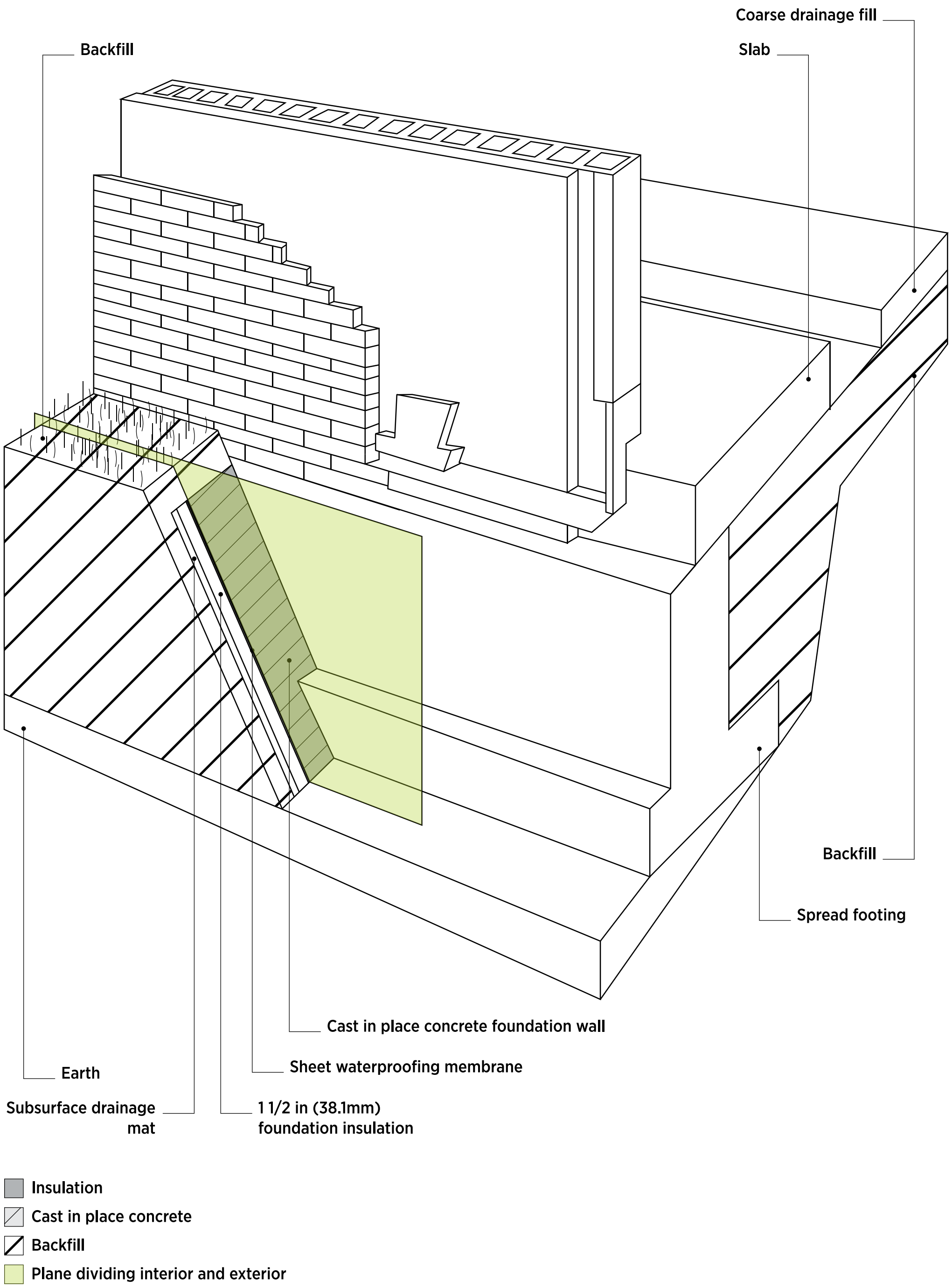


Figure 4. Cast in place concrete foundation wall

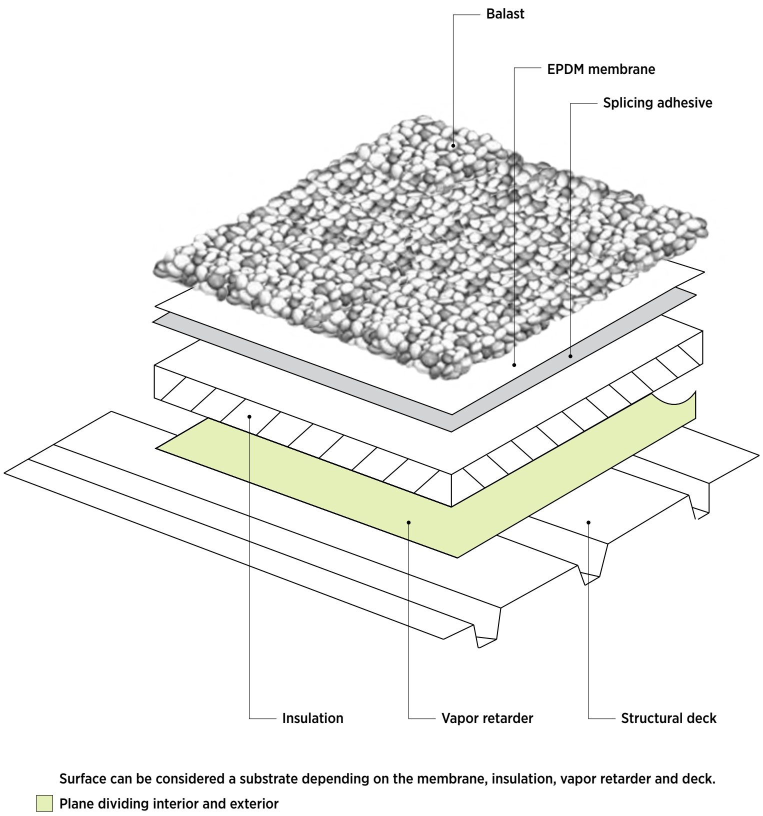


Figure 5. EPDM roof assembly

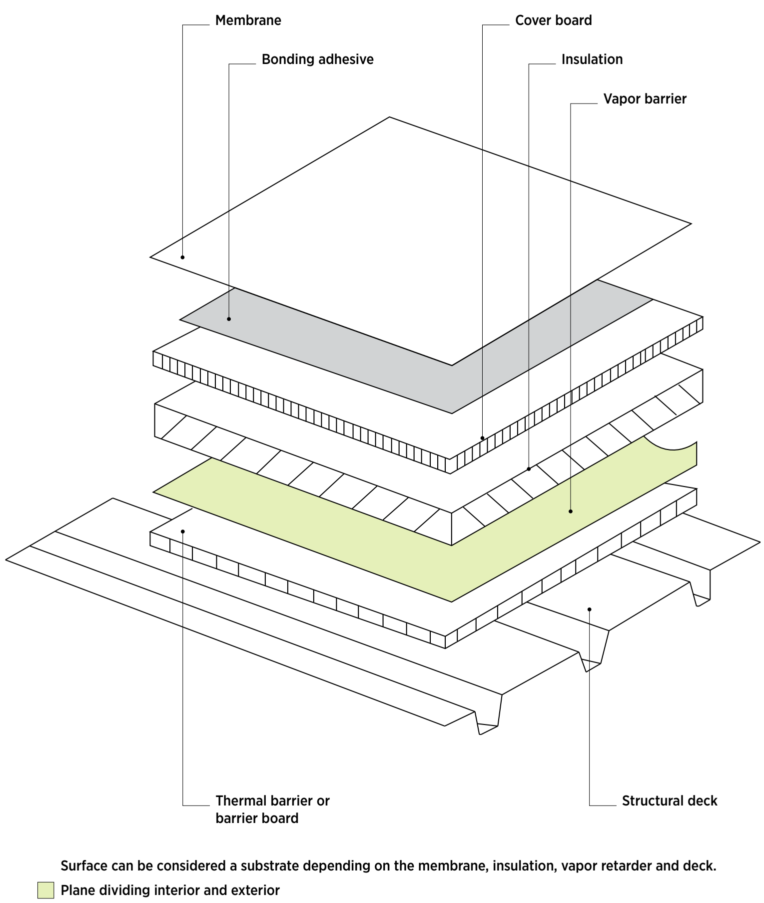


Figure 6. TPO roof assembly

RATING SYSTEM VARIATIONS

Core and Shell
Credit will be given for each product category installed in the core and shell of the building.

Healthcare and Schools
Exterior applied adhesives, sealants, coatings, roofing, and waterproofing applied on site must meet the VOC limits of the California Air Resources Board (CARB) 2007 Suggested Control Measures (SCM) for Architectural Coatings, and South Coast Air Quality Management District (SCAQMD) Rule 1168, effective July 1, 2005.

Submit a list of all exterior applied materials and products used on site.

Identify the regulatory VOC content, allowable VOC limit, and the total volume used on site for each product to determine whether 90% by volume has been achieved. The regulatory VOC content must be expressed as g/L less water and exempt solvents except for low-solids coatings, which show the content in g/L less exempt solvents. Hot-mopped asphalt and coal tar sealants are prohibited.

Equation 1 of the credit requirements for Healthcare and Schools must be modified to account for exterior applied finishes as follows:

EQUATION 1. Total percentage compliance

$$\text{Total \% compliant for projects without furniture} = \left\{ \frac{(\text{\% compliant walls} + \text{\% compliant ceilings} + \text{\% compliant flooring} + \text{\% compliant insulation}) + (\text{\% compliant exterior finishes})}{5} \right\}$$

$$\text{Total \% compliant for projects without furniture} = \left\{ \frac{(\text{\% compliant walls} + \text{\% compliant ceilings} + \text{\% compliant flooring} + \text{\% compliant insulation}) + (\text{\% compliant exterior finishes} + \text{\% compliant furniture})}{6} \right\}$$

CAMPUS

Group Approach
All buildings in the group may be documented as one.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
USGBC low-emitting materials calculator	X	X
Product information (e.g., MSDS, third-party certifications, testing reports)	X	X

RELATED CREDIT TIPS

MR Credit Furniture and Medical Furnishings (Healthcare only). The testing standards for Option 2 of this related credit also meet this credit's testing standard requirements for furniture and furnishings products.

EQ Credit Indoor Air Quality Assessment. Using products with low emissions can significantly improve indoor air quality. Each product category pursued increases the chance of passing the indoor air quality testing limits for the related credit.

CHANGES FROM LEED 2009

- Former individual credit paths have been combined into one credit, with a scaled point system for each path earned.
- Compliance of interior finishes may be demonstrated in assemblies with multiple layers in combination, or in each system individually.
- Consideration of furniture emissions has been included for all rating systems.
- New referenced standards have been added to address international projects and new product requirements.
- Ceilings are now included in the requirements.
- Emissions from insulation are now included.
- Emissions requirements for on-site, wet-applied, full-spread products measured via chamber tests in air are now included. VOC content limits for on-site, wet-applied products are still required.

REFERENCED STANDARDS

CDPH Standard Method v1.1–2010: cal-iaq.org

ISO 17025: iso.org

ISO Guide 65: iso.org

AgBB—2010: umweltbundesamt.de/sites/default/files/medien/377/dokumente/agbb-evaluation-scheme2010.pdf

ISO 16000 parts 3, 6, 7, 11: iso.org

South Coast Air Quality Management District (SCAQMD) Rule 1168: aqmd.gov

South Coast Air Quality Management District (SCAQMD) Rule 1113: aqmd.gov

European Decopaint Directive: ec.europa.eu/environment/air/pollutants/stationary/paints/paints_legis.htm

Canadian VOC Concentration Limits for Architectural Coatings:
ec.gc.ca/lcpe-cepa/eng/regulations/detailReg.cfm?intReg=117

Hong Kong Air Pollution Control Regulation:
epd.gov.hk/epd/english/environmentinhk/air/air_maincontent.html

CARB 93120 ATCM: arb.ca.gov/toxics/compwood/compwood.htm

ANSI/BIFMA M7.1 Standard Test Method for Determining VOC Emissions from Office Furniture Systems, Components and Seating: bifma.org

ANSI/BIFMA e3–2011 Furniture Sustainability Standard: bifma.org

EN 717-1:2004 Wood-based panels - Determination of formaldehyde release - Formaldehyde emission by the chamber method: http://www.en-standard.eu/

CEN/TS 16516:2013 Construction products - Assessment of release of dangerous substances - Determination of emissions into indoor air: http://www.cen.eu

EXEMPLARY PERFORMANCE

Option 1. Earn all points and reach 100% of products.

Option 2. Reach 100% of products.

DEFINITIONS

building exterior a structure's primary and secondary weatherproofing system, including waterproofing membranes and air- and water-resistant barrier materials, and all building elements outside that system

building interior everything inside a structure's weatherproofing membrane

furniture and furnishings the stand-alone furniture items purchased for the project, including individual and group seating; open-plan and private-office workstations; desks and tables; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted visual-display products (e.g., marker boards and tack boards, excluding electronic displays); and miscellaneous items, such as easels, mobile carts, freestanding screens, installed fabrics, and movable partitions. Hospitality furniture is included as applicable to the project. Office accessories, such as desktop blotters, trays, tape dispensers, waste baskets, and all electrical items, such as lighting and small appliances, are excluded.

hot-mopped asphalt roofing a mopping-grade oxidized asphalt as defined by NIOSH: "an oxidized asphalt used principally in the construction of built-up roofing (BUR) and some modified bitumen systems; mopping-grade asphalts are produced in four grades (Types I through IV), according to the steepness of the roof".

interior floor finish all the layers applied over a finished subfloor or stairs, including stair treads and risers, ramps, and other walking surfaces. Interior finish excludes building structural members, such as beams, trusses, studs, or subfloors, or similar items. Interior finish also excludes nonfull spread wet coatings or adhesives.

interior wall and ceiling finish all the layers comprising the exposed interior surfaces of buildings, including fixed walls, fixed partitions, columns, exposed ceilings, and interior wainscoting, paneling, interior trim or other finish applied mechanically or for decoration, acoustical correction, surface fire resistance, or similar purposes

INDOOR ENVIRONMENTAL QUALITY CREDIT

Construction Indoor Air Quality Management Plan

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To promote the well-being of construction workers and building occupants by minimizing indoor air quality problems associated with construction and renovation.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

Develop and implement an indoor air quality (IAQ) management plan for the construction and preoccupancy phases of the building. The plan must address all of the following.

During construction, meet or exceed all applicable recommended control measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008, Chapter 3.

Protect absorptive materials stored on-site and installed from moisture damage.

Do not operate permanently installed air-handling equipment during construction unless filtration media with a minimum efficiency reporting value (MERV) of 8, as determined by ASHRAE 52.2–2007, with errata (or equivalent filtration media class of F5 or higher, as defined by CEN Standard EN 779–2002, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance), are installed at each return air grille and return or transfer duct inlet opening such that there is no bypass around the filtration media. Immediately before occupancy, replace all filtration media with the final design filtration media, installed in accordance with the manufacturer's recommendations.

Prohibit the use of tobacco products inside the building and within 25 feet (7.5 meters) of the building entrance during construction.

HEALTHCARE

Moisture. Develop and implement a moisture control plan to protect stored on-site and installed absorptive materials from moisture damage. Immediately remove from site and properly dispose of any materials susceptible to microbial growth and replace with new, undamaged materials. Also include strategies for protecting the building from moisture intrusion and preventing occupants' exposure to mold spores.

Particulates. Do not operate permanently installed air-handling equipment during construction unless filtration media with a minimum efficiency reporting value (MERV) of 8, as determined by ASHRAE 52.2–2007, with errata (or equivalent filtration media class of F5 or higher, as defined by CEN Standard EN 779–2002, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance), are installed at each return air grille and return or transfer duct inlet opening such that there is no bypass around the filtration media. Immediately before occupancy, replace all filtration media with the final design filtration media, installed in accordance with the manufacturer's recommendations.

VOCs. Schedule construction procedures to minimize exposure of absorbent materials to VOC emissions. Complete painting and sealing before storing or installing "dry" materials, which may accumulate pollutants and release them over time. Store fuels, solvents, and other sources of VOCs separately from absorbent materials.

Outdoor emissions. For renovation projects involving waterproofing, repairing asphalt roofing, sealing parking lots, or other outdoor activities that generate high VOC emissions, develop a plan to manage fumes and avoid infiltration to occupied spaces. Comply with the procedures established by NIOSH, Asphalt Fume Exposures during the Application of Hot Asphalt to Roofs (Publication 2003–112).

Tobacco. Prohibit the use of tobacco products inside the building and within 25 feet (7.5 meters) of the building entrance during construction.

Noise and vibration. Develop a plan based on the British Standard (BS 5228) to reduce noise emissions and vibrations from construction equipment and other nonroad engines by specifying low-noise emission design or the lowest decibel level available that meets performance requirements in the British Standard. Construction crews must wear ear protection in areas where sound levels exceed 85 dB for extended periods.

Infection control. For renovations and additions adjacent to occupied facilities or phased occupancy in new construction, follow the FGI 2010 Guidelines for Design and Construction of Health Care Facilities and the Joint Commission on Standards to establish an integrative infection control team comprising the owner, designer, and contractor to evaluate infection control risk and document the required precautions in a project-specific plan. Use the infection control risk assessment standard published by the American Society of Healthcare Engineering and the U.S. Centers for Disease Control and Prevention (CDC) as a guideline to assess risk and to select mitigation procedures for construction activities.

BEHIND THE INTENT

Construction activities adversely affect indoor air quality (IAQ) when they generate dust, toxic substances, or other contaminants, which can cause health problems not only for construction workers but also those who occupy the building long after construction is complete. Incorporating IAQ best practices during construction has many benefits. One is the protection of building occupants from airborne pollutants associated with the construction. Another is the protection of construction workers from toxins and dust during build-out. A less obvious one, finally, is the benefit gained when building material and HVAC equipment last longer and perform better over time.

This credit requires teams to develop and implement a construction IAQ management plan that follows the Sheet Metal and Air Conditioning National Contractors' Association (SMACNA) IAQ guidelines. The SMACNA standard identifies major sources of construction-related indoor air pollution and spells out best practices for controlling them.

By implementing SMACNA IAQ strategies, projects will capture dust and other airborne pollutants, keep contaminants and toxic substances out of building systems, and prevent mold and other damage to building materials. Additionally, projects must protect absorptive material from moisture damage, prohibit smoking during construction inside the building and near entrances, and ensure that any permanent air handlers operated during construction meet filtration requirements.

Because of the special sensitivities of patients, health care facilities have additional requirements to address noise, vibration, and infection control that go beyond the basic SMACNA guidelines.

STEP-BY-STEP GUIDANCE

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

STEP 1. INTEGRATE SMACNA CONTROL MEASURES INTO PROJECT DRAWINGS AND SPECIFICATIONS

Include compliance with SMACNA guidelines and other credit requirements in drawings and specifications (see *Further Explanation, SMACNA Guidelines*).

- Consider how the requirements and guidelines may affect design decisions. If used during construction, the air-handling equipment must be designed to accommodate MERV 8 or higher filters. Finishes such as paints and coatings specified by the design team must be consistent with SMACNA guidelines, regardless of whether those materials will contribute to other LEED credits.
- Include SMACNA requirements in project specifications. For example, specify that air handlers and ducts be delivered to the site prewrapped in plastic, to avoid having to protect equipment after delivery.
- Review the credit requirements and SMACNA guidelines in detail with all pertinent members of the design and construction team, specifically, the construction manager, general contractor, and mechanical subcontractor(s).

STEP 2. DEVELOP INDOOR AIR QUALITY PLAN

Before construction begins, develop an IAQ management plan that meets or exceeds the credit requirements. The IAQ plan is typically prepared by the general contractor or construction manager. It includes IAQ management practices implemented during construction and preoccupancy phases and describes how each requirement in the SMACNA guidelines and credit requirements will be addressed and managed on the job site. The plan should adhere to the SMACNA guidelines and cover the following additional items:

- Specify procedures for protecting stored and installed absorptive materials from moisture damage.
- Highlight the nonsmoking policy. Prohibit the use of tobacco products inside the building and within 25 feet (7.5 meters), or more if required by the local jurisdiction, of the building entrance at all times during construction. Consider prohibiting smoking on the entire job site.

- Indicate whether air handlers will be operated during construction, and specify compliant filtration procedures for permanent equipment that will be used.

A detailed checklist instead of an IAQ management plan is also acceptable.

STEP 3. IMPLEMENT INDOOR AIR QUALITY PLAN

Ensure that the IAQ management plan is in place before starting above-ground construction, storing materials on site, or roughing in mechanical systems. Take photographs of each IAQ measure for documentation.

The following best practices support successful implementation of the plan:

- Identify the key players and someone responsible for implementing the plan, such as the HVAC installer and the general contractor. Make sure they understand the requirements of the plan and help champion its goals.
- Include the IAQ management plan requirements in contract agreements with subcontractors.
- As subcontractors are selected and deployed on site, familiarize them with the plan and how it will affect their daily activities. Hold a subcontractors' orientation meeting to review the plan requirements as a group.
- Include construction IAQ progress check-ins as a regular item in weekly subcontractor meetings and safety meetings.
- Provide a copy of the plan on site, preferably posted in an accessible area. Translate the plan into the languages spoken by subcontractors and their crews.
- General contractors, construction managers, and owners should verify that the IAQ management plan is being followed on job walks, ideally daily, so that issues can be addressed with subcontractors as necessary. Creating a checklist of major items for easy reference is often effective.
- Decide whether air handlers need to be used during construction. If so, substituting stand-alone temporary air handlers or heaters may make it easier to meet the HVAC protection requirement. If permanent air handlers are used during construction, record the filtration media used to meet the documentation requirements.
- Annotate photographs to indicate each IAQ measure depicted and its general location.
- Provide photographs of the methods employed to protect stored and installed absorptive materials from moisture damage during construction and preoccupancy.

HEALTHCARE

STEP 1. EVALUATE INFECTION CONTROL RISK

For renovations, additions adjacent to occupied facilities, or phased occupancy projects, evaluate infection control risk.

Follow the 2010 FGI Guidelines for Design and Construction of Health Care Facilities and the Joint Commission on Standards to establish an integrative infection control team comprising the owner, designer, and contractor to evaluate infection control risk. Include an infection control risk assessment as part of the indoor air quality plan—known as an environmental quality management plan—and document the required precautions in the project-specific plan. The plan should take into account the occupants, patients, and programming unique to the project and the building as a whole.

STEP 2. INTEGRATE ENVIRONMENTAL QUALITY MANAGEMENT PLAN INTO PROJECT SPECIFICATIONS

Develop an environmental quality management plan (EQMP).

- Include a noise and nuisance plan based on British Standard 5228–2009. This standard addresses noise pollution and nuisance to neighboring properties, specifying reductions in noise and vibration from construction equipment and other nonroad engines.
- Limit construction noise (both the level of noise and its duration). Use construction equipment with low noise emissions or the lowest decibel level available that meets performance requirements in the British Standard.
- Construction crews must wear ear protection wherever sound levels exceed 85 dB for extended periods. Provide training and protective gear for workers.
- Limit the effects of vibration on nearby historic or otherwise sensitive buildings. For example, conduct demolition in stages rather than using a single large blast explosive.

- Implement source-reduction strategies by providing properly graded and maintained circulation paths, establishing no-idling and sequential equipment start-up policies, and retrofitting loud equipment with noise and vibration attenuators.
- Use the Infection Control Risk Assessment Standard, published by the American Society of Healthcare Engineering and the U.S. Centers for Disease Control and Prevention, as a guideline for assessing the risk of construction activities and selecting mitigation procedures. Incorporate appropriate measures into the EQMP. Draw on both this standard and the FGI guidelines to develop the project's EQMP.
- For renovation projects with any waterproofing, asphalt roofing needing repair, parking lot sealing, or other outdoor activities with high VOC emissions, comply with procedures in National Institute for Occupational Safety and Health, NIOSH Publication 2003-112, Asphalt Fume Exposures During the Application of Hot Asphalt to Roofs, Sections 4 and 5. Include details for compliance in the project EQMP to manage fumes and avoid infiltration to occupied spaces.
- Include compliance with SMACNA guidelines and other credit requirements in the project drawings and specifications (see *Further Explanation, SMACNA Guidelines*).

A detailed checklist instead of an EQMP is also acceptable.

STEP 3. COORDINATE ENVIRONMENTAL QUALITY MANAGEMENT PLAN WITH DESIGN

Consider how the environmental quality management requirements and guidelines may relate to design decisions.

- Decide whether air handlers need to be used during construction. If so, substituting stand-alone temporary air handlers or heaters may make it easier to meet the HVAC protection requirement. If used during construction, the air-handling equipment must be designed to accommodate MERV 8 or higher filters.
- Finishes such as paints and coatings specified by the design team must be consistent with SMACNA guidelines, regardless of whether those materials will contribute to other LEED credits.
- Include SMACNA requirements in project specifications. For example, specify that air handlers and ducts be delivered to the site prewrapped in plastic, to avoid having to protect equipment after delivery.

STEP 4. IMPLEMENT ENVIRONMENTAL QUALITY MANAGEMENT PLAN

Ensure that the EQMP is in place before starting above-ground construction, storing materials on- site, or roughing in mechanical systems. Photograph each measure for documentation.

The following best practices support successful implementation of the plan:

- Review the credit requirements and SMACNA guidelines in detail with members of the design and construction team, particularly the construction manager, general contractor, and mechanical subcontractor(s).
- Identify the key players and someone responsible for implementing the plan, such as the HVAC installer and the general contractor. Make sure they understand the requirements of the plan and help champion its goals.
- Include the IAQ management plan requirements in contract agreements with subcontractors.
- As subcontractors are selected and deployed on site, familiarize them with the plan and how it will affect their daily activities. Hold a subcontractors' orientation meeting to review the plan requirements as a group.
- Include construction IAQ progress check-ins as a regular item in weekly subcontractor meetings and safety meetings.
- Provide a copy of the plan on site, preferably posted in an accessible area. Translate the plan into the languages spoken by subcontractors and their crews.
- General contractors, construction managers, and owners should verify that the IAQ management plan is being followed on job walks, ideally daily, so that issues can be addressed with subcontractors as necessary. Creating a checklist of major items for easy reference is often effective.

Document the implementation.

- Photograph each IAQ measure and annotate the images for documentation.
- Photograph the methods employed to protect stored and installed absorptive materials from moisture damage during construction and preoccupancy.
- Record the filtration media used in HVAC equipment.

FURTHER EXPLANATION

SMACNA GUIDELINES

The following SMACNA guidelines apply to teams seeking this credit.

HVAC protection. Keep contaminants out of the HVAC system. Do not run permanently installed equipment if possible, or maintain proper filtration if it is used.

- If conditioning is required during construction, use supplementary HVAC units instead of permanently installed equipment if possible.
- If permanently installed HVAC system must be used during construction, install filtration to protect the return (negative pressure) side of the system. Replace these filters regularly during construction.
- Seal all ductwork, registers, diffusers, and returns with plastic when stored on site or not in service. Seal unfinished runs of ductwork at the end of each day.
- Replace all filtration media before occupancy.
- Do not store materials in mechanical rooms, to reduce potential debris and contamination to mechanical systems.

Source control. Keep sources of contaminants out of the building and have a plan to eliminate any that are introduced.

- Use low-toxicity and low-VOC materials to the greatest extent possible.
- Develop protocols for the use of any high-toxicity materials. Isolate areas where high-toxicity materials are being installed and use temporary ventilation for that area.
- Prevent exhaust fumes (from idling vehicles, equipment, and fossil-fueled tools) from entering the building.
- Enforce the no-smoking job site policy.
- Protect stored materials from moisture because absorbent materials exposed to moisture during construction can mold and degenerate long after installation. Store materials in dry conditions indoors, under cover, and off the ground or floor.
- If materials are improperly exposed to moisture, replace the material and consider testing air quality before occupancy to make sure no mold contamination has occurred.

Pathway interruption. Prevent circulation of contaminated air when cutting concrete or wood, sanding drywall, installing VOC-emitting materials, or performing other activities that affect IAQ in other work spaces.

- Isolate areas of work to prevent contamination of other spaces, whether they are finished or not. Seal doorways, windows, or tent off areas as needed using temporary barriers, such as plastic separations. Provide walk-off mats at entryways to reduce introduced dirt and pollutants.
- Depressurize the work area to allow a differential between construction areas and clean areas. Exhaust to the outdoors using 100% outdoor air, if possible.
- Use dust guards and collectors on saws and other tools.

Housekeeping. Maintaining a clean job site results in fewer IAQ contaminants to manage.

- Maintain good job site housekeeping on a daily basis. Use vacuum cleaners with high-efficiency particulate filters and use sweeping compounds or wetting agents for dust control when sweeping.
- Keep materials organized to improve job site safety as well as indoor air quality.

Scheduling. Sequence construction activities to reduce air quality problems in new construction projects. For major renovations, coordinate construction activities to minimize or eliminate disruption of operations in occupied areas.

- Keep trades that affect IAQ physically isolated on site and separated from each other by the construction schedule. For example, schedule drywall finishing and carpet installation for different days or different sections of the building. Consider after-hours or weekend work if practical.

- Install absorptive-finish materials after wet-applied materials have fully cured whenever possible. For example, install carpet and ceiling tile after paints and stains are completely dry.
- If applicable, plan adequate time to conduct a flush-out and/or perform IAQ testing before occupancy, in compliance with EQ Credit Indoor Air Quality Assessment (see *Related Credit Tips*).
- Remove all temporary filtration media and replace them with new filters before occupancy.

INTERNATIONAL TIPS

In countries where filters with MERV ratings are not available, filtration media must be Class F5 or higher, as defined by CEN Standard EN 779–2002. Filtration media with a minimum dust spot efficiency of 30% or higher and greater than 90% arrestance on a particle size of 3–10 μg are also acceptable.

CAMPUS

Group Approach
All buildings may be documented as one. One master indoor air quality management plan is allowed. The plan should include building specific guidelines if necessary. Photo documentation must include a sampling for all buildings.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects except Healthcare	Healthcare
IAQ management plan or detailed checklist, highlighting nonsmoking policy	X	
EQMP or detailed checklist, highlighting nonsmoking policy		X
Narrative describing protection measures for absorbent materials	X	X
Annotated photographs of indoor air and environmental quality measures	X	X
Record of filtration media	X	X

RELATED CREDIT TIPS

EQ Credit Enhanced Indoor Air Quality Strategies. The related credit builds on the best practices implemented during construction to maintain optimal indoor air quality. Both credits have filtration requirements; however, the related credit requires MERV 13 filtration (or Class F7 filters for projects outside the U.S.) to be installed immediately before occupancy, whereas this credit does not specify a MERV rating for filtration installed before occupancy.

EQ Credit Low-Emitting Materials. Both the related credit and this credit's SMACNA source control strategies require the use of low-VOC and low-toxicity materials. Although earning one credit does not necessarily mean that all requirements are met for the other, implementing a comprehensive strategy of using low-VOC and low-toxicity materials can contribute to earning both credits.

EQ Credit Indoor Air Quality Assessment. A single IAQ management plan can be developed for both this credit and the related credit. Teams may pursue the assessment credit without pursuing this credit.

CHANGES FROM LEED 2009

The use of tobacco products during construction is now explicitly prohibited inside the building and within 25 feet (7.5 meters) (or greater, if required by the local jurisdiction) of the building entrance.

REFERENCED STANDARDS

Sheet Metal and Air-Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008 (Chapter 3): smacna.org

ASHRAE 52.2–2007: ashrae.org

CEN Standard EN 779–2002: cen.eu

British Standard 5228—2009 (Healthcare): bsigroup.com

Infection Control Risk Assessment (ICRA) Standard, published by the American Society of Healthcare Engineering (ASHE) and the U.S. Centers for Disease Control and Prevention (CDC) (Healthcare): ashe.org/advocacy/organizations/CDC

NIOSH, Asphalt Fume Exposures During the Application of Hot Asphalt to Roofs, Publication No. 2003-112 (Healthcare): cdc.gov/niosh/topics/asphalt

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Indoor Air Quality Assessment

This credit applies to:

New Construction (1–2 points)
Schools (1–2 points)
Retail (1–2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1–2 points)

INTENT

To establish better quality indoor air in the building after construction and during occupancy.

REQUIREMENTS

Select one of the following two options, to be implemented after construction ends and the building has been completely cleaned. All interior finishes, such as millwork, doors, paint, carpet, acoustic tiles, and movable furnishings (e.g., workstations, partitions), must be installed, and major VOC punch list items must be finished. The options cannot be combined.

OPTION 1. FLUSH-OUT (1 POINT)

Path 1. Before Occupancy
Install new filtration media and perform a building flush-out by supplying a total air volume of 14,000 cubic feet of outdoor air per square foot (4 267 140 liters of outdoor air per square meter) of gross floor area while maintaining an internal temperature of at least 60°F (15°C) and no higher than 80°F (27°C) and relative humidity no higher than 60%.

OR

Path 2. During Occupancy
If occupancy is desired before the flush-out is completed, the space may be occupied only after delivery of a minimum of 3,500 cubic feet of outdoor air per square foot (1 066 260 liters of outdoor air per square meter) of gross floor area while maintaining an internal temperature of at least 60°F (15°C) and no higher than 80°F (27°C) and relative humidity no higher than 60%.

Once the space is occupied, it must be ventilated at a minimum rate of 0.30 cubic foot per minute (cfm) per square foot of outdoor air (1.5 liters per second per square meter of outdoor air) or the design minimum outdoor air rate determined in EQ Prerequisite Minimum Indoor Air Quality Performance, whichever is greater. During each day of the flush-out period, ventilation must begin at least three hours before occupancy and continue during occupancy. These conditions must be maintained until a total of 14,000 cubic feet per square foot of outdoor air (4 270 000 liters of outdoor air per square meter) has been delivered to the space.

OR

OPTION 2. AIR TESTING (2 POINTS)

After construction ends and before occupancy, but under ventilation conditions typical for occupancy, conduct baseline IAQ testing using protocols consistent with the methods listed in Table 1 for all occupied spaces. Use current versions of ASTM standard methods, EPA compendium methods, or ISO methods, as indicated. Laboratories that conduct the tests for chemical analysis of formaldehyde and volatile organic compounds must be accredited under ISO/IEC 17025 for the test methods they use. Retail projects may conduct the testing within 14 days of occupancy.

Demonstrate that contaminants do not exceed the concentration levels listed in Table 1.

TABLE 1. Maximum concentration levels, by contaminant and testing method

Contaminant			Maximum concentration	ASTM and U.S. EPA methods	ISO method
Particulates	**PM10** (for all buildings)		50 µg/m^3 Healthcare only: 20 µg/m^3	EPA Compendium Method IP-10	ISO 7708
	PM2.5 (for buildings in EPA nonattainment areas for PM2.5, or local equivalent)		15 µg/m^3		
Ozone (for buildings in EPA nonattainment areas for Ozone, or local equivalent)			0.075 ppm	ASTM D5149 - 02	ISO 13964
Carbon monoxide (CO)			9 ppm; no more than 2 ppm above outdoor levels	EPA Compendium Method IP-3	ISO 4224
Total volatile organic compounds (TVOCs)			500 µg/m^3 Healthcare only: 200 µg/m^3	EPA TO-1, TO-17, or EPA Compendium Method IP-1	ISO 16000-6
Formaldehyde			27 ppb Healthcare only: 16.3 ppb	ASTM D5197, EPA TO-11, or EPA Compendium Method IP-6	ISO 16000-3
Target volatile organic compounds*	1	Acetaldehyde	140 µg/m^3		
	2	Benzene	3 µg/m^3	ASTM D5197; EPA TO-1, TO-17, or EPA Compendium Method IP-1	ISO 16000-3, ISO 16000-6
	3	Carbon disulfide	800 µg/m^3		
	4	Carbon tetrachloride	40 µg/m^3		
	5	Chlorobenzene	1000 µg/m^3		
	6	Chloroform	300 µg/m^3		
	7	Dichlorobenzene (1,4-)	800 µg/m^3		
	8	Dichloroethylene (1,1)	70 µg/m^3		
	9	Dimethylformamide (N,N-)	80 µg/m^3		
	10	Dioxane (1,4-)	3000 µg/m^3		
	11	Epichlorohydrin	3 µg/m^3		
	12	Ethylbenzene	2000 µg/m^3		
	13	Ethylene glycol	400 µg/m^3		
	14	Ethylene glycol monoethyl ether	70 µg/m^3		
	15	Ethylene glycol monoethyl ether acetate	300 µg/m^3		
	16	Ethylene glycol monomethyl ether	60 µg/m^3		
	17	Ethylene glycol monomethyl ether acetate	90 µg/m^3		
	18	Hexane (n-)	7000 µg/m^3		
	19	Isophorone	2000 µg/m^3		
	20	Isopropanol	7000 µg/m^3		
	21	Methyl chloroform	1000 µg/m^3		
	22	Methylene chloride	400 µg/m^3		
	23	Methyl *t*-butyl ether	8000 µg/m^3		
	24	Naphthalene	9 µg/m^3		
	25	Phenol	200 µg/m^3		
	26	Propylene glycol monomethyl ether	7000 µg/m^3		
	27	Styrene	900 µg/m^3		
	28	Tetrachloroethylene (Perchloroethylene)	35 µg/m^3		
	29	Toluene	300 µg/m^3		
	30	Trichloroethylene	600 µg/m^3		
	31	Vinyl acetate	200 µg/m^3		
	32-34	Xylenes, technical mixture (m-, o-, pxylene combined)	700 µg/m^3		

ppb = parts per billion; ppm = parts per million; µg/m^3 = micrograms per cubic meter

*The target volatile organic compounds are from CDPH Standard Method v1.1, Table 4-1. The Maximum concentration limits for these target compounds are the full CREL adopted by Cal/EPA OEHHA in effect on June 2014 http://oehha.ca.gov/air/allrels.html.

Conduct all measurements before occupancy but during normal occupied hours, with the building ventilation system started at the normal daily start time and operated at the minimum outdoor airflow rate for the occupied mode throughout the test.

For each sampling point where the concentration exceeds the limit, take corrective action and retest for the noncompliant contaminants at the same sampling points. Repeat until all requirements are met.

BEHIND THE INTENT

Many building materials contain substances that are hazardous to human health, and construction activity can introduce contaminants into the indoor environment. Harmful substances include formaldehyde and volatile organic compounds (VOCs) from building materials. Dust, ozone, and fine particulate matter generated by construction activity, diesel engines, or unfiltered outdoor air can also be harmful. Reducing indoor air contaminants has significant human health benefits and typically improves occupants' comfort, lowers absenteeism, and increases productivity.

Testing airborne pollutant levels is the best way to demonstrate that source control strategies have been effectively and properly implemented. For VOCs, this credit follows the California Department of Public Health Standard Method v1.1, which is widely recognized by the industry for its science-based best practices and rigorous, well-established testing procedures.

An alternative to testing that can improve indoor air quality is a building flush-out, an effective method to disperse off-gassed compounds and other contaminants left behind at the end of construction. The threshold for duration of building flush-out is based on a typical mechanical ventilation system. A typical ventilation system supply airflow rate is 0.7 cubic feet per minute per square foot (3.55 liters per second per square meter). Therefore, if a system operates at 100% outdoor air continuously for two weeks, the cubic feet of outdoor air per square foot of floor area is calculated as follows:

$$\begin{array}{c}\text{14,112 cu ft of}\\ \text{outdoor air/ft}^2\\ \text{of floor area}\end{array} = \left\{ 0.7 \left(\frac{\text{cfm}}{\text{ft}^2}\right) \times 14 \text{ days} \times \left(\frac{24 \text{ hours}}{\text{day}}\right) \times \left(\frac{60 \text{ mins}}{\text{hr}}\right) \right\}$$

In SI units,

$$\begin{array}{c}\text{4 294 080 l of}\\ \text{outdoor air/sq meter}\\ \text{of floor area}\end{array} = \left\{ 3.55 \left(\frac{\text{lps}}{\text{m}^2}\right) \times 14 \text{ days} \times \left(\frac{24 \text{ hours}}{\text{day}}\right) \times \left(\frac{60 \text{ mins}}{\text{hr}}\right) \times \left(\frac{60 \text{ sec}}{\text{min}}\right) \right\}$$

This demonstrates that two weeks of flush-out provides adequate time for removing contaminants from the construction process.

STEP-BY-STEP GUIDANCE

STEP 1. ASSESS OPTIONS

Develop a plan for the preferred option. Teams can change to a different option later if, for example, they run out of time to complete a flush-out. Options 1 and 2 cannot be combined to meet the credit requirements.

- Option 1 may be feasible if the project's schedule allows time for a flush-out. Work with the mechanical engineer to estimate the flush-out duration before the construction schedule is established (see *Further Explanation, Calculations,* and *Considerations for Flush-Out*).
- Option 2 can typically be completed in less time than a flush-out, but the cost of air quality testing must be factored into the project budget.

STEP 2. SPECIFY LOW-EMITTING PRODUCTS AND MATERIALS

Use the requirements of the source control credits in this credit category, such as EQ Credit Low-Emitting Materials and EQ Credit Construction Indoor Air Quality Management Plan, as guidance during selection and installation of products and materials.

By incorporating low-emitting products, the project team can reduce the contaminant load before the flush-out and position the project for good test results. However, project teams are not required to achieve EQ Credit Low-Emitting Materials to meet the requirements of this credit.

STEP 3. INSTALL FINISHES, FURNITURE, AND FURNISHINGS

Install all finishes, furniture, and furnishings before testing or beginning a flush-out.

- Ensure that all owner-provided furniture has been installed in residential projects.
- Complete all punch-list items that would generate VOCs or other contaminants.
- Complete testing and balancing of the HVAC system before testing.

STEP 4. CLEAN BUILDING

Thoroughly clean the building, including the ductwork, before testing or beginning a flush-out.

- Consider using low-emitting cleaning products to prevent high short-term VOC levels that may affect test results.
- Consider using vacuum cleaners with HEPA filtration to capture particulates.

Option 1. Flush-out

STEP 1. SELECT PATH 1 OR PATH 2

Path 1 is preferable if the schedule permits, since it exposes occupants to lower levels of potential toxins; Path 2 is appropriate if the schedule does not allow time for Path 1 (see *Further Explanation, Examples 1–4*).

- For Path 2, begin the flush-out three hours before daily occupancy and continue throughout the occupied portion of the day.
- For Path 2, ensure that outdoor air volume is at least 0.30 cubic feet per minute per square foot (1.5 liters per second per square meter) or the design minimum outdoor air rate, whichever is greater.

STEP 2. CALCULATE REQUIRED VOLUME

Use the gross square footage (or square meters) to calculate the total cubic feet (or liters) of air required. The area used must be consistent with the area used for other credits. Every space in the building must be flushed out (see *Further Explanation, Calculations*).

STEP 3. DETERMINE DURATION OF FLUSH-OUT

Determine the rate of outdoor air the HVAC system can provide and calculate the duration of flush-out with the required volume calculated in Step 1 (see *Further Explanation, Calculations*).

- If a shorter duration is desired, or if the HVAC system is unable to provide at least 0.3 cubic feet per minute per square foot (1.5 liters per second per square meter) for an occupied flush-out, supplemental units may be used. Ventilation fans without supplemental cooling or heating, or temporary, supplemental HVAC units (installed in window or door openings) may be used, provided the outdoor conditions are within the required temperature and humidity constraints at all times during the flush-out. See the credit requirements.
- Commissioning can occur during the flush-out, provided none of the commissioning procedures introduce contaminants into the space and none of the flush-out procedures circumvent the commissioning process. Complete testing and balancing of the HVAC system after the flush-out is complete.
- If even partial construction work occurs during the flush-out (e.g., repainting a room) the flush-out must be started again from the beginning for that space.
- If multiple, discrete HVAC systems operate independently, the team may flush out portions of the building as work is completed in each area served by a given system.

STEP 4. REPLACE OR INSTALL FILTERS

If the permanent HVAC system will be used to perform the flush-out procedure, first replace used filters.

- Replace the used HVAC filtration media with new media. Filter selection has implications for other credits (see *Related Credit Tips*).
- Remove any temporary filters or duct coverings installed as part of the construction indoor air quality management plan.

STEP 5. COMPLETE FLUSH-OUT

Complete the flush-out, following the requirements for Path 1 or Path 2.

STEP 6. PREPARE FLUSH-OUT REPORT

Provide a flush-out report that includes the following information:

- Duration calculations. Include the capacity of all HVAC units used and indicate which are permanent and which temporary; capacity should take into account the volume of outdoor air and temperature and humidity allowances.
- Description of flush-out procedure. Include a log of dates, hours, and recorded temperature and humidity.
- If the amount of outdoor air is more than has been designed in EQ Prerequisite Minimum Indoor Air Quality Performance or more than shown on the mechanical schedules, include a narrative explaining how the additional air was provided to the building.

Option 2. Air Testing

STEP 1. DETERMINE AIR-TESTING LOCATIONS

Determine where in the building IAQ testing will be performed.

First, perform an initial analysis to identify potential locations to test in the building. Consider locations that are most representative of the building space, and where occupants will normally spend their time.

- Identify at least one location per ventilation system. Include locations that represent the worst-case zones where the highest concentrations of contaminants of concern are likely to occur.
- Identify at least one location per floor of the building.
- Identify at least one location per space type. In most cases, only regularly occupied spaces need to be included. Additionally, for each space type identified, if the air is not well mixed or contaminants are not expected to be uniform throughout the space include more than one location in the space for testing.

Next, determine whether a sampling protocol can be used to reduce the number of testing locations identified in the initial analysis. A sampling protocol is particularly useful if the project has many floors or a large number of ventilation systems.

- Identify and group spaces (or floors) that are very similar in their construction, finishes, configuration, size, and HVAC systems.
- Randomly select one out of every seven identical spaces to include in the testing. In addition, for buildings with a large number of identical spaces (more than 21 spaces in a sample group), test a minimum of three spaces in the sample group.

STEP 2. PERFORM TEST

Ensure that the following procedures are followed at all test locations. If a test fails, take corrective action (e.g., clean and flush out the space) and retest. If a test fails and a sampling protocol was used, conduct re-testing to assess whether the failure is unique or the rest of the spaces are likely to have similar failings. The duration of any flush-out between tests is at the discretion of the project team.

- The measurement equipment must be positioned in the breathing zone, between 3 and 6 feet (900 and 1 800 millimeters) above the floor.
- The test must occur during normal occupied hours, with the HVAC system starting at the normal start time and delivering outdoor air at the minimum rate.
- Testing must be performed by an appropriately accredited professional, using the approved test methods. The accredited professional should determine the sampling time based on the test method, maximum allowable concentration, and expert judgment.

STEP 3. PREPARE INDOOR AIR QUALITY TESTING REPORT

Develop an IAQ testing report that includes the following:

- Narrative describing procedures and how locations were determined
- Dates and results of each test

FURTHER EXPLANATION

CALCULATIONS

Option 1, Path 1. Flush-Out before Occupancy

EQUATION 1. Flush-out outdoor air volume

$$\text{Cubic feet of outdoor air needed prior to occupancy} = \text{Area (ft}^2) \times 14{,}000 \text{ ft}^3/\text{ft}^2$$

$$\text{Liters of outdoor air needed prior to occupancy} = \text{Area (m}^2) \times 4\,267\,140 \text{ l/m}^2$$

Option 1, Path 2. Flush-Out during Occupancy

EQUATION 2. Flush-out outdoor air volume before occupancy

$$\text{Cubic feet of outdoor air needed prior to occupancy} = \text{Area (ft}^2) \times 3{,}500 \text{ ft}^3/\text{ft}^2$$

$$\text{Liters of outdoor air needed prior to occupancy} = \text{Area (m}^2) \times 1\,066\,260 \text{ l/m}^2$$

EQUATION 3. Flush-out outdoor air volume during occupancy

$$\text{Cubic feet of outdoor air needed during occupancy to complete flush-out} = \text{Area (ft}^2) \times 10{,}500 \text{ ft}^3/\text{ft}^2$$

$$\text{Liters of outdoor air needed during occupancy to complete flush-out} = \text{Area (m}^2) \times 3\,200\,880 \text{ l/m}^2$$

Options 1 and 2

EQUATION 4. Flush-out duration

$$\text{Duration (Days)} = \left\{ \frac{(\text{Area (ft}^2) \times 14{,}000 \text{ ft}^3/\text{ft}^2)}{(\text{Air handler capacity} \div 1440 \text{ minutes/day})} \right\}$$

$$\text{Duration (Days)} = \left\{ \frac{(\text{Area (m}^2) \times 4\,267\,140 \text{ l/m}^2)}{(\text{Air handler capacity} \div 86\,400 \text{ seconds/day})} \right\}$$

EXAMPLES

The figures below assume that air handlers are capable of delivering 100% outdoor air while maintaining 60–80°F (15–27°C) and 60% relative humidity 24 hours per day.

Example 1. Option 1, Path 1, flush-out before occupancy calculation (IP)

TABLE 2. Option 1, Path 1 (IP)						
	Gross floor area (ft^2)	**Total Outdoor Air Required (ft^3/ft^2)**	**Volume of air required before occupancy (cf)**	**Air handler outdoor air capacity (cfm)**	**Duration of preoccupancy flush-out (minutes)**	**Duration of preoccupancy flush-out (days)**
Space type 1	50,000	14,000	700,000,000	15,000	46,667	32.4
Space type 2	10,000	14,000	140,000,000	4,000	35,000	24.3
Space type 3	5,000	14,000	70,000,000	5,000	14,000	9.7

Example 2. Option 1, Path 1, flush-out before occupancy calculation (SI)

TABLE 3. Option 1, Path 1 (SI)						
	Gross floor area (sq m)	**Total Outdoor Air Required (l/m^2)**	**Volume of air required before occupancy (liters)**	**Air handler outdoor air capacity (lps)**	**Duration of preoccupancy flush-out (seconds)**	**Duration of preoccupancy flush-out (days)**
Space type 1	4645	4267 140	19 820 865 300	7 079	2 799 953	32.4
Space type 2	929	4267 140	3 964 173 060	1 888	2 099 668	24.3
Space type 3	464	4267 140	1 979 952 960	2 360	838 963	9.7

Example 3. Option 1, Path 2, flush-out during occupancy calculation (IP)

TABLE 4. Option 1, Path 2 (IP)											
	Gross floor area (ft^2)	**Total outdoor air required before occupancy (ft^3/ft^2)**	**Volume of air required before occupancy (cf)**	**Air handler outdoor air capacity (cfm)**	**Duration of preoccupancy flush-out (minutes)**	**Duration of preoccupancy flush-out (days)**	**Total outdoor air required to complete flush-out (ft^3/ft^2)**	**Volume of air required to complete flush-out (ft^3) if applicable**	**Minimum outdoor air delivery rate postoccupancy (cfm)**	**Time to complete flush-out at min. delivery rate (minutes)**	**Time to complete flush-out at min. delivery rate (days)**
Space type 1	50,000	3,500	175,000,000	15,000	11,667	8.1	10,500	525,000,000	15,000 (0.3 cfm/ ft^2)	35,000	24.3
Space type 2	10,000	3,500	35,000,000	4,000	8,750	6.1	10,500	105,000,000	4,000*	26,250	18.2
Space type 3	5,000	3,500	17,500,000	5,000	3,500	2.4	10,500	52,500,000	5,000*	10,500	7.3

* Minimum rate required in Prerequisite Minimum Indoor Air Quality Performance

Example 4. Option 1, Path 2, flush-out during occupancy calculation (SI)

TABLE 5. Option 1, Path 2 (SI)

	Gross floor area (sq m)	Total outdoor air required before occupancy (l/m^2)	Volume of air required before occupancy (liters)	Air handler outdoor air capacity (lps)	Duration of preoccupancy flush-out (seconds)	Duration of preoccupancy flush-out (days)	Total outdoor air required to complete flush-out (l/m^2)	Volume of air required to complete flush-out (liters)	Minimum outdoor air delivery rate postoccupancy (lps)	Time to complete flush-out at min. delivery rate (seconds)	Time to complete flush-out at min. delivery rate (days)
Space type 1	4 645	1 066 260	4 952 777 700	7 079	699 644	8.1	3 200 880	14 868 087 600	7 079 (0.3 cfm/sqft)	2 100 309	24.3
Space type 2	929	1 066 260	990 555 540	1 888	524 659	6.1	3 200 880	2 973 617 520	1 888*	1 575 009	18.2
Space type 3	464	1 066 260	494 744 640	2 360	209 638	2.4	3 200 880	1 485 208 320	2 360*	629 326	7.3

* Minimum rate required in EQ Prerequisite Minimum Indoor Air Quality Performance

CONSIDERATIONS FOR FLUSH-OUT

Before committing to a flush-out, check with the mechanical engineer to confirm that proposed mechanical systems are capable of providing outdoor air at the required rate. Flush-out during occupancy requires at least 0.3 cubic feet per minute per square foot (1.5 liters per second per square meter) of outdoor air.

Systems that meet ASHRAE 62.1–2010 airflow rates and provide a fixed volume of outdoor air may not be able to provide sufficient outdoor air, or the flush-out could take a long time.

For systems that can provide a sufficient volume of outdoor air, confirm that heating and cooling equipment can handle the additional load from increased outdoor air during times of peak heating and cooling. The equipment must be able to maintain an internal temperature between 60°F (15°C) and 80°F (27°C), with a relative humidity no higher than 60%.

Buildings with air-side economizers may be able to provide the required outdoor air during the free cooling season, reducing the energy required to provide the increased outdoor air, assuming it can be provided at a constant volume.

INTERNATIONAL TIPS

To address PM2.5 and ozone (see Table 1), use an equivalent to the U.S. EPA standards for nonattainment areas. If no equivalent exists, consider the project to be in a nonattainment area.

CAMPUS

Group Approach

Submit separate documentation for each building.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1, Path 1	Option 1, Path 2	Option 2
Flush-out report	X	X	
IAQ testing report			X

RELATED CREDIT TIPS

EQ Prerequisite Minimum Indoor Air Quality Performance. Projects that pursue Option 1, Path 2 (flush-out during occupancy), must use the greater of the minimum outdoor air rate determined for this prerequisite or 0.30 cubic feet per minute per square foot (1.5 liters per second per square meter) for the occupied portion of the flush-out.

EQ Credit Enhanced Indoor Air Quality Strategies. Projects that pursue Option 1 must install new MERV 13 or Class F7 filters before the flush-out to meet the requirements of this credit. Using comprehensive strategies will improve indoor air quality, increase the effectiveness of a flush-out, and increase the likelihood of passing the air quality tests.

EQ Credit Low-Emitting Materials. Specifying low-emitting products and materials will improve indoor air quality, increase the effectiveness of a flush-out, and increase the likelihood of passing the air quality tests.

EQ Credit Construction Indoor Air Quality Management Plan. For projects that pursue Option 1, new filters that meet the appropriate specifications and were installed immediately before the flush-out also satisfy the requirements of this credit. Proper attention to contaminants during construction will improve overall indoor air quality, increase the effectiveness of a flush-out, and increase the likelihood of passing the air quality tests.

CHANGES FROM LEED 2009

- Installation of movable furnishings (such as workstations and partitions) before testing or flush-out is now required rather than just recommended.
- Options can no longer be combined.
- An upper interior temperature limit is now identified in Option 1.
- Testing is now required for an expanded list of contaminants in Option 2.
- There is no longer a 4-hour sampling time requirement in Option 2.

REFERENCED STANDARDS

ASTM D5197–09e1 Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (**Active Sampler Methodology**): astm.org/Standards/D5197.htm

ASTM D5149–02(2008) **Standard Test Method for Ozone in the Atmosphere: Continuous Measurement by Ethylene Chemiluminescence**: astm.org/Standards/D5149

ISO 16000-3, Indoor air–Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air—Active sampling method:
iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51812

ISO 16000-6, Indoor air–Part 6: Determination of volatile organic compounds in indoor and test chamber air

by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS or MS-FID: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=52213

ISO 4224 Ambient air—Determination of carbon monoxide—Nondispersive infrared spectrometric method: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=32229

ISO 7708 Air quality—Particle size fraction definitions for health-related sampling: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=14534

ISO 13964 Air quality—Determination of ozone in ambient air—Ultraviolet photometric method: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=23528

U.S. EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air, IP-1: Volatile Organic Compounds, IP-3: Carbon Monoxide and Carbon Dioxide, IP-6: Formaldehyde and other aldehydes/ ketones, IP-10 Volatile Organic Compounds: nepis.epa.gov

U.S. EPA Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air, TO-1: Volatile Organic Compounds, TO-11: Formaldehyde, TO-15: Volatile Organic Compounds, TO-17:

Volatile Organic Compounds: epa.gov/ttnamti1/airtox.html

California Department of Public Health, Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers, v1.1–2010: cal-iaq.org/separator/voc/standard-method

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Thermal Comfort

This credit applies to:

New Construction (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To promote occupants' productivity, comfort, and well-being by providing quality thermal comfort.

REQUIREMENTS

Meet the requirements for both thermal comfort design and thermal comfort control.

Thermal Comfort Design

NEW CONSTRUCTION, SCHOOLS, RETAIL, DATA CENTERS, HOSPITALITY, HEALTHCARE

OPTION 1. ASHRAE STANDARD 55-2010

Design heating, ventilating, and air-conditioning (HVAC) systems and the building envelope to meet the requirements of ASHRAE Standard 55–2010, Thermal Comfort Conditions for Human Occupancy, with errata or a local equivalent.

For natatoriums, demonstrate compliance with ASHRAE HVAC Applications Handbook, 2011 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions, with errata.

OR

OPTION 2. ISO AND CEN STANDARDS

Design HVAC systems and the building envelope to meet the requirements of the applicable standard:

- ISO 7730:2005, Ergonomics of the Thermal Environment, analytical determination and interpretation of thermal comfort, using calculation of the PMV and PPD indices and local thermal comfort criteria; and
- CEN Standard EN 15251:2007, Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings, addressing indoor air quality, thermal environment, lighting, and acoustics, Section A2.

DATA CENTERS ONLY

Meet the above requirements for regularly occupied spaces.

WAREHOUSES AND DISTRIBUTION CENTERS

Meet the above requirements for office portions of the building.

In regularly occupied areas of the building's bulk storage, sorting, and distribution areas, include one or more of the following design alternatives:

- radiant flooring;
- circulating fans;
- passive systems, such as nighttime air, heat venting, or wind flow;
- localized active cooling (refrigerant or evaporative-based systems) or heating systems; and
- localized, hard-wired fans that provide air movement for occupants' comfort.
- other equivalent thermal comfort strategy.

Thermal Comfort Control

NEW CONSTRUCTION, SCHOOLS, RETAIL, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

Provide individual thermal comfort controls for at least 50% of individual occupant spaces. Provide group thermal comfort controls for all shared multioccupant spaces.

Thermal comfort controls allow occupants, whether in individual spaces or shared multioccupant spaces, to adjust at least one of the following in their local environment: air temperature, radiant temperature, air speed, and humidity.

HOSPITALITY ONLY

Guest rooms are assumed to provide adequate thermal comfort controls and are therefore not included in the credit calculations.

RETAIL ONLY

Meet the above requirements for at least 50% of the individual occupant spaces in office and administrative areas.

HEALTHCARE

Provide individual thermal comfort controls for every patient room and at least 50% of the remaining individual occupant spaces. Provide group thermal comfort controls for all shared multioccupant spaces.

Thermal comfort controls allow occupants, whether in individual spaces or shared multioccupant spaces, to adjust at least one of the following in their local environment: air temperature, radiant temperature, air speed, and humidity.

BEHIND THE INTENT

A large body of laboratory and field research has demonstrated how thermal conditions inside buildings directly affect people's satisfaction and performance.[1] Although often associated only with air temperature, thermal comfort is a complex amalgam of six primary factors (Figure 1), all of which are influenced by building design and operation. An effective thermal comfort strategy considers all six concurrently, meaning that close collaboration between the owner, architect, and engineer is critical to achieving this credit.

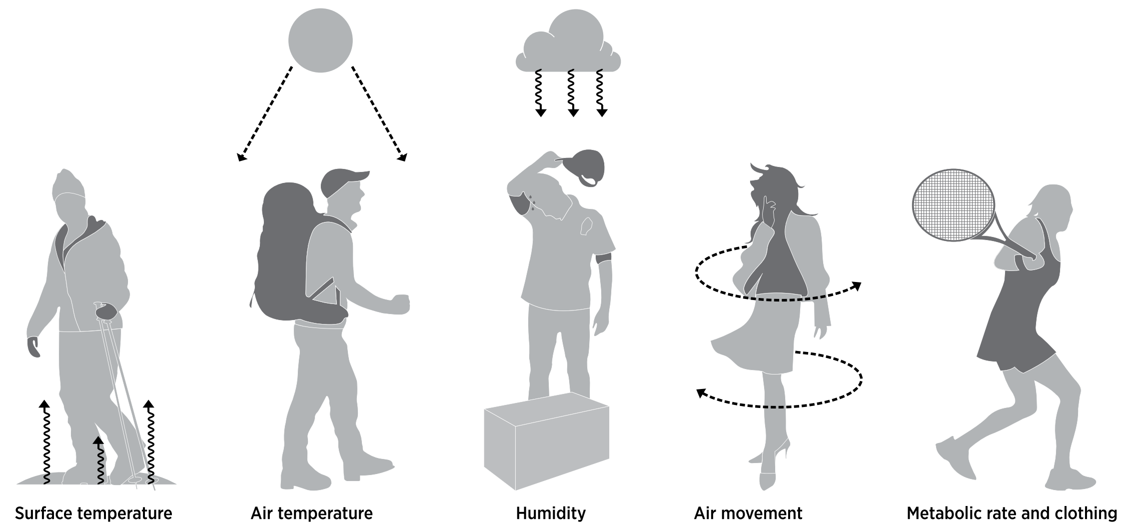


Figure 1. Primary factors that affect thermal comfort

Modifying one or more of the six comfort factors can greatly improve occupants' perception of the thermal environment while still supporting energy reduction goals. Working closely with the owner during design, the project team can maximize comfort by coordinating design with operational policies. For example, a flexible dress code that permits seasonally appropriate clothing can allow design air temperatures to be adjusted upward during the cooling season and downward during the heating season without affecting occupants' perception of comfort.

Occupants who are able to modify their thermal environment through thermal controls will perceive more comfort regardless of conditioning strategy, and they may exhibit additional satisfaction and productivity. Indoor environment quality surveys administered by the Center for the Built Environment have shown significant increases in satisfaction among occupants who have individual control of a thermostat or an operable window.[2] Likewise, research from the International Centre for Indoor Environment and Energy suggests that giving occupants +/–5°F (3°C) of local temperature control can result in productivity gains of 2.7% to 7%.[3]

The referenced standards for this credit use two indices: predicted mean vote (PMV) and predicted percentage of dissatisfied (PPD). The PMV was developed by placing test subjects in climate chambers and asking them to rate their level of comfort on a seven-point thermal sensation scale. The scale runs from plus 3 (too hot) to minus 3 (too cold), with zero representing neutral. The PPD index is then determined; it predicts the percentage of people who are likely to be dissatisfied with a given thermal condition. The referenced standards for this credit also use field-based research as the basis of the adaptive model, which relates indoor design temperatures or acceptable temperature ranges to outdoor meteorological or climatological parameters. [4]

1. *Fisk, W. 2001. "Estimates of Potential Nationwide Productivity and Health Benefits from Better Indoor Environments: An Update." In Spengler, J., J. Samet, and J. McCarthy. Indoor Air Quality Handbook. New York: McGraw Hill, 4.1–4.31.*
2. *Huizenga, C., S. Abbaszadeh, L. Zagreus, and E. Arens. 2006. "Air Quality and Thermal Comfort in Office Buildings: Results of a Large Indoor Environmental Quality Survey." In Proceedings of Healthy Buildings 2006, vol. III, Lisbon, Portugal, pp. 393–397.*
3. *Wyon, D. 1996. "Individual Microclimate Control: Required Range, Probable Benefits, and Current Feasibility." In Proceedings of Indoor Air 1996: Seventh International Conference of Indoor Air Quality and Climate, vol. 1, Nagoya, Japan, pp.1067–1072.*
4. *ASHRAE Standard 55–2010, Thermal Environmental Conditions for Human Occupancy.*

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH THERMAL COMFORT GOALS

Work with the owner to understand expectations for the indoor thermal environment, the level of control that occupants should have, and characteristics of the occupant population.

- Determine whether a tightly controlled environment is required or whether some variation in indoor conditions is acceptable.
- Determine whether occupants would see natural conditioning as a workplace benefit.
- Consider including factors and design criteria related to occupants in the owner's project requirements (OPR) for commissioning activities.

Thermal comfort needs for natatoriums are unique (see *Further Explanation, Project Type Variations*). Data Center and Warehouses and Distribution Center projects also have different needs (see *Further Explanation, Rating System Variations*).

STEP 2. SELECT CONDITIONING SYSTEM

Based on the thermal comfort goals, determine the best conditioning approach for the project (see *Further Explanation, Thermal Comfort Conditioning Approaches*).

- Consider whether the project is a candidate for natural conditioning. Examine the climate by season, including temperature, humidity, and air quality, to determine optimal times of the year for natural conditioning.
- Identify program areas that could be designed to accommodate cross or stack ventilation and consider ways they could be organized to create microclimates to expand annual hours of natural conditioning (see *Further Explanation, Criteria for Occupant-Controlled Naturally Conditioned Spaces*).

STEP 3. SELECT COMFORT CONTROLS

Determine the best thermal comfort controls for the conditioning system(s) selected, based on the type of project and occupant's activities (see *Further Explanation, Rating System Variations* and *Project Type Variations*).

- Consider thermal comfort controls that allow occupants to control air temperature, radiant temperature, air speed, and humidity.
- Examples of eligible thermal comfort controls include thermostats, ceiling fans, adjustable underfloor diffusers, task-mounted controls (such as plug-in desktop fans, humidifiers, or dehumidifiers), and operable windows. Examples of ineligible thermal comfort controls include a ceiling diffuser without an accessible control, and a thermostat with a fixed setpoint that cannot be adjusted by occupants.
- Zone the conditioning system to ensure that at least 50% of individual occupant spaces have individual thermal comfort controls. Additional controls may be appropriate for some projects but are not required by this credit.
- Provide at least one group thermal comfort control in each shared multioccupant space. Meeting spaces that can be subdivided (e.g., a convention hall with movable walls) must be designed such that each group of occupants can control their area.

STEP 4. SELECT THERMAL COMFORT STANDARD

Decide which standard or set of standards is suited to the project. Either option is appropriate for common space types, such as offices, educational buildings, hospitals, hotels and restaurants, and retail buildings. For other building types, see *Further Explanation, Project Type Variations.*

- Option 1 is suitable for most U.S. project teams, who are likely familiar with ASHRAE Standard 55–2010. This option also allows project teams to use the same standard for both mechanically and naturally conditioned spaces.
- Option 2 relies on two international standards, ISO 7730–2005 and EN 15251–2007, to document mechanically and naturally conditioned spaces, respectively.

Both options include compliance paths for mechanically and naturally conditioned spaces based on the same comfort models.

Option 1. ASHRAE Standard 55–2010

STEP 1. SELECT ANALYSIS METHOD(S)

Select the methodology from ASHRAE Standard 55–2010 that will be used for the thermal comfort analysis.

- For mechanically conditioned spaces, select one or more of the following from Section 5.2, Methods for Determining Acceptable Conditions in Occupied Spaces:
- Section 5.2.1, Graphic Comfort Zone Method for Typical Indoor Environments
- Section 5.2.1.2, Computer Model Method for General Indoor Application
- Section 5.2.3.1, Graphic Elevated Air Speed Method
- Section 5.2.3.2, SET Method

Section 5.2.4 must also be followed for potential sources of local discomfort.

- For naturally conditioned spaces, select Section 5.3, Optional Method for Determining Acceptable Thermal Conditions in Naturally Conditioned Spaces. The optional method is available only for spaces that meet certain criteria (see *Further Explanation, Criteria for Occupant-Controlled Naturally Conditioned Spaces*). Spaces that do not meet these criteria must follow one of the mechanically conditioned spaces methods.

For mixed-mode spaces, each seasonal conditioning strategy must be documented separately. For example, demonstrate heating season compliance using Section 5.2 and cooling season compliance using Section 5.3.

STEP 2. PERFORM ANALYSIS

If using Section 5.2, perform the analysis as described in the standard.

- Estimate occupants' personal factors, such as clothing and activity levels.
- Using the owner's comfort expectations, energy goals, and occupancy factors, set seasonal comfort criteria for operative temperature, humidity, and air speed for each programmed area. Refer to ASHRAE 55–2010, Appendices A and B, for recommended values.
- Calculate the effects of any likely local discomfort sources, such as radiant temperature asymmetry, vertical air temperature difference, floor surface temperature, and drafts, as described in Section 5.2.4. Confirm that dissatisfaction is within the allowable ranges listed in Table 5.2.4.

This analysis may be an iterative process in which thermal conditions are revised or refined to meet the ASHRAE requirements. By using the standard in this way, project teams can ensure that the thermal conditions meet the credit requirements before they begin detailed design work.

If using Section 5.3, perform the analysis as described in the standard.

- Calculate mean monthly outdoor temperature for the project's location, as described in the ASHRAE standard, for times of the year when natural conditioning is used.
- Use Figure 5.3 to establish the upper and lower operative temperature limits of the comfort zone. It may be helpful to plot mean monthly outdoor temperatures, comfort zone boundaries, and design operative temperatures on Figure 5.3.
- Compare indoor operative temperatures with the comfort zone boundaries.

STEP 3. DESIGN PROJECT'S CONDITIONING SYSTEMS

Design the project's conditioning systems to provide the acceptable comfort conditions identified in the previous step. Additionally, verify that all spaces at risk for discomfort, such as locations close to entrances prone to drafts or west-facing walls that may retain heat, have been addressed.

ASHRAE 55–2010, Section 6.1, requires the design to be within the acceptable comfort range at all combinations of conditions that are expected to occur, including variations in internal loads and the exterior environment, and at both full- and partial-load conditions. Systems that cannot maintain comfort under all conditions (e.g., a constant-volume rooftop unit with a single compressor may have problems controlling humidity levels) do not meet the credit requirements (see *Further Explanation, Examples*).

Option 2. ISO 7730–2005 and EN 15251–2007

STEP 1. SELECT ANALYSIS METHOD(S)

Select the methodology that will be used for the thermal comfort analysis.

- For mechanically conditioned spaces, select ISO 7730–2005.
- For naturally conditioned spaces, select EN 15251–2007, Annex A.2, Acceptable Indoor Temperatures for Design of Buildings without Mechanical Cooling Systems. The EN method is available only for spaces that meet certain criteria (see *Further Explanation, Criteria for Occupant-Controlled Naturally Conditioned Spaces*). Spaces that do not meet these criteria must follow ISO.

For mixed-mode spaces, each seasonal conditioning strategy must be documented separately. For example, demonstrate heating season compliance using ISO 7730 and cooling season compliance using EN 15251.

STEP 2. SELECT BUILDING CATEGORY

Identify the space category and comfort threshold for the project based on the selected standard's classifications.

- The ISO and EN standards set different ranges of comfort acceptability for specific building types and occupant populations (Table 1).
- Category B (ISO) and Category II (EN) are appropriate for most new buildings.

TABLE 1. Comparison of comfort acceptability ranges, ISO 7730–2005 and EN 15251–2007

Category		Description	Allowable predicted mean vote	Allowable predicted percentage dissatisfied
ISO 7730– 2005	EN 15251– 2007			
A	I	Recommended for spaces occupied by very sensitive and fragile persons with special requirements (very young children, elderly, ill)	–0.2 < PMV < 0.2	<6%
B	II	Suitable for most new buildings and renovations	–0.5 < PMV < 0.5	<10%
C	III	Suitable for existing buildings	–0.7 < PMV < 0.7	<15%
	IV	Values other than above; acceptable for only part of year	PMV < –0.7 or PMV > 0.7	>15%

PMV = predicted mean vote (index of thermal comfort) PPD = predicted percentage (of people) dissatisfied

Source: This excerpt is adapted and modified from ISO 7730:2005 and EN 15251:2007 with the permission of ANSI on behalf of ISO.

STEP 3. PERFORM ANALYSIS

If using ISO 7730-2005, perform the analysis as described in the standard.

- Estimate occupants' personal factors, such as clothing and activity levels.
- Using the owner's comfort expectations, energy goals, and occupancy factors, set seasonal comfort criteria for operative temperature, humidity, and air speed for various programmed areas. Refer to ISO 7730–2005, Appendices A and C, for recommended values.
- Use the simplified look-up tables provided in ISO 7730–2005, Annex E, to determine PMV for spaces with 50% relative humidity and minimal difference between air and mean radiant temperature. For spaces that do not meet Annex E criteria, calculate PMV as described in Section 4.1 or Annex D.
- Confirm that PMV falls within the allowable range for general thermal comfort for appropriate building category (Table 1).
- Calculate the effects of any likely local discomfort sources, such as draughts, vertical air temperature difference, floor surface temperature, and radiant temperature asymmetry, as described in ISO 7730–2005, Section 6, and Annex A, Section A.3, and confirm that dissatisfaction is within the allowable ranges listed in Annex A, Table A1.

This analysis may be an iterative process in which thermal conditions are revised or refined to meet the ISO requirements. By using the standard in this way, project teams can ensure that design criteria meet the credit requirements before they begin detailed design work.

If using EN 15251–2007, perform the analysis as described in the standard.

- Calculate running mean outdoor temperatures for the project's location, as described in Section 3.11 of the EN standard, for times of the year when natural conditioning is used.

- Use Figure A1 or the equations in Section A.2 of the EN standard to establish the upper and lower operative temperature limits of the comfort zone. It may be helpful to plot running mean outdoor temperatures, comfort zone boundaries, and design operative temperatures on Figure A1.
- Compare design operative temperatures with the comfort zone boundaries.

STEP 4. DESIGN PROJECT'S CONDITIONING SYSTEMS

Design the project's conditioning systems to provide the acceptable comfort conditions identified in the previous step. Additionally, verify that all spaces at risk for discomfort, such as locations close to entrances prone to drafts or west-facing walls that may retain heat, have been addressed.

ISO 7730–2005, Section A.2, requires the mechanical conditioning system design to maintain the specified comfort ranges "at all locations within the occupied zone of a space ... at all times." Systems that cannot maintain comfort under all conditions (e.g., a constant-volume rooftop unit with a single compressor may have problems controlling humidity levels) do not meet the credit requirements (see *Further Explanation, Examples*).

FURTHER EXPLANATION

CALCULATIONS

All calculations are found in the referenced standards.

THERMAL COMFORT CONDITIONING APPROACHES

There are three basic approaches to conditioning for thermal comfort: mechanical, natural, and a combination.

Mechanical conditioning is the use of mechanical systems, such as chillers and boilers, to supply cooling or heating to a space. Comfort is based on the predicted mean vote (PMV) model, which is the result of laboratory-based controlled climate chamber research in which test subjects assigned comfort values to different conditions. PMV assumes relatively consistent comfort conditions with minimal adjustment for seasonal variations. Occupants of mechanically conditioned spaces have come to expect a tightly controlled indoor thermal environment and a narrow band of indoor conditions.

Natural conditioning is the use of zero-energy strategies, such as cross or stack natural ventilation paths, passive solar heating, and thermal mass, to moderate exterior conditions. The thermal comfort zone is determined using the adaptive comfort model, which accounts for outdoor climate as well changes in occupants' expectations, clothing adjustments and use of controls, such as operable windows. Occupants of naturally conditioned spaces typically expect a broader comfort zone and accept more variation in comfort conditions, both of which can facilitate lower-energy solutions than are possible with mechanical conditioning alone.

Mixed-mode conditioning combines mechanical and natural conditioning systems, which may be used concurrently or on an alternating basis (within a working day or seasonally) in the same space, or may be used independently in different spaces in the same building.

CRITERIA FOR OCCUPANT-CONTROLLED NATURALLY CONDITIONED SPACES

The referenced standards, ASHRAE 55–2010, Section 5.3, and EN 15251–2007, Section A.2, set the following requirements for when the occupant-controlled naturally conditioned spaces (or adaptive) method may be used:

- Occupants' metabolic rate is between 1.0 and 1.3 metabolic equivalent of task (MET).
- Occupants are free to adapt their clothing to the indoor and/or outdoor thermal conditions.
- User-controlled operable windows are present.

- No mechanical cooling is installed.
- Running mean outdoor temperatures are within the ranges specified in the standards at times of year when natural conditioning is used.
- The natural conditioning comfort model cannot be applied to times of the year when the heating system is operating.

EXAMPLES

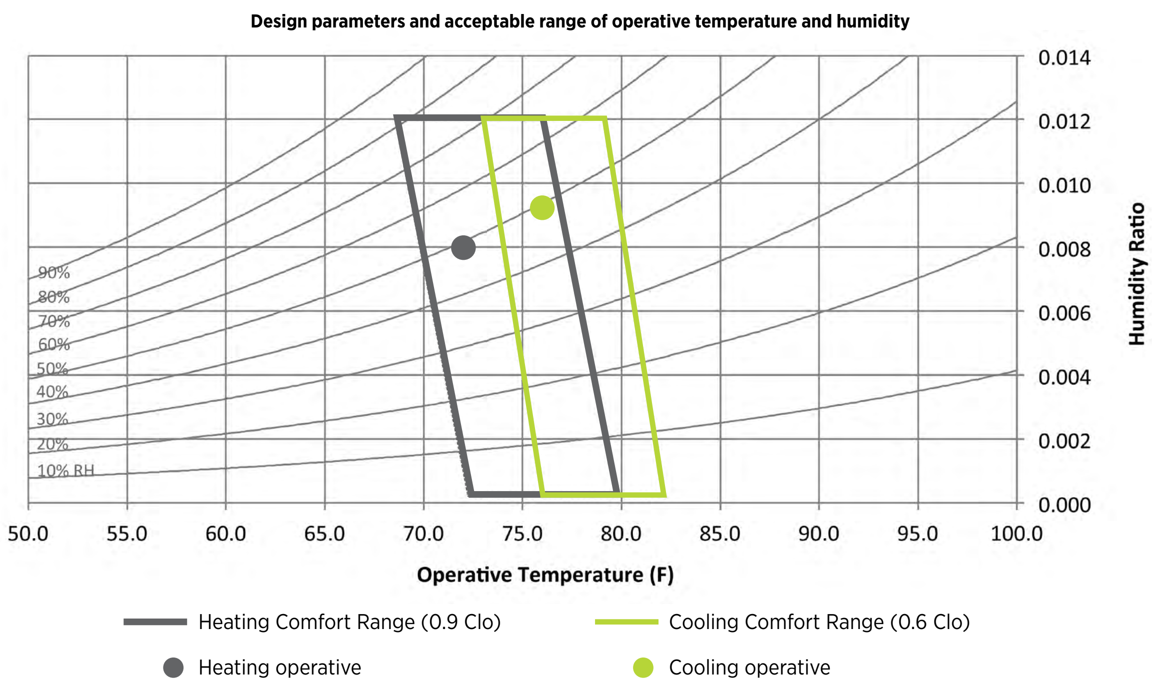
Example 1. Option 1, mechanically conditioned, graphic method

An office space is cooled with an underfloor air system and heated by perimeter fin tube radiators. The metabolic rate for the space is 1.1, per ASHRAE Appendix A. The clothing insolation (clo) is calculated as 0.9 when the outdoor environment is cool and 0.6 when the outdoor environment is warm, per garment insulation values from ASHRAE 55–2010, Appendix A, Table B2.

The project team has decided to determine compliance using the graphic method, described in ASHRAE 55–2010, Section 5.2.1.1. The design air speeds (less than 40 feet per minute), clothing insulation levels (0.5–1.0 clo), and occupant metabolic rate1.0–1.3 MET) are all within the specified ranges for this method.

The comfort zone boundaries are calculated using the ASHRAE equations for T_{max}, I_{cl}, T_{min}, I_{cl}, and I_{cl}. The design parameters and comfort zone boundaries are plotted on a psychometric chart (Figure 2). The team has determined that any local thermal discomfort effects are unlikely. Because the space's operative temperature and humidity levels fall within the comfort zone in heating and cooling modes, the project achieves the credit.

Figure 2. Supporting documentation for Example 1



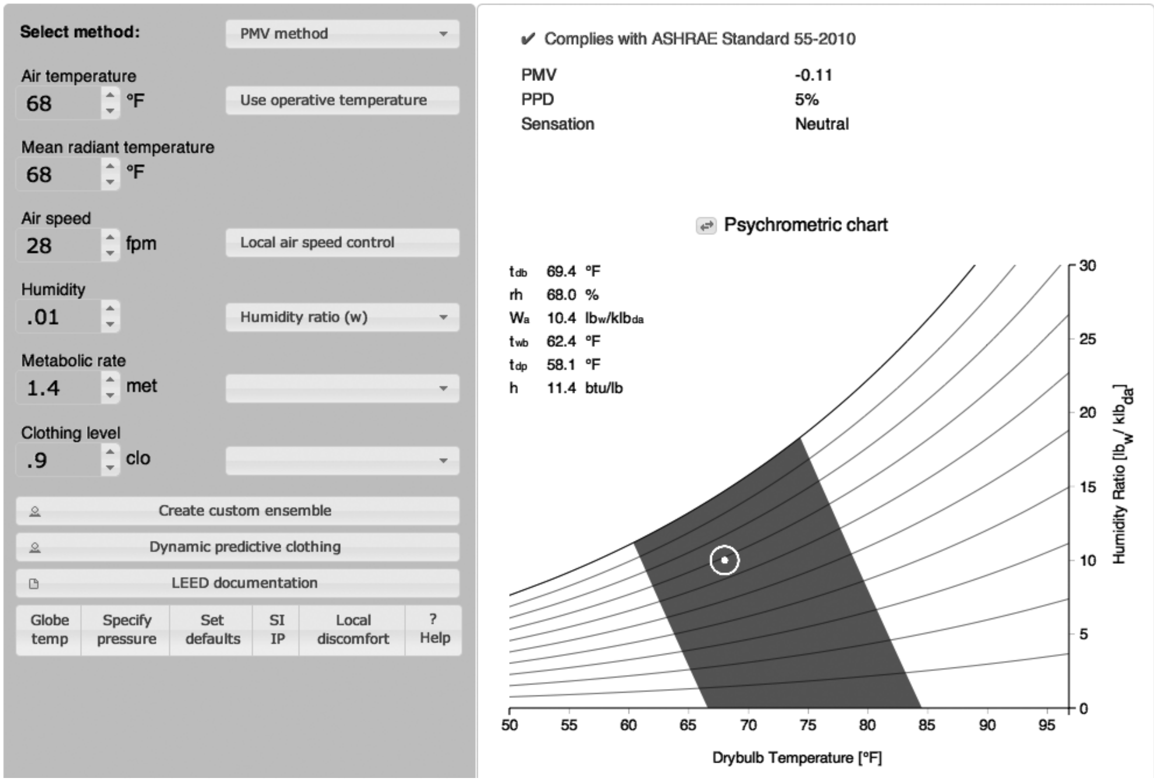
Example 2. Option 1, mechanically conditioned, computer model method

An office's file room is heated and cooled by a fan coil unit. Because the occupants of this space will be standing and filing, the expected metabolic rate is 1.4 MET, per ASHRAE 55–2010, Appendix A. The clo is calculated as in Example 1.

The project team is determining compliance using the computer model method, described in ASHRAE 55–2010, Section 5.2.1.2, because the activity level exceeds the upper metabolic limit of the graphic method (1.3 MET) but falls below the 2.0 limit for computer model method.

The design parameters are entered into the Center for the Built Environment (CBE) Thermal Comfort Tool for ASHRAE-55, which performs the required PMV and PPD calculation. The results from the tool (Figure 3) indicate that the room's operative temperature and humidity levels comply with the standard, and the project meets the credit requirements.

Figure 3. Supporting documentation for Example 2.
Source: Hoyt Tyler, Schiavon Stefano, Piccioli Alberto. 2013, CBE Thermal Comfort Tool for ASHRAE-55. Center for the Built Environment, University of California Berkeley, http://cbe.berkeley.edu/comforttool/



Example 3. Option 1, naturally conditioned, adaptive method

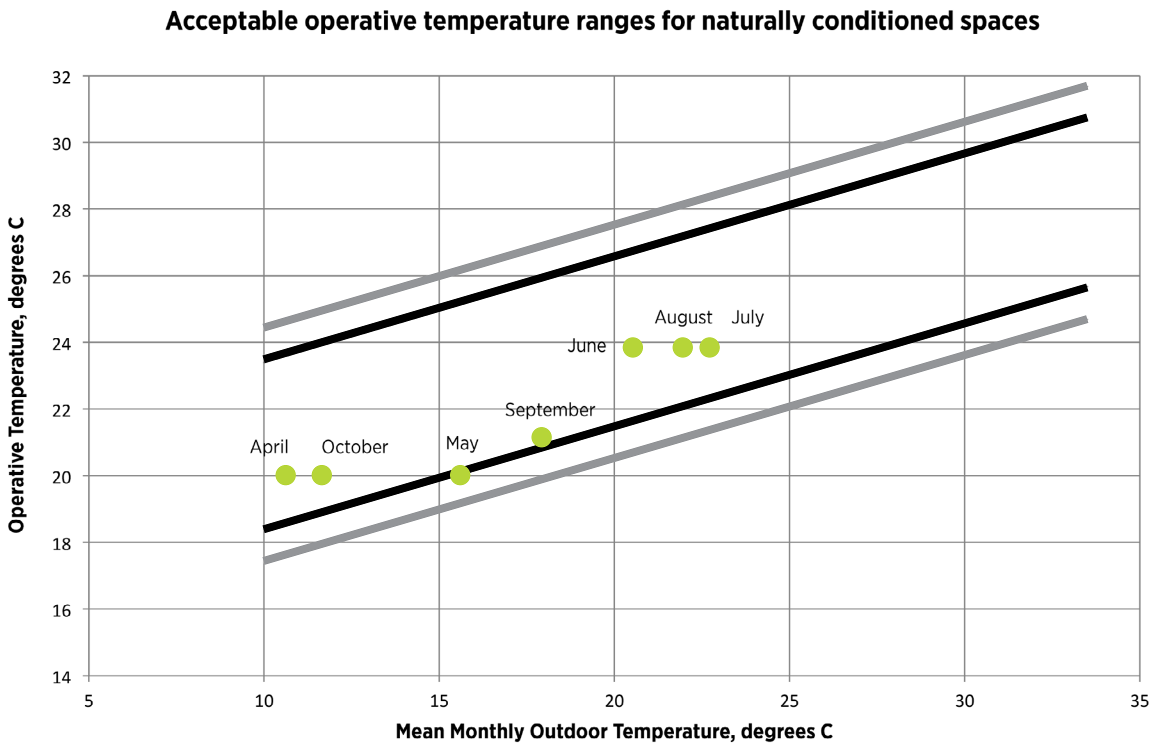
An open office space is naturally cooled with occupant-controlled operable windows and does not have any mechanical cooling system installed. Heating is provided by fin tube radiators.

The project team has decided to determine compliance for the cooling period (April through October) using the adaptive method, described in ASHRAE 55–2010, Section 5.3, Optional Method for Determining Acceptable Thermal Conditions in Naturally Conditioned Spaces.

The average monthly outdoor temperatures and design operative temperatures are plotted on Figure 5.3, found in Section 5.3 of the standard (Figure 4).

The project team must also determine compliance for the mechanically conditioned heating period (November through March) and uses the CBE Thermal Comfort Tool for ASHRAE-55, as described in Example 2.

Figure 4. Supporting documentation for Example 3



Example 4. Option 2

A classroom is naturally cooled via operable windows that are manually operated by teachers and students. The heating system consists of a hydronic radiant panel supplied with hot water from a central boiler system and controlled by a local thermostat in each classroom.

The project team has decided to determine compliance for the cooling period using the adaptive method, described in EN 15251–2007, Annex A, Section A.2, and will determine compliance for the mechanically conditioned heating period using ISO 7730–2005, Table E.3.

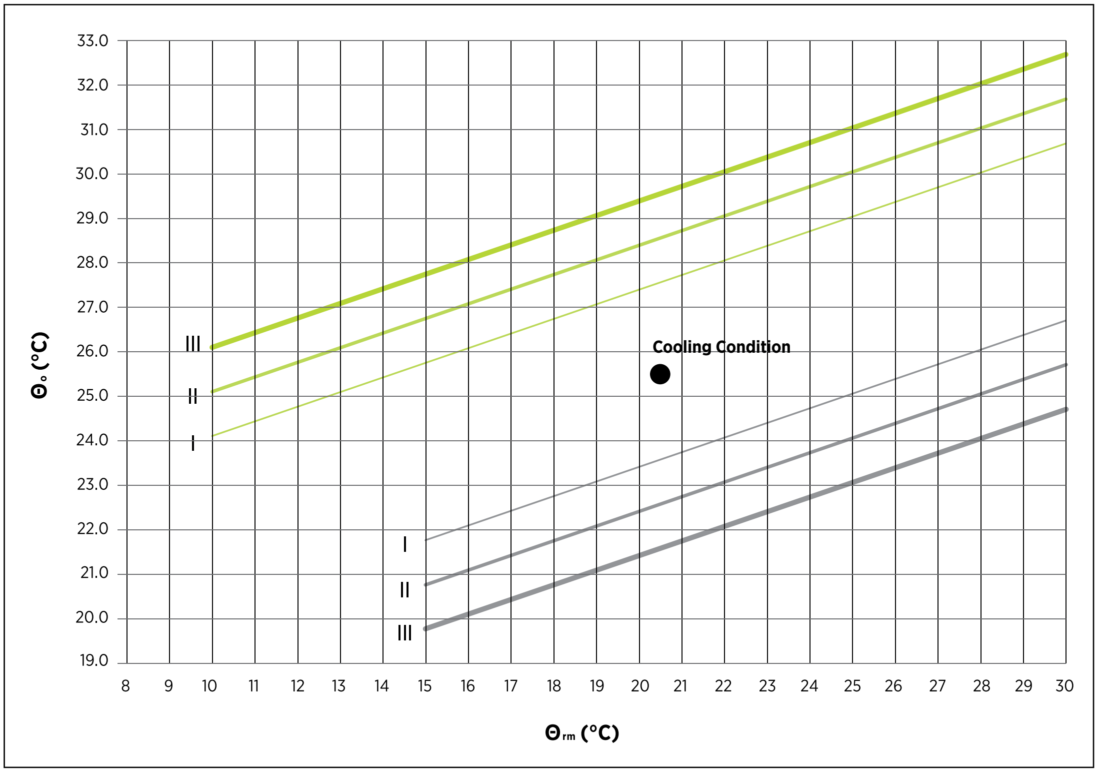
The project team creates a summary table for the design parameters (Table 2).

TABLE 2. Summary table for Example 4

	Space type	Activity level (MET)	Operative temperature (°C)	Mean monthly outdoor temperature (°C)	Relative humidity (%)	Air speed (m/s)
Cooling	Classroom	1.2	25.5	20	N/A	1
Heating	Classroom	1.2	22.2	N/A	50	0.15

The average mean monthly outdoor temperature and design operative temperature is plotted on Figure A1 in Annex A of the EN standard (Figure 5).

Figure 5. Supporting documentation for naturally conditioned period for Example 4. This excerpt is adapted and modified from ISO 7730:2005 and EN 15251:2007 with the permission of ANSI on behalf of ISO.



The design parameters were compared with ISO 7730–2005, Annex E, Table E.3 (Figure 6), and the PMV was determined to be –0.40. This is within the acceptable range for a Category B building, which is –0.5<PMV<+0.5.

Figure 6. Supporting documentation for mechanically conditioned period for Example 4. This excerpt is adapted and modified from ISO 7730:2005 and EN 15251:2007 with the permission of ANSI on behalf of ISO. © ISO 2013 – All rights reserved.

Table E.3 — Activity level: 69,6 W/m² (1,2 met)

Clothing		Operative temperature	Relative air velocity							
			m/s							
clo	m² · K/W	°C	< 0,10	0,10	0,15	0,20	0,30	0,40	0,50	1,00
0	0	25	−1,33	−1,33	−1,59	−1,92				
		26	−0,83	−0,83	−1,11	−1,40				
		27	−0,33	−0,33	−0,63	−0,88				
		28	0,15	0,12	−0,14	−0,36				
		29	0,63	0,56	0,35	0,17				
		30	1,10	1,01	0,84	0,69				
		31	1,57	1,47	1,34	1,24				
		32	2,03	1,93	1,85	1,78				
0,25	0,039	23	−1,18	−1,18	−1,39	−1,61	−1,97	−2,25		
		24	−0,79	−0,79	−1,02	−1,22	−1,54	−1,80	−2,01	
		25	−0,42	−0,42	−0,64	−0,83	−1,11	−1,34	−1,54	−2,21
		26	−0,04	−0,07	−0,27	−0,43	−0,68	−0,89	−1,06	−1,65
		27	0,33	0,29	0,11	−0,03	−0,25	−0,43	−0,58	−1,09
		28	0,71	0,64	0,49	0,37	0,18	0,03	−0,10	−0,54
		29	1,07	0,99	0,87	0,77	0,61	0,49	0,39	0,03
		30	1,43	1,35	1,25	1,17	1,05	0,95	0,87	0,58
0,50	0,078	18	−2,01	−2,01	−2,17	−2,38	−2,70			
		20	−1,41	−1,41	−1,58	−1,76	−2,04	−2,25	−2,42	
		22	−0,79	−0,79	−0,97	−1,13	−1,36	−1,54	−1,69	−2,17
		24	−0,17	−0,20	−0,36	−0,48	−0,68	−0,83	−0,95	−1,35
		26	0,44	0,39	0,26	0,16	−0,01	−0,11	−0,21	−0,52
		28	1,05	0,98	0,88	0,81	0,70	0,61	0,54	−0,31
		30	1,64	1,57	1,51	1,46	1,39	1,33	1,29	1,14
		32	2,25	2,20	2,17	2,15	2,11	2,09	2,07	1,99
0,75	0,116	16	−1,77	−1,77	−1,91	−2,07	−2,31	−2,49		
		18	−1,27	−1,27	−1,42	−1,56	−1,77	−1,93	−2,05	−2,45
		20	−0,77	−0,77	−0,92	−1,04	−1,23	−1,36	−1,47	−1,82
		22	−0,25	−0,27	−0,40	−0,51	−0,66	−0,78	−0,87	−1,17
		24	0,27	0,23	0,12	0,03	−0,10	−0,19	−0,27	−0,51
		26	0,78	0,73	0,64	0,57	0,47	0,40	0,34	0,14
		28	1,29	1,23	1,17	1,12	1,04	0,99	0,94	0,80
		30	1,80	1,74	1,70	1,67	1,62	1,58	1,55	1,46
1,00	0,155	16	−1,18	−1,18	−1,31	−1,43	−1,59	−1,72	−1,82	−2,12

For the heating period, the project reviews the potential for local discomfort effects, as required by the ISO standard, and determines that draft rate, vertical air distribution, and warm and cool floors are not likely. Radiant asymmetry was considered likely, however, so the team must perform additional calculations.

Radiant asymmetry was calculated to be 10°C from warm walls and 5°C from cool walls. Figure 4 from Section 6.5, ISO 7730–2005 provides the associated percentages dissatisfied, <2% and <1%, respectively. The team compares percentages dissatisfied with the local discomfort limits listed in ISO 7730–2005, Annex A, Table A.1 and sees that they are well below the 5% limit for Category B buildings.

Alternatively, the project could have compared the radiant temperature asymmetry with Annex A, Table A.4, which shows that for a Category B building, the radiant temperature asymmetry must be below 23°C for warm walls and below 10°C for cool walls.

Example 5. Thermal comfort controls

A project consists of a library that has private offices, open library space with reference desks, meeting rooms, and a children's storytime room. All spaces are regularly occupied. The project develops a table to summarize the controls for each space (Table 3).

TABLE 3. Summary table for Example 5

Space type	Occupancy	Spaces	Spaces with controls	Type of control
Private office	Individual occupant	16	12	Operable window
Reference desk	Individual occupant	6	2	Adjustable underfloor diffuser
Meeting rooms	Multioccupant	8	8	Thermostat
Storytime room	Multioccupant	2	2	Operable window
Percentage of individual occupant spaces with controls			**64% (=14/22)**	
Percentage of multioccupant spaces with controls			**100% (=10/10)**	

The project team earns the credit because the percentage of individual occupant spaces with controls is above 50% and all multioccupant spaces have controls.

Example 6. Warehouses and distribution centers

A warehouse and distribution center project has two regularly occupied areas: a warehouse storage space, and a distribution and loading dock. The project is using radiant heating, ceiling fans, and radiant flooring to condition the spaces.

To demonstrate compliance, the project compiles a table describing the conditioning systems (Table 4).

TABLE 4. Summary table for Example 6

Space type	Design strategy and conditioning system	System description
Warehouse storage	Radiant heating; ceiling fans	Gas-fired infrared heaters hung from ceiling (6 zones); variable-speed ceiling fans for air circulation; heater thermostat and fan speed controlled by occupants
Distribution and loading dock	Radiant flooring	Electric radiant concrete floor

With the radiant heating, ceiling fans, and radiant flooring design strategies, the project meets the thermal comfort design requirements for the building's bulk storage, sorting, and distribution areas.

RATING SYSTEM VARIATIONS

Warehouses and Distribution Centers

The thermal comfort design and thermal comfort control requirements are the same as those in *Step-by-Step Guidance* with the exception of regularly occupied bulk storage, sorting, and distribution areas. Design each of these areas to include one of the alternative systems noted in the credit requirements.

Healthcare

The thermal comfort design and thermal comfort control requirements are the same as those in *Step-by-Step Guidance* with the exception of patients' rooms. Each patient room must have an individual comfort control for each patient in the room.

Hospitality

The thermal comfort design and thermal comfort control requirements are the same as those in *Step-by-Step Guidance* with the exception of guest rooms, which are assumed to have individual thermal comfort controls and are therefore excluded from the controls requirements of this credit.

Retail
The thermal comfort design requirements are the same as those in *Step-by-Step Guidance*. The thermal comfort control requirements are the same as those in *Step-by-Step Guidance* but apply only to individual occupant spaces in office and administrative areas. All other spaces may be excluded.

Data Centers
The thermal comfort design and thermal comfort control requirements are the same as those in *Step-by-Step Guidance* but apply only to regularly occupied spaces, such as network operation centers, security offices, and administrative spaces. Spaces that are not regularly occupied, such as areas that house data center equipment and mechanical equipment, may be excluded.

PROJECT TYPE VARIATIONS

Gymnasiums, Fitness Areas, and Other Spaces with High Metabolic Rates
ASHRAE 55–2010, Normative Appendix A, permits use of a time-weighted average metabolic rate over a period of an hour or less. Any space with a rate of 2.0 MET or less must be addressed using standard compliance methods. Although the ASHRAE standard does not apply where the time-averaged metabolic rate is above 2.0 MET, thermal comfort in these spaces must still be addressed. For spaces with a rate above 2.0 MET, address how the project meets the intent of the credit.

ISO 7730–2005 addresses metabolic rates up to 4.0 MET.

Kitchens
Many kitchens are not conditioned, not cooled, or are only indirectly cooled and may have difficulties achieving the requirements of ASHRAE 55–2010 or ISO 7730–2005. For kitchens that cannot meet the requirements of these standards, address how the project meets the intent of the credit.

Apparatus Bays in Fire Stations
Typically, these spaces are not designed for human occupancy and thus would not have to meet the credit requirements. However, if these spaces are designed for human occupancy, the project must meet the thermal comfort criteria. The requirements for Warehouses and Distribution Centers may be applied to earn the credit.

Vehicle Repair Facilities
The requirements for Warehouses and Distribution Centers may be applied to earn the credit. This space type, which is not typically cooled, also includes military buildings where trucks, tanks, aircraft, and other vehicles are being serviced.

Natatoriums
Discuss with the owner how the natatorium will be used and the associated activity levels. Design the space to meet the thermal comfort design requirements in the ASHRAE HVAC Applications Handbook, 2011 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions. Calculate internal loads and rates of evaporation and verify that the design criteria will result in acceptable comfort. Retain all activity levels and factors, evaporation rates, and design calculations for credit documentation.

Residential
The thermal comfort design requirements are the same as those in *Step-by-Step Guidance*. The thermal comfort control requirements are the same as those in *Step-by-Step Guidance*, except the entire residential unit only needs one thermal comfort control.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Thermal comfort design		Thermal comfort controls	Warehouses and distribution centers only
	Option 1	Option 2		
Description of weather data used to determine operative temperatures, relative humidity, outdoor temperatures	X			
Plots or calculation results verifying that design parameters meet ASHRAE Standard 55–2010 for 80% acceptability (e.g., psychometric chart; PMV or PPD calculations; ASHRAE Thermal Comfort Tool results; copy of ASHRAE 55–2010, Figure 5.2.4.1, Figure 5.2.4.3, or Figure 5.2.4.4; or predicted worst-case indoor conditions for each month on copy of Figure 5.3)	X			
Documentation to verify thermally conditioned spaces meet ISO 7730 or EN 15251, as applicable (e.g., for ISO, calculations based on Sections 4.1 and 6 or Annex H, computer program results based on Annex D, tables based on Annex E, or copy of Figures 2, 3, 4, A.1, A.2; for EN, documentation of worst-case indoor conditions for each month on copy of Figure A1)		X		
List of spaces by type, quantity, and controls			X	
List of regularly occupied bulk storage, sorting, and distribution areas				X
Narrative describing design strategy used in each space				X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. Any plug-in devices that are claimed as thermal controls must be included in Option 1 of the related prerequisite.

EQ Prerequisite Minimum Indoor Air Quality Performance. The requirements for natural conditioning (ASHRAE 55–2010) are different from those for natural ventilation (ASHRAE 62.1–2010). The former standard does not specify a minimum window size or any location or proximity requirements. The latter specifies minimum window or ventilation opening area as well as maximum distance from the ventilation opening that may be considered naturally ventilated. Refer to ASHRAE 62.1–2010, Section 6.4, for additional information. Adjustable diffusers used to provide thermal control (whether floor, wall, or ceiling mounted) can affect the supply air flow of ventilation and should be coordinated with the ventilation design under the related prerequisite.

EQ Credit Enhanced Indoor Air Quality Strategies. Natural ventilation and mixed mode systems must meet additional requirements of CISBE AM10 and AM13 to earn the related credit.

EQ Credit Interior Lighting. The quantity of individual occupant spaces and shared multioccupant spaces for this credit must be consistent with the quantity in the related credit.

CHANGES FROM LEED 2009

- This thermal comfort credit combines the LEED 2009 credits Controllability of Systems: Thermal Comfort (IEQ Credit 6.2, IEQ Credit 6) and Thermal Comfort: Design (IEQ Credit 7.1, IEQ Credit 7) into a single credit.
- The referenced standard has been updated to ASHRAE 55–2010. Refer to *ASHRAE Journal* (June 2011) for an explanation of changes from the 2004 version of the standard: ashrae.org/resources--publications/periodicals/ashrae-journal/.
- International standards have been included to provide more relevant compliance options for non-U.S. projects.

- The requirements for natatoriums are now applicable to all rating systems.
- New compliance paths have been established for data centers and warehouses.

REFERENCED STANDARDS

ASHRAE Standard 55–2010, Thermal Environmental Conditions for Human Occupancy: ashrae.org

ASHRAE HVAC Applications Handbook, 2011 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions: ashrae.org

ISO 7730–2005 Ergonomics of the thermal environment, Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria: iso.org

EuropeanStandard EN 15251: 2007, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics: cen.eu

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

individual occupant space an area where an occupant performs distinct tasks. Individual occupant spaces may be within multioccupant spaces and should be treated separately where possible.

nonregularly occupied space an area that people pass through or an area used for focused activities an average of less than one hour per person per day. The one-hour timeframe is continuous and should be based on the time a typical occupant uses the space. For spaces that are not used daily, the one-hour timeframe should be based on the time a typical occupant spends in the space when it is in use.

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

regularly occupied space an area where one or more individuals normally spend time (more than one hour per person per day on average) seated or standing as they work, study, or perform other focused activities inside a building. The one-hour timeframe is continuous and should be based on the time a typical occupant uses the space. For spaces that are not used daily, the one-hour timeframe should be based on the time a typical occupant spends in the space when it is in use.

unoccupied space an area designed for equipment, machinery, or storage rather than for human activities. An equipment area is considered unoccupied only if retrieval of equipment is occasional.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Interior Lighting

This credit applies to:

New Construction (1–2 points)
Schools (1–2 points)
Retail (2 points)
Data Centers (1–2 points)
Warehouses and Distribution Centers (1–2 points)
Hospitality (1–2 points)
Healthcare (1 point)

INTENT

To promote occupants' productivity, comfort, and well-being by providing high-quality lighting.

REQUIREMENTS

NEW CONSTRUCTION, SCHOOLS, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

Select one or both of the following two options.

OPTION 1. LIGHTING CONTROL (1 POINT)

For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences, with at least three lighting levels or scenes (on, off, midlevel). Midlevel is 30% to 70% of the maximum illumination level (not including daylight contributions).

For all shared multioccupant spaces, meet all of the following requirements.

- Have in place multizone control systems that enable occupants to adjust the lighting to meet group needs and preferences, with at least three lighting levels or scenes (on, off, midlevel).
- Lighting for any presentation or projection wall must be separately controlled.
- Switches or manual controls must be located in the same space as the controlled luminaires. A person operating the controls must have a direct line of sight to the controlled luminaires.

HOSPITALITY ONLY

Guest rooms are assumed to provide adequate lighting controls and are therefore not included in the credit calculations.

AND/OR

OPTION 2. LIGHTING QUALITY (1 POINT)

Choose four of the following strategies.

A. For all regularly occupied spaces, use light fixtures with a luminance of less than 2,500 cd/m^2 between 45 and 90 degrees from nadir.
Exceptions include wallwash fixtures properly aimed at walls, as specified by manufacturer's data, indirect uplighting fixtures, provided there is no view down into these uplights from a regularly occupied space above, and any other specific applications (i.e. adjustable fixtures).

B. For the entire project, use light sources with a CRI of 80 or higher. Exceptions include lamps or fixtures specifically designed to provide colored lighting for effect, site lighting, or other special use.

C. For at least 75% of the total connected lighting load, use light sources that have a rated life (or L70 for LED sources) of at least 24,000 hours (at 3-hour per start, if applicable).

D. Use direct-only overhead lighting for 25% or less of the total connected lighting load for all regularly occupied spaces.

E. For at least 90% of the regularly occupied floor area, meet or exceed the following thresholds for area-weighted average surface reflectance: 85% for ceilings, 60% for walls, and 25% for floors.

F. If furniture is included in the scope of work, select furniture finishes to meet or exceed the following thresholds for area-weighted average surface reflectance: 45% for work surfaces, and 50% for movable partitions.

G. For at least 75% of the regularly occupied floor area, meet a ratio of average wall surface illuminance (excluding fenestration) to average work plane (or surface, if defined) illuminance that does not exceed 1:10. Must also meet strategy E, strategy F, or demonstrate area-weighted surface reflectance of at least 60% for walls.

H. For at least 75% of the regularly occupied floor area, meet a ratio of average ceiling illuminance (excluding fenestration) to work surface illuminance that does not exceed 1:10. Must also meet strategy E, strategy F, or demonstrate area-weighted surface reflectance of at least 85% for ceilings.

RETAIL

For at least 90% of the individual occupant spaces in office and administrative areas, provide individual lighting controls.

In sales areas, provide controls that can reduce the ambient light levels to a midlevel (30% to 70% of the maximum illumination level not including daylight contributions).

HEALTHCARE

Provide individual lighting controls for at least 90% of individual occupant spaces in staff areas.

For at least 90% of patient positions, provide lighting controls that are readily accessible from the patient's bed. In multioccupant patient spaces, the controls must be individual lighting controls. In private rooms, also provide exterior window shades, blinds, or curtain controls that are readily accessible from the patient's bed. Exceptions include in-patient critical care, pediatric, and psychiatric patient rooms.

For all shared multioccupant spaces, provide multizone control systems that enable occupants to adjust the lighting to meet group needs and preferences, with at least three lighting levels or scenes (on, off, midlevel). Midlevel is 30% to 70% of the maximum illumination level (not including daylight contributions).

BEHIND THE INTENT

Studies of lighting in buildings have shown that workers are more comfortable and productive in an environment that is carefully illuminated and where lighting controls are provided for individual and group needs.[1] Also, high-quality lighting helps eliminate distractions, creates visual interest and a sense of place, supports interaction and communication, contributes to occupants' well-being, and reduces health problems.[2] This credit rewards lighting quality that dramatically improves occupants' comfort and productivity.[3]

The credit encourages lighting quality in multiple ways.

- Minimizing light fixture luminance (strategy A) helps reduce disability and discomfort glare; the threshold, 2,500 candela per square meter, was selected because research by the Light Right Consortium found that above that level, glare became objectionable.
- Using light sources with a color rendering index above 80 (strategy B) helps approximate natural light.
- Using light sources with long lamp life (strategy C) can lengthen the period over which the integrity of the lighting design is maintained; it also reduces maintenance costs and lowers material and resource inputs. A lamp life of 24,000 hours promotes the use of longer-life fluorescents.
- Designing spaces with less direct-only overhead lighting (strategy D) helps minimize glare, reduces the perceived brightness of the direct luminaires, and reduces contrast between ceiling and luminaire.
- Specifying surfaces with high reflectance (strategies E and F) helps make the space brighter through reflection, minimizing the difficulty of viewing light documents on dark surfaces; the specific surface reflectance values for ceilings, walls, and floors are above the standard industry assumptions of 80, 50, and 20, respectively, as recommended in the latest edition of the Illuminating Engineering Society (IES) *Lighting Handbook*.[4]
- Designing for an illuminance ratio less than 1:10 (strategies G and H) minimizes the amount of contrast that occupants experience between their work surface and the ceiling and wall surfaces around them; the 1:10 illuminance ratio represents one log scale difference in lighting levels (human eyes are logarithmic, but illuminance is linear).

Research on lighting and visual performance is cited in *Further Explanation, Additional Lighting Resources.*

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH LIGHTING NEEDS

Work with the owner to understand occupants' lighting needs and desires.

- Document the types of tasks that will occur in each space and the tools and equipment that occupants will use regularly, and determine appropriate light levels for tasks.
- Identify the level of control that occupants should have and the characteristics of the occupant population.

STEP 2. SELECT OPTION(S)

Determine which option(s) are appropriate for the project. All projects except Healthcare and Retail may earn one or both options.

- Option 1 requires lighting controls for 90% of the individual occupant spaces and 100% of shared, multioccupant spaces. Standard on-off switches are not acceptable; at least three lighting levels or scenes must be provided. Project teams that are familiar with previous versions of LEED may prefer

1. *Lighting Quality and Office Work: A Field Simulation Study, lrc.rpi.edu/researchAreas/pdf/LRAlbanyStudyReport.pdf (accessed June 11, 2013).*
2. *Federal Lighting Guide, eere.energy.gov/femp/pdfs/light_controls.pdf (accessed June 11, 2013).*
3. *Veitch, J.A., et al., "Lighting Appraisal, Well-Being, and Performance in Open-Plan Offices: A Linked Mechanisms Approach," Lighting Research and Technology 40(2) (June 2008): 133-151.*
4. *DiLaura, David, Kevin Houser, Richard Mistrick, and Gary Steff, eds., The Lighting Handbook, 10th edition (New York: Illuminating Engineering Society of North America, 2011).*

this option, and it is easier to implement in later phases of design than Option 2.

- Option 2 offers eight strategies (Table 1), of which four must be implemented to meet the requirements. Strategies A–D are based on characteristics of the lighting fixtures, light sources, and luminaires. Strategies E–H are based on characteristics of the surfaces in the project and the illuminance levels that fall on those surfaces. This option requires attention during early design phases because achievement depends on luminaire selection and configuration and architectural surface specifications.

For the different requirements for Healthcare and Retail projects, see *Further Explanation, Rating System Variations.*

TABLE 1. Strategies for Option 2, Lighting Quality

Strategy	Scope	Exceptions, exclusions
A. Light fixture luminance	All light fixtures located in regularly occupied spaces	• Wallwash fixtures properly aimed at walls, as specified by manufacturer • Indirect uplighting fixtures, provided there is no view down into these uplights from a regularly occupied space above • Any other specific applications (e.g., adjustable fixtures)
B. Color rendering index (CRI)	All light fixtures	• Lamps or fixtures specifically designed to provide colored lighting for effect • Site lighting • Any other special use
C. Lamp life	75% connected lighting load	—
D. Direct overhead lighting	25% connected lighting load for regularly occupied spaces.	—
E. Surface reflectance: ceilings, walls, floors	90% of regularly occupied floor area	—
F. Surface reflectance: furnishings	All furniture used for work surfaces	—
G. Surface illuminance ratio: wall to work surface	75% regularly occupied floor area	—
H. Surface illuminance ratio: ceiling to work surface	75% regularly occupied floor area	—

STEP 3. COMPLY WITH OPTION REQUIREMENTS

For the option(s) selected, follow the appropriate set of steps to confirm compliance.

Option 1. Lighting Control

Identify all individual occupant and shared, multioccupant spaces in the project (see *EQ Overview*).

- Design lighting controls for individual and multioccupant spaces to meet the credit requirements. Task lighting may be used to meet the credit requirements for individual occupant spaces. Task lights are not required to be hardwired.
- All lighting controls must provide at least three lighting levels or scenes: including on, off, and a midlevel, defined as 30% to 70% of the maximum illumination level (not including daylight contributions). Daylight does not qualify as a separate lighting level.
- For multioccupant spaces that can be subdivided by movable walls or partitions, provide the required lighting controls for each subdivision of the space.
- Tabulate all individual and multioccupant spaces and their respective lighting controls. Confirm that at least 90% of individual occupant spaces and 100% of multioccupant spaces meet the credit requirements. The percentage of compliant individual occupant spaces is based on the number of spaces, not floor area.

Option 2. Lighting Quality

Option 2. Lighting Quality, Strategy A

Identify all regularly occupied spaces in the project and all light fixtures in these spaces (see *EQ Overview*). The following fixtures may be excluded:

- Wallwash fixtures properly aimed at walls, as specified by manufacturer's data
- Indirect uplighting fixtures, provided there is no view down into these uplights from a regularly occupied space above
- Any other specific applications (e.g., adjustable fixtures)

For the light fixtures, review luminaires cutsheets, Illuminating Engineering Society photometric files, or other documentation to identify luminance between 45 degrees and 90 degrees from nadir and select products that meet the credit requirements. The luminance must be below 2,500 candela per square meter.

Compile documentation that confirms compliance with the credit requirements for luminance.

Option 2. Lighting Quality, Strategy B

Specify all light sources to meet the credit requirements for color rendering index (CRI).

- The following light sources may be excluded: lamps or fixtures specifically designed to provide colored lighting for effect, site lighting, and lamps or fixtures designed for some other special use.
- For the light sources, determine the CRI, not to be confused with correlated color temperature (CCT), which refers to the spectrum of warm to cool. A light source can have a high or low CRI regardless of its CCT.
- Compile documentation that confirms compliance with the credit requirements for the lighting's CRI.

Option 2. Lighting Quality, Strategy C

Specify all light sources to meet the credit requirements for lamp life.

- Calculate the total connected lighting load for all lighting in the project, in watts or kilowatts. Refer to the lighting power calculations prepared for EA Prerequisite Minimum Energy Performance and tabulate luminaire quantities and wattages to determine the total connected load. For guidance on determining connected lighting load, see ASHRAE 90.1–2010, Sections 9.1.3 and 9.1.4. Plug-in lighting is included in the calculation for connected load.
- For lamp life, review luminaire cutsheets or other documentation. Lamp life depends on the type of source. For traditional light sources, the lamp life is based on the time at which 50% of the test samples have burned out. For LED light sources, the lamp life criterion L70 is based on the time at which the light source has a 30% reduction in light output. Review the IES *Lighting Handbook* for more information on lamp life.
- Calculate the amount of connected lighting load with compliant light source; it must be 75% or greater.
- Compile documentation that confirms compliance with the credit requirements for lamp life.

Option 2. Lighting Quality, Strategy D

Specify a combination of direct-only overhead lighting and other lighting. Minimize the use of direct-only overhead lighting to meet the credit requirements for strategy D.

- Identify all regularly occupied spaces in the project and the total connected lighting load associated with these spaces (see *EQ Overview*). Refer to the lighting power calculations prepared for EA Prerequisite Minimum Energy Performance and tabulate luminaire quantities and wattages to determine the total connected load. For guidance on determining connected lighting load, see ASHRAE 90.1–2010, Sections 9.1.3 and 9.1.4. Plug-in lighting is included in the calculation for connected load.
- Determine the connected lighting load that is associated with direct-only overhead lighting; it must be 25% or less.
- Compile documentation that confirms compliance with the credit requirements for overhead lighting.

Option 2. Surface Reflectance, Strategies E and F

Select or specify high-reflectance finish materials as applicable to the strategy pursued: ceilings, walls, and floors for strategy E, and work surfaces and movable partitions for strategy F.

- Before construction begins, review manufacturers' cutsheets to identify reflectance, typically expressed as a fraction or percentage LR (light reflectance) or LRV (light reflectance value). If manufacturers' data do not include reflectance, measure the reflectance of product samples (before construction) or the installed product (postconstruction) using the methodology described in IES *Lighting Handbook*, Section 9.12.2, Measuring Reflectance and Transmittance. Or use reflectance charts, such as Lighting Guide 11, Surface Reflectance and Colour.[5]
- For strategy E, 10% of the regularly occupied floor area may be excluded.
- For strategy F, work surfaces include desk and table surfaces where individuals perform tasks. The surface area for movable partitions is limited to opaque surfaces of the partition; transparent or partially transparent surfaces are not included in the calculation.
- Use Equation 1 to calculate the average surface reflectance for walls, ceilings, and floors (strategy E) and work surfaces and movable partitions (strategy F).

EQUATION 1. Average surface reflectance

$$\text{Weighted average of surface reflectances} = \left\{ \frac{\left(\text{reflectance of surface 1} \times \text{surface area of surface 1}\right) + \left(\text{reflectance of surface 2} \times \text{surface area of surface 2}\right) + \ldots + \left(\text{reflectance of surface n and surface area of surface n}\right)}{\text{total surface area}} \right\}$$

- Confirm that the average surface reflectance of the specified surfaces meets or exceeds the values in the credit requirements.

Option 2. Illuminance, Strategies G and H

Develop a lighting design strategy to minimize the ratio of wall surface illuminance (strategy G) or ceiling surface illuminance (strategy H) to work surface illuminance. Consider the following design strategies:

- Specify ceiling and wall finishes that are light colored or have high surface reflectance.
- Design the lighting system to intentionally light the walls or ceiling.
- Consider luminaires that throw 20% to 30% of light on ceiling or wall, such as direct-indirect lighting.
- Arrange luminaires to provide wall wash.

Use lighting calculation software or measurements to determine the average illuminance levels on work, wall, and ceiling surfaces for each regularly occupied space. If illuminance values vary widely throughout the space, either subdivide or use the predominant illuminance level. Work surfaces include desks or other table surfaces where individuals perform tasks. Where work surfaces are not specified, calculate the illuminance at a height of 30 inches (750 millimeters) above the finished floor. Alternatively, calculate illuminance at the height where most visual tasks are expected to be performed. For existing building projects or after construction is complete, the illuminance may be measured. The illuminance of a given surface is measured with a light meter, with the sensor facing away from the surface for which the measurement is being taken.

Use Equation 2 (for Strategy G) and Equation 3 (for Strategy H) to calculate an illuminance ratio for each regularly occupied space. Determine the percentage of regularly occupied area that achieves an illuminance ratio of 1:10 or less, it must be at least 75%.

EQUATION 2. Wall to work plane illuminance ratio

$$\text{Illuminance ratio} = 1: \left\{ \frac{\text{average work surface illuminance}}{\text{average wall surface illuminance}} \right\}$$

EQUATION 3. Ceiling to work plane illuminance ratio

$$\text{Illuminance ratio} = 1: \left\{ \frac{\text{average work surface illuminance}}{\text{average ceiling illuminance}} \right\}$$

5. *cibseknowledgeportal.co.uk (accessed June 11, 2013).*

Spaces where similar ratios of wall surface or ceiling surface illuminance to work surface illuminance are expected can be assessed through a single representative calculation.

Compile documentation that confirms compliance with the credit requirements for illuminance, As applicable, include confirmation that one of the following has also been met: strategy E, strategy F, area-weighted surface reflectances of at least 60% for walls, or area-weighted surface reflectances of at least 85% for ceilings.

FURTHER EXPLANATION

CALCULATIONS

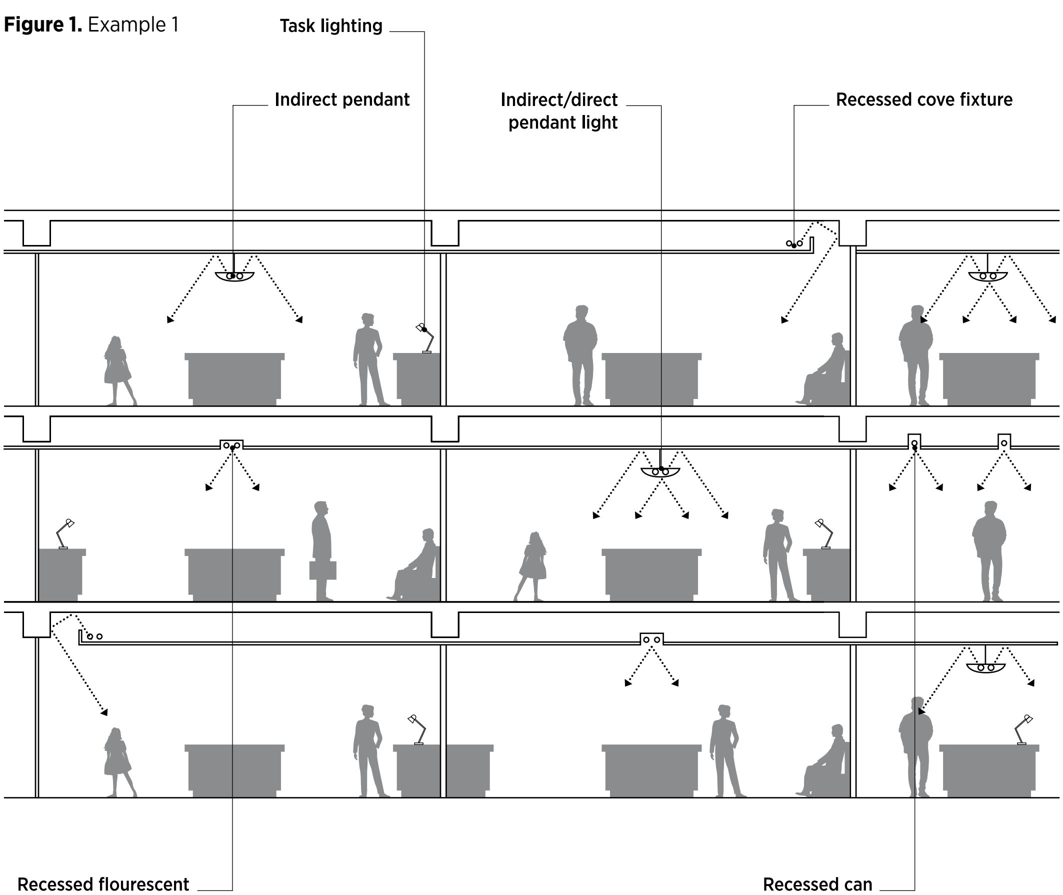
See calculations in *Step-by-Step Guidance*.

EXAMPLES

Example 1. Option 1

An office has individual occupant spaces (workstations), private offices, and a conference room. The workstations have task lighting that is part of the furniture system; the control allows for four distinct light levels. The private offices have overhead lighting with manual dimming controls. The conference room can be divided into two spaces, each with its own set of manual controls for overhead lighting. The overhead lighting is divided into two separate zones and is also fully dimmable. There are separate controls for lighting the presentation wall. Because this office has the appropriate lighting controls for at least 90% of the individual occupant spaces and all shared, multioccupant spaces, the project earns 1 point under Option 1 of the credit.

Figure 1. Example 1



Example 2. Option 2, lighting quality, strategies A and D

The data for all luminaires specified in the project building's regularly occupied spaces are summarized in Table 2.

For strategy A, two luminaire types (indirect pendant and indirect-direct pendant) are excluded because there is no view of these luminaires from above. There is one luminaire type that does not meet the requirement, the surface-mounted luminaires. For this reason, the project does not achieve strategy A.

For strategy D, there are two direct-only overhead lights: recessed and surface mounted. The percentage of connected lighting load attributed to these lights is 5.7 % which is well below the 25% threshold. For this reason, the project achieves strategy D.

TABLE 2. Luminaire information for Example 2

Description	Connected load per luminaire (W)	Luminaires	Total connected load (W)	Luminance <2,500 cd/m^2 between 45° and 90° from nadir (Y/N)	Excluded from strategy A	Direct-only?
Indirect pendant	112	8	896	N	Y	N
Recessed	56	4	224	Y	N	Y
Surface mounted	32	1	32	N	N	Y
Indirect-direct pendant	168	20	3,360	N	Y	N
Total connected lighting load (W): 4,512						
Percentage of connected lighting load that is direct-only: 5.7% (256 W)						

Example 3. Option 2, lighting quality, strategies B and C

Data for all light sources in the building are summarized in Table 3.

For strategy B, all three light sources have a CRI above 80. For this reason, the project achieves strategy B.

For strategy C, the lamp life for the linear fluorescent T8 and linear LED cove light both meet the lamp life requirement of 24,000 hours or more rated life or L70. The percentage of connected lighting load attributed to the light fixtures with these lamps is 96.2 % which is well above the 75% threshold. For this reason, the project achieves strategy C.

TABLE 3. Example 3 Light source information

Light source description	Total connected load for fixtures (W)	CRI	Lamp life (hours)
Linear fluorescent T8	5,320	82	26,000
Halogen	250	99	5,000
Linear LED cove light	1,000	81	L70
Total connected load (W): 6,570			
Percentage of connected lighting load that meets lamp life requirement: 96.2% (6,320 W)			

Example 4. Option 2, lighting quality, strategies E and F (surface reflectance)

The values of the reflectance for the ceilings, walls, floors, work surfaces, and partitions were determined. The results are summarized in Figure 2 below.

Figure 2. Supplemental calculator

Surface Information		Surface Reflectance for Ceilings, Walls, Floors			Surface Reflectance for Furnishings	
Description of Surface	Reflectance (%)	Pctg. total regularly occupied floor area included below (%)		100%	Work Surface Area (sq ft)	Moveable Partition Area (sq ft)
		Ceiling Area (sq ft)	Wall Area (sq ft)	Floor Area (sq ft)		
high reflectance ceiling	90.00%	26786.00				
generic ceiling	80.00%	216.00				
wall type 1	65.00%		7312.00			
wall type 2	55.00%		500.00			
light wood floor	27.00%			500.00		
dark carpet	12.00%			216.00		
light carpet	25.00%			26286.00		
workstation type 1	60.00%				2000.00	
workstation type 2	50.00%				20.00	
workstation type 3	10.00%				500.00	
partition type 1	50.00%					80.00
partition type 2	55.00%					40.00
Total area incl. in calculation		**27002.00**	**7812.00**	**27002.00**	**2520.00**	**120.00**
E. Surface Reflectance for Ceilings, Walls, Floors	Average surface reflectance for ceilings					90%
	Average surface reflectance for walls					64%
	Average surface reflectance for floors					25%
F. Surface Reflectance for Furnishings	Average surface reflectance for work surfaces					50%
	Average surface reflectance for moveable partitions					52%

E. Ceilings calculation: (90% × 26786 sq ft + 80% × 216 sq ft) ÷ 27002 sq ft = 90%
E. Walls calculation: (65% × 7312 sq ft + 55% × 500 sq ft) ÷ 7812 sq ft = 64%
E. Floors calculation: (27% × 500 sq ft + 12% × 216 sq ft + 25% × 26286 sq ft) ÷ 27002 sq ft = 25%
F. Work surfaces calculation: (60% × 2000 sq ft + 50% × 20 sq ft + 10% × 500 sq ft) ÷ 2520 sq ft = 50%
F. Moveable partitions calculation: (50% × 80 sq ft + 55% × 40 sq ft) ÷ 120 sq ft = 52%

Example 5. Option 2, lighting quality, strategies G and H (illuminance)

The project's lighting designer has used lighting calculation software to determine the average illuminance levels for wall, ceiling, and work surfaces and compiled (Table 4). Private office 2 was excluded from the calculation because the office has low wall and ceiling illuminance values.

The project team wishes to use strategies G and H. The wall to work surface illuminance ratio exceeds 1:10 in the open office, which constitutes the majority of the floor area in the project, so the project does not attain strategy G.

However, the ceiling to work surface illuminance ratio is below 1:10 for the open office, private office 1, and the conference room. The project has also achieved strategy E, so the project complies with strategy H.

TABLE 4. Illuminance information for Example 5						
Space	Floor area (ft^2)	Average illuminance (footcandles)			Illuminance ratio	
		Work surface	Wall	Ceiling	Wall to work surface	Ceiling to work surface
Open office	26,284	80 (861 lux)	7 (75 lux)	20 (214 lux)	1:11.4	1:4
Private office 1	96	75 (807 lux)	10 (107 lux)	25 (267 lux)	1:7.5	1:3
Conference room	500	60 (642 lux)	10 (107 lux)	15 (160 lux)	1:6	1:4
Private office 2	120	n/a	n/a	n/a	n/a	n/a
Total regularly occupied floor area (ft^2): 27,000						
Percentage of regularly occupied floor area that meets wall to work surface illuminance ratio of 1:10 or less (must be 75%): 2.2% (596 ft^2)						
Percentage of regularly occupied floor area that meets ceiling to work surface illuminance ratio of 1:10 or less (must be 75%): 99.6% (26,880 ft^2)						

ADDITIONAL LIGHTING RESOURCES

Studies of the effect of lighting on visual performance and comfort can be found in the following sources:

Peter R. Boyce, *Human Factors in Lighting*, 2nd edition (Taylor and Francis, 2003).

Lighting and Human Performance II (available at no cost from EPRI): my.epri.com/portal/server.pt?

Lighting Guide 11: Surface Reflectance and Colour: cibseknowledgeportal.co.uk/

Lighting Research Center, Rensselaer Polytechnic Institute: lrc.rpi.edu/

National Research Council Canada Institute for Research in Construction: nrc-cnrc.gc.ca/eng/rd/construction/

J.A. Veitch, "Psychological Processes Influencing Lighting Quality," *Journal of the Illuminating Engineering Society* 30(1) (2001): 124–40.

The Lighting Handbook, 10th edition, Illuminating Engineering Society of North America (2011).

RATING SYSTEM VARIATIONS

Healthcare

Follow the steps for Option 1 for individual occupant spaces in staff areas and for all shared multioccupant spaces.

Identify all patient positions in the project, and classify whether each is in a private room (see *Definitions* and exclude in-patient critical care, pediatric, and psychiatric patient rooms).

- Design the individual lighting controls. Task lighting may be used and is not required to be hardwired.
- If the position is in a private room, provide exterior window shades, blinds, or curtain controls that are readily accessible from the patient's bed.
- Tabulate all positions and their respective lighting controls. Confirm that at least 90% of patient positions meet the credit requirements. The percentage of compliant positions is based on the number of spaces, not floor area.

Retail

Follow the step-by-step guidance for Option 1 for office and administration areas. In addition, provide at least three lighting levels: on, off, and a midlevel in sales areas.

Hospitality

Option 1. Lighting Control Exclude guest rooms from lighting control calculations.

PROJECT TYPE VARIATIONS

Residential

For Option 1, residential units must have one lighting control for each individual occupant and multioccupant space. For example, a bedroom is listed as individual occupancy. A task light in the bedroom or an overhead light with manual dimmable control would be acceptable. See *EQ Overview* for a detailed list of individual and multioccupant space types in residential buildings.

CAMPUS

Group Approach

All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2							
		A	B	C	D	E	F	G	H
Table of individual occupant and multioccupant spaces and lighting controls in each space	x								
Table of regularly occupied spaces and associated lighting details		x			x				
Calculations of total connected lighting load				x	x				
Lighting details, including manufacturer and model, results of estimations, or in situ or laboratory photometric tests		x	x	x	x				
List of ceiling, wall, and floor surfaces and their associated surface reflectance values						x			
List of work surfaces and movable partitions and their associated surface reflectance values							x		
Average surface reflectance calculations						x	x		
List of work surfaces and illuminance values (lux)								x	
List of wall or ceiling surfaces with illuminance values (lux)									x
Illuminance ratio calculations								x	x

RELATED CREDIT TIPS

EQ Credit Thermal Comfort. Individual and multioccupant spaces for this credit must be consistently with those for the related credit.

EA Prerequisite Fundamental Commissioning and Verification and EA Credit Enhanced Commissioning. All lighting controls must be included in the commissioning process.

CHANGES FROM LEED 2009

- An additional point and option for lighting quality have been added.
- The requirements for lighting control have been revised to require at least three lighting levels: on, off, and a midlevel.

REFERENCED STANDARDS

The Lighting Handbook, 10th edition, Illuminating Engineering Society of North America: ies.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

color rendering index a measurement from 0 to 100 that indicates how accurately an artificial light source, as compared with an incandescent light, displays hues. The higher the index number, the more accurately the light is rendering colors. Incandescent lighting has a color rendering index above 95; standard high-pressure sodium lighting (such as orange-hued roadway lights) measures approximately 25; many fluorescent sources using rare earth phosphors have a color rendering index of 80 and above. (Adapted from U.S. ENERGY STAR)

illuminance the incident luminous flux density on a differential element of surface located at a point and oriented in a particular direction, expressed in lumens per unit area. Since the area involved is differential, it is customary to refer to this as illuminance at a point. The unit name depends on the unit of measurement for area: footcandles if square feet are used for area, and lux if square meters are used. (Adapted from Illuminating Engineering Society) In lay terms, illuminance is a measurement of light striking a surface. It is expressed in footcandles in the U.S. (based on square feet) and in lux in most other countries (based on square meters).

individual occupant space an area where an occupant performs distinct tasks. Individual occupant spaces may be within multioccupant spaces and should be treated separately where possible.

shared multioccupant space a place of congregation, or where occupants pursue overlapping or collaborative tasks

patient position a patient bed, infusion chair, recovery room bay, or other location where a patient receives clinical care

INDOOR ENVIRONMENTAL QUALITY CREDIT

Daylight

This credit applies to:

New Construction (1–3 points)
Core and Shell (1–3 points)
Schools (1–3 points)
Retail (1–3 points)
Data Centers (1–3 points)
Warehouses and Distribution Centers (1–3 points)
Hospitality (1–3 points)
Healthcare (1–2 points)

INTENT

To connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.

REQUIREMENTS

Provide manual or automatic (with manual override) glare-control devices for all regularly occupied spaces.

Select one of the following three options.

OPTION 1. SIMULATION: SPATIAL DAYLIGHT AUTONOMY AND ANNUAL SUNLIGHT EXPOSURE (2–3 POINTS, 1-2 POINTS HEALTHCARE)

Demonstrate through annual computer simulations that spatial daylight autonomy$_{300/50\%}$ (sDA$_{300/50\%}$) of at least 55%, 75%, or 90% is achieved. Use regularly occupied floor area. Healthcare projects should use the perimeter area determined under EQ Credit Quality Views. Points are awarded according to Table 1.

TABLE 1. Points for daylit floor area: Spatial daylight autonomy

New Construction, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality		Healthcare	
sDA (for regularly occupied floor area)	Points	sDA (for perimeter floor area)	Points
55%	2	75%	1
75%	3	90%	2

AND

Demonstrate through annual computer simulations that annual sunlight exposure1000,250 (ASE1000,250) of no more than 10% is achieved. Use the regularly occupied floor area that is daylit per the sDA300/50% simulations.

The sDA and ASE calculation grids should be no more than 2 feet (600 millimeters) square and laid out across the regularly occupied area at a work plane height of 30 inches (760 millimeters) above finished floor (unless otherwise defined). Use an hourly time-step analysis based on typical meteorological year data, or an equivalent, for the nearest available weather station. Include any permanent interior obstructions. Moveable furniture and partitions may be excluded.

CORE AND SHELL ONLY

If the finishes in the space will not be completed, use the following default surface reflectances: 80% for ceilings, 20% for floors, and 50% for walls. Assume that the entire floor plate, except for the core, will be regularly occupied space.

OR

OPTION 2. SIMULATION: ILLUMINANCE CALCULATIONS (1–2 POINTS)

Demonstrate through computer modeling that illuminance levels will be between 300 lux and 3,000 lux for 9 a.m. and 3 p.m., both on a clear-sky day at the equinox, for the floor area indicated in Table 2. Use regularly occupied floor area. Healthcare projects should use the perimeter area determined under EQ Credit Quality Views.

TABLE 2. Points for daylit floor area: Illuminance calculation

New Construction, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality		Healthcare	
Percentage of regularly occupied floor area	Points	Percentage of perimeter floor area	Points
75%	1	75%	1
90%	2	90%	2

Calculate illuminance intensity for sun (direct component) and sky (diffuse component) for clear-sky conditions as follows:

- Use typical meteorological year data, or an equivalent, for the nearest available weather station.
- Select one day within 15 days of September 21 and one day within 15 days of March 21 that represent the clearest sky condition.
- Use the average of the hourly value for the two selected days.

Exclude blinds or shades from the model. Include any permanent interior obstructions. Moveable furniture and partitions may be excluded.

CORE AND SHELL ONLY

Assume the following default surface reflectances if the finishes in the space will not be completed: 80% for ceilings, 20% for floors, and 50% for walls. Assume that the entire floor plate, except for the core, will be regularly occupied space.

OR

OPTION 3. MEASUREMENT (2-3 POINTS, 1-2 POINTS HEALTHCARE)

Achieve illuminance levels between 300 lux and 3,000 lux for the floor area indicated in Table 3.

TABLE 3. Points for daylit floor area: Measurement

New Construction, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality		Healthcare	
Percentage of regularly occupied floor area	**Points**	**Percentage of perimeter floor area**	
75	2	75	1
90	3	90	2

With furniture, fixtures, and equipment in place, measure illuminance levels as follows:

- Measure at appropriate work plane height during any hour between 9 a.m. and 3 p.m.
- Take one measurement in any regularly occupied month, and take a second as indicated in Table 4.
- For spaces larger than 150 square feet (14 square meters), take measurements on a maximum 10 foot (3 meter) square grid.
- For spaces 150 square feet (14 square meters) or smaller, take measurements on a maximum 3 foot (900 millimeters) square grid.

TABLE 4. Timing of measurements for illuminance

If first measurement is taken in ...	take second measurement in ...
January	May-September
February	June-October
March	June-July, November-December
April	August-December
May	September-January
June	October-February
July	November-March
August	December-April
September	December-January, May-June
October	February-June
November	March-July
December	April-August

BEHIND THE INTENT

Increased access to daylight has positive human behavioral and health effects because it reinforces our circadian rhythms.[1] Access to sufficient daylight has been shown to increase healing times in hospitals, improve students' performance,[2] increase productivity in the workplace,[3] fight depression and lethargy, and even increase sales in retail environments.[4] A well-designed daylit building also uses less electric lighting energy, conserving natural resources and reducing air pollution.

This credit has evolved significantly and now focuses on using simulated daylight analysis and actual measurement to estimate daylight quality and daylight levels. These methods more accurately predict daylight access and support the design process for optimizing daylight. The previous prescriptive method for calculating daylight using window design less accurately accounted for such project-specific factors as building orientation, exterior conditions, the interaction with interior finishes, time of day and year, and other performance variables. The new simulation requirements use global metrics and performance values for daylight established by daylighting professionals. Other globally recognized standards-setting organizations are using the credit's language, metric conversions, and performance goals to create consistency in the daylighting and building professions.

Projects have three compliance options. The options that require more detailed design input and analysis or that demonstrate actual performance earn a correspondingly higher number of points. A good computer simulation is the best way to inform the design phase and help create a more effective daylit project. Project teams should integrate daylight concerns into the design process while taking into account such factors as heat gain and loss, glare control, visual quality, and variations in daylight availability.

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH DESIGN CRITERIA

During predesign, work with the owner to understand lighting and daylighting goals. Specify daylighting performance criteria in the owner's project requirements.

STEP 2. CONSIDER SITE AND MASSING

During schematic design, determine how best to orient the building to allow for passive solar strategies, and explore ways to improve daylight penetration and distribution.

- Consider identifying and preserving existing topography and landscape features that will shade the building or minimize glare.
- Consider proximity to neighboring buildings and their effects on daylighting availability and shading.
- Evaluate the building footprint, the structural floor-to-floor height, and finished ceiling clearances to determine an adequate ratio of window to floor area.
- Consider incorporating atria, clerestories, courtyards, and shallow floor plates.
- Weigh the effects of the envelope design on energy efficiency. Incorporate exterior shading to minimize solar heat gains and glare while admitting daylight.

STEP 3. DESIGN TO MAXIMIZE DAYLIGHT

Consider how best to allocate interior space to ensure that daylight is available in all regularly occupied spaces. Enclosure design and furniture selection will affect daylight penetration. Possible design strategies include the following:

- Use transparent partitions or interior glazing to provide daylight to enclosed spaces.

1. *Kellert, Stephen R., Judith H. Heerwagen, and Martin L. Mador, Biophilic Design: The Theory, Science and Practice of Bringing Life into Buildings (New York: Wiley, 2008), p. 99.*
2. *Boyce, Peter, Reviews of Technical Reports on Daylight and Productivity (Rensselaer Polytechnic Institute, 2004); Heschong Mahone Group, Daylighting in Schools: An Investigation into the Relationship between Daylighting and Human Performance (1999).*
3. *Edwards, L., and P. Torcellini. A Literature Study of the Effects of Natural Light on Building Occupants (Golden, Colorado: NREL, 2002).*
4. *Peet, Ramona, Lisa Heschong, Roger Wright, and Don Aumann, Daylighting and Productivity in the Retail Sector (2004), eceee.org/conference_proceedings/ACEEE_buildings/2004/Panel_7/p7_24/paper (accessed June 12, 2013).*

- In open-plan offices, select low partitions or incorporate glazed panels above 42 inches (1 070 millimeters).
- Consider using daylighting simulations early in the design process to ensure effective daylighting and to identify and minimize sources of glare.

STEP 4. IDENTIFY REGULARLY OCCUPIED SPACES

Identify all regularly occupied spaces within the project (see *EQ Overview, Regularly versus nonregularly occupied spaces*). Highlight regularly occupied spaces on the floor plan or furniture plan and create a tracking table that lists all regularly occupied spaces and their respective floor area (square footage or square meters).

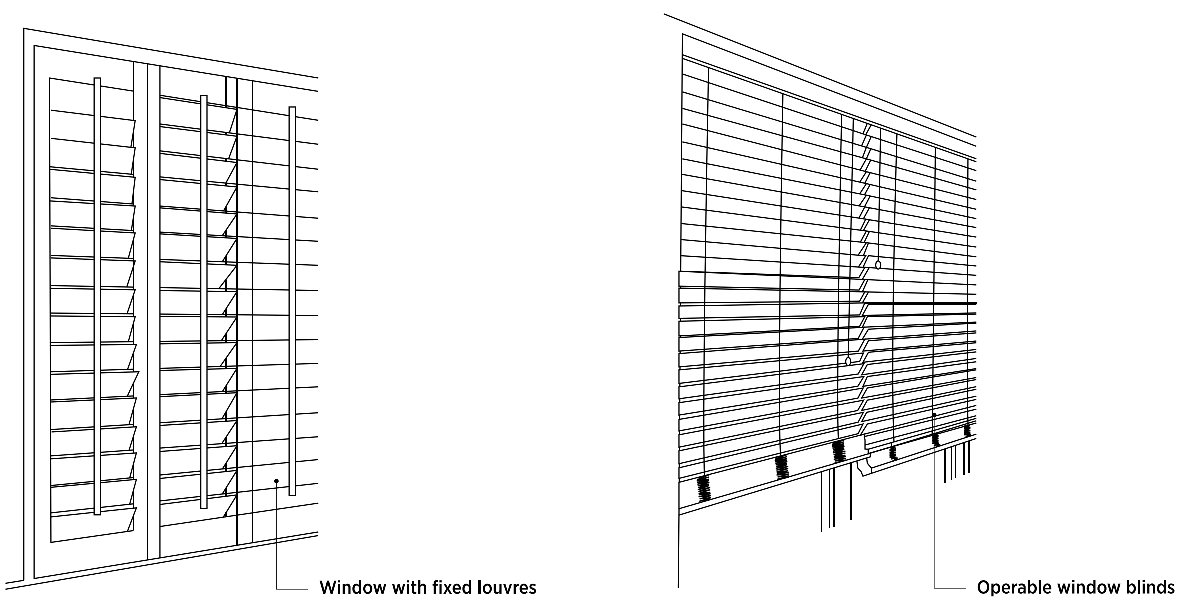
Determine whether any regularly occupied spaces should be excluded from the daylight requirements (see *Further Explanation, Project Type Variations)*. Spaces where tasks would be hindered by the use of daylight may be excluded. Spaces may not be excluded for security or noise concerns.

For Healthcare projects, only consider regularly occupied spaces within the perimeter area (see EQ Credit Quality Views*, Further Explanation, Perimeter Areas*).

STEP 5. PROVIDE GLARE CONTROLS

Provide glare-control devices for all transparent glazing in regularly occupied spaces, regardless of whether the glazing receives direct sunlight or whether the space meets the illuminance requirements of this credit (Figure 1).

- All glare-control devices must be operable by the building's occupants to address unpredicted glare. Automatic devices with user override are acceptable.
- Acceptable glare-control devices include interior window blinds, shades, curtains, movable exterior louvers, movable screens, and movable awnings.
- Systems not acceptable as glare-control devices include fixed exterior overhangs, fixed fins and louvers, dark-colored glazing, and frit and other glazing treatments.
- Diffused and translucent glazing systems do not require glare-control devices.



Unacceptable Glare Control Devices

- Fixed exterior overhangs
- Fixed fins
- Fixed louvres
- Dark color glazing
- Frit glazing treatment
- Additional glazing treatments

Acceptable Glare Control Devices

- Interior window blinds
- Interior shades
- Curtains
- Moveable exterior louvres
- Moveable screens
- Moveable awnings

Figure 1. Glare control devices

STEP 6. SELECT ONE OPTION

Determine which option the project will pursue. Options 1 and 2 involve different modeling procedures (see IES LM 83-12 and *Further Explanation, Illuminance Simulation Procedure*) and different point values. Option 3 requires no modeling.

- **Option 1** requires project teams to simulate both hourly illuminance and direct sunlight in each space over an entire year and likely necessitates engaging a daylighting consultant. The method uses a daylight simulation program that generates spatial daylight autonomy (sDA) ratios,[5] a metric that determines annual daylight performance based on annual weather data and occupancy use. This temporal analysis provides more information for design decisions than single-point-in-time calculations.[6] Only spatial daylight autonomy (and not continuous autonomy or daylight autonomy) is modeled.
- **Option 2** is similar to the simulation option in previous versions of LEED and may require the help of a daylighting consultant. This compliance method has been carried over from previous LEED versions because illuminance calculation is still used by many daylighting professionals. However, project teams are now required to use site-specific daylight illuminance values instead of the program default values for weather. This provides daylight performance data that better reflect actual site conditions, leading to better design decisions.
- **Option 3** is typically for renovations that involve minimal modifications to the building envelope and for substantiating a completed project's design strategies with a performance-based metric. Consider the schedule before selecting Option 3: the second required measurement must occur at least five months after the first measurement. Measurement compliance method is similar to the method used in previous versions and is now the only method for credit compliance that is not simulation based. This method has been revised to better address the differences in daylight experienced throughout the year by requiring measurements at two times—when the sun is high in the sky and when the sun is low in the sky.

Option 1. Simulation—Spatial Daylight Autonomy

STEP 1. COLLECT SDA SIMULATION INPUTS

Work with the daylighting consultant to identify information needed for the daylight simulation. At a minimum, compile the following:

- Exterior building geometry and obstructions
- Site plan, location, and context
- Floor plan and furniture plan
- Interior finishes and surface reflectance (see *Further Explanation, Surface Reflectance*).
- Glazing performance specifications
- Glare-control device specifications
- Project occupancy schedule
- Local climate weather files, such as typical meteorological year (TMY2 or TMY3) data, available at nrel.gov

STEP 2. PERFORM SDA SIMULATION

Prepare the sDA model based on information collected in Step 1. Follow the modeling methodology outlined in IES LM 83 (section numbers below refer to this standard).

- See Section 2.2, sDA—Building 3D Modeling Methodology, for guidance on the period of analysis, illuminance threshold information, temporal threshold, analysis area, analysis points, operation of blinds and shades, optical properties of blinds and shades, exterior obstructions, window and skylight details, interior surface reflectances, and furniture and partitions. For building geometries, develop a complete building model.
- Ensure that the software program selected is capable of simulating the sDA model per Section 2.3.3, Modeling Parameters.

5. *Illuminating Engineering Society, Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE), IES document LM-83 (2013), ies.org/store/product/approved-method-ies-spatial-daylight-autonomy-sda-and-annual-sunlight-exposure-ase-1287.cfm (accessed June 12, 2013).*
6. *Heschong Mahone Group, Daylighting Metrics (California Energy Commission, PIER Daylighting Plus Research Program, February 2012), energy.ca.gov/2012publications/CEC-500-2012-053/CEC-500-2012-053.pdf (accessed June 12, 2013).*

- Determine how the regularly occupied spaces will be divided into analysis areas. The analysis areas must cover all regularly occupied floor area. For the annual sunlight exposure (ASE) calculations, at a minimum, each floor must be an analysis area (for Healthcare, use all regularly occupied perimeter floor area).
- Include glare-control devices in the model as described in Section 2.2.6, Blinds/Shades Operation, and 2.2.7, Blinds/Shades Optical Properties.
- Set thresholds for the simulation to 300 lux for 50% of the hours between 8 A.M. and 6 P.M. local clock time, for a full calendar year, from January 1 to December 31. See Sections 2.2.1, Period of Analysis; 2.2.2, Illuminance Threshold Information; and 2.2.3, Temporal Threshold.
- Ensure that the model includes all permanent interior obstructions. Moveable furniture and partitions may be excluded. See Section 2.2.11 for suggestions on modeling furniture and partitions.
- Refer to Section 2.3, sDA—Climatic Modeling Methodology, for guidance on climate conditions for the project's location (see *Further Explanation, Finding Meteorological Data*).

Perform the sDA simulation.

Consult with the project team on assumptions developed for early design simulations. The assumptions should be further refined as design develops. Simulation results used for credit documentation should be based on the design that is closest to the completed construction documents for the as-built scenario.

STEP 3. EVALUATE SDA COMPLIANCE

Review the simulation output results and determine the sDA value for all regularly occupied floor area (for Healthcare, the regularly occupied perimeter floor area).

- Record the areas that are daylit (i.e., they contribute to the sDA value by meeting the threshold for the simulation).
- Confirm that the project meets or exceeds the requirements in Table 1 in the credit requirements.

STEP 4. PERFORM ANNUAL SUNLIGHT EXPOSURE SIMULATION

- Prepare the annual sunlight exposure (ASE) model based on information collected in Step 1 and the sDA model created in Step 2. The sDA model can be used for ASE analysis with a few modifications. Follow the modeling methodology outlined in IES LM 83 (section numbers below refer to this standard).
- See Section 3.2, ASE—Building 3D Modeling Details, for guidance on the period of analysis, illuminance threshold information, temporal threshold, analysis area, analysis points, operation of blinds and shades, optical properties of blinds and shades, and exterior obstructions.
- The analysis areas should be the same as those used for the sDA simulations. To align with the supporting research for ASE, small analysis areas (ideally space by space, or orientation per floor) are recommended. At a minimum, the analysis area must be for all regularly occupied floor area on a single floor (for Healthcare, the regularly occupied perimeter area on a single floor).
- Glare-control devices are not included in the analysis per Section 3.2.6, Blinds/Shade Operation.
- Set thresholds for the simulation to 1,000 lux of direct sunlight for more than 250 hours of the hours between 8 A.M. and 6 P.M. local clock time, for a full calendar year, from January 1 to December 31. See Sections 3.2.1, Period of Analysis; 3.2.2, Illuminance Threshold Information; and 3.2.3, Temporal Threshold).
- Refer to Section 3.3, ASE—Climatic Modeling Methodology, for guidance on climate conditions for the project's location. The ASE analysis does not require modeling of sky luminance or ground reflectance. If the software being used does not accommodate direct sunlight as described in Section 3.3, ASE may be identified based on illuminance compared with adjacent nodes.

For an alternative way to determine ASE, see *Further Explanation, Direct Sunlight Based on Lux Differences between Adjacent Grid Points*.

STEP 5. EVALUATE COMPLIANCE FOR ANNUAL SUNLIGHT EXPOSURE

Review the simulation output results and determine the ASE values for each analysis area.

- Record the ASE values for each floor area being analyzed.
- Confirm that the ASE value does not exceed 10% for each analysis area. The 10% threshold should be determined for small areas, ideally space by space or orientation per floor. At a minimum, the 10% threshold must be determined for all regularly occupied floor area (for Healthcare, the regularly occupied perimeter area) on a single floor.

Option 2. Simulation—Illuminance Calculations

STEP 1. COLLECT ILLUMINANCE SIMULATION INPUTS

Work with the daylighting consultant or modeler to identify information needed for the daylight simulation. At a minimum, compile the following:

- Exterior building geometry and obstructions
- Site plan, location, and context
- Floor plan and furniture plan
- Interior finishes and surface reflectance (see *Further Explanation, Surface Reflectance*)
- Glazing performance specifications
- Local climate weather files, such as typical meteorological year (TMY2 or TMY3) data, available at nrel.gov

STEP 2. PERFORM ILLUMINANCE SIMULATION

Prepare the illuminance model based on information collected in Step 1.

- Follow the modeling methodology outlined and illustrated in *Further Explanation, Illuminance Simulation Procedure*.
- Perform the point-in-time simulations.
- Consult with the project team on assumptions developed for early design simulations. The assumptions should be further refined as design develops. Simulation results used for credit documentation should be based on the design that is closest to the completed construction documents for the as-built scenario.
- Perform one illuminance simulation at 9 A.M. on the equinox (September 21 or March 21).
- Perform a second illuminance simulation at 3 P.M. on the equinox (September 21 or March 21).

STEP 3. EVALUATE ILLUMINANCE COMPLIANCE

Review the simulation output results and determine the illuminance values for all regularly occupied floor area (for Healthcare, the regularly occupied perimeter floor area).

- Record the areas that are daylit (have illuminance levels between 300 lux and 3,000 lux for both 9 A.M. and 3 P.M.) and the associated floor area.
- Confirm that the project meets or exceeds the values in Table 2 in the credit requirements.

Option 3. Measurement

STEP 1. PREPARE FOR MEASUREMENTS

Determine when the first and second measurements will be taken.

- Schedule the first day of measurement after the project construction is complete, all furniture is moved in, window shades are installed, and people have occupied the space.
- Review Table 4 in the credit requirements to determine timing of the second measurement. Both measurements must occur during regularly occupied months. For example, measurements for a school may not be taken during school breaks.
- Review the regularly occupied space floor area (for Healthcare, all regularly occupied perimeter floor area) to determine the required measurement grid. Draw the measurement grid and the measurement nodes (usually located at the center of each grid space) on a floor plan.

STEP 2. PERFORM MEASUREMENTS

Use a light meter to take a daylight illuminance measurement at workplane height (30 inches [750 millimeters] above finished floor, unless otherwise defined) between 9 A.M. and 3 P.M. (see *Further Explanation, Solar Time or Local Time*).

- Refer to the Illuminating Engineering Society (IES) Lighting Handbook, 10th edition, Section 9.7, for more information on light meters.
- Identify the location of each measurement node in the actual space.
- Record the measured illuminance at each node on the floor plan or in a tracking table.
- If measurements cannot be completed for the entire project in one day, continue the following day between 9 A.M. and 3 P.M.

- Repeat the process using the same nodes for the second measurement (see *Further Explanation, Examples, Option 3*).

STEP 3. EVALUATE ILLUMINANCE COMPLIANCE

Review the measurement results and determine the illuminance values for all regularly occupied floor area (for Healthcare, the perimeter floor area).

- Record the areas that are daylit (have illuminance levels between 300 lux and 3,000 lux for both measurements) and the associated floor area.
- Confirm that the project meets or exceeds the values in Table 3 in the credit requirements.

FURTHER EXPLANATION

CALCULATIONS

See the daylight and quality views calculator provided by USGBC.

SURFACE REFLECTANCE

IES LM 83-12, Section 2.2.10, provides general guidance for interior surface reflectances.

If surface reflectance values are not available in manufacturers' information, field measurements may be performed. Refer to IES LM 83-12, Section 9.12.2, on measuring illuminance and luminance.

Field measurements may be performed as follows:

- Use a reflectance chart, such as that found in the CIBSE's Lighting Guide 11: Surface Reflectance and colour document, to measure reflectance.
- Measure illuminance with an illuminance meter, and luminance with a spot luminance meter.
- Reflectance is defined as illuminance divided by luminance in the space.

DIRECT SUNLIGHT BASED ON LUX DIFFERENCES BETWEEN ADJACENT GRID POINTS

For ASE analysis, direct sunlight can be assumed to occur for any grid point that has an hourly illuminance level at least 1,000 lux higher than any directly adjacent grid point. This could be determined from manual postprocessing of the simulation results, through a sun path and shadow program, or with software that automatically postprocesses the simulation results.

FINDING METEOROLOGICAL DATA

Obtain typical meteorological year data for the nearest available weather station in a format the simulation program can accept. Example formats include TMY2 and TMY3, EPW, and WEA.

Most U.S. and international weather data can be downloaded from the U.S. Department of Energy, at apps1.eere.energy.gov/buildings/energyplus/weatherdata_about.cfm.

The National Renewable Energy Laboratory provides a weather file viewer (DView) at beopt.nrel.gov/downloadDView.

ILLUMINANCE SIMULATION PROCEDURE

The simulation methodology for illuminance simulation is similar to that described in IES LM 83-12 for sDA and ASE.

For building geometries, develop a complete building model. Some programs allow energy model geometries to be transferred to the daylight modeling interface. Include exterior walls, roofs, shading devices, glazed assemblies (including mullion thickness), skylight and window recesses, rough opening thicknesses, and light shelves. Refer to LM 83, Section 2.2, for general guidance on the level of detail for the model.

Period of analysis. The analysis is performed at 9 A.M. and 3 P.M. on the equinox (September 21 or March 21), adjusted for daylight savings time and longitude.

Illuminance threshold. The illuminance threshold for analysis is 300 lux or greater and below 3,000 lux at the horizontal workplane, which is 30 inches (750 mm) above the finished floor, unless otherwise defined.

Analysis area and points. The analysis area should cover all regularly occupied floor area. For Healthcare projects, the analysis area must cover all perimeter floor area, which is any area within 15 feet (4.5 meters) of the building perimeter. Refer to LM 83, Section 2.2.5, for guidance on the calculation grid and location of the analysis points.

Exterior obstructions. Refer to LM 83-12, Section 2.2.8, for guidance on modeling exterior obstructions.

Window and skylight details. Refer to LM 83-12, Section 2.2.9, for guidance on modeling windows and skylights. If the modeling software requires an input of glazing transmissivity, use the visible light transmittance value provided by the manufacturer. Glare-control devices are not included in the analysis.

Surface reflectances. Prepare a list of material finishes for all model surfaces and verify material specifications with the design team. A library of materials is available with most daylight programs, such as the material.rad file structure for the RADIANCE-based[7] simulation programs. The material.rad file may be customized, but in RADIANCE, the simulation fails if a material is incorrectly defined. Check the normal direction of model surfaces. To receive daylight, exposed surfaces should face outward from the center of each zone in which they belong. Ground surfaces should face upward. Refer to LM 83, Section 2.2.10, for further guidance on modeling interior surface reflectances.

Furniture and partitions. The model must include all permanent interior obstructions. Moveable furniture and partitions may be excluded. See LM 83, Section 2.2.11, for suggestions on modeling furniture and partitions.

Illuminance climatic modeling methodology. Proceed as follows.

1. Obtain typical meteorological year data (see *Further Explanation, Finding Meteorological Data*). Use local weather data or TMY weather data files for the nearest city. If the simulation program is capable of automatically determining clear sky condition, select that option.
2. To calculate the illuminance intensity for sun (direct component) and sky (diffuse component) in a TMY2 or TMY 3 file, export the data into a text file or spreadsheet format.
3. From the TMY, select the day within 15 days of September 21 that has the clearest sky condition (total sky cover at its lowest value) at 9 A.M.
4. From the TMY, select the day within 15 days of March 21 that has the clearest sky condition at 9 A.M.
5. Determine the direct horizontal irradiance (Wh/m^2) values at 9 A.M. for the day selected in September and at 9 A.M. for the day selected in March. Average the two values and use the result in the 9 A.M. simulation as the direct horizontal irradiance input. If the file does not explicitly state direct horizontal irradiance, calculate it as follows:

   Direct horizontal irradiance = Global horizontal irradiance − Diffuse horizontal irradiance[8]

6. Determine the diffuse horizontal irradiance (Wh/m^2) values at 9 A.M. for the day selected in September and at 9 A.M. for the day selected in March. Average the two values and use the result in the 9 A.M. simulation as the diffuse horizontal irradiance input.
7. Repeat procedures 3–6 for 3 P.M. (see *Further Explanation, Examples*).
8. Prepare the model to run a simulation to input custom values for direct horizontal and diffuse horizontal irradiance.

Refer to LM83, Sections 2.3.1 and 2.3.2, for additional guidance on climate conditions for the project's location such as, the sun position and intensity, sky illuminance distribution, and modeling parameters. Refer to IES LM83, Section 2.3.3, for guidance on modeling parameters.

The daylight simulation is most successful when the light is reflected back from the interior walls into the space. The daylight modeler can specify a certain number of inter-reflections before a ray path is discarded.

7. *radsite.lbl.gov/radiance/HOME.html (accessed June 12, 2013).*
8. *More information on determining different kinds of irradiance is available at the Natural Frequency wiki site: wiki.naturalfrequency.com/wiki/SolarRadiation/Components (accessed June 12, 2013).*

SOLAR TIME OR LOCAL TIME

When performing daylight measurements, determine whether the measurements will be taken at solar or local time. Both are acceptable, but solar time may be more appropriate because it is based on the position of the sun in the sky.

Solar time varies from the local standard time because of eccentricities in Earth's orbit and because of time zones and daylight saving adjustments. Solar time is typically calculated using a third-party calculator, such as the National Oceanic and Atmospheric Administration's solar calculator.

EXAMPLES

Example 1. Option 2

An open office with core areas is being assessed for compliance with Option 2 Illuminance Simulation. The office is in New York City and has six regularly occupied spaces (Table 5) plus several nonregularly occupied spaces, such as mechanical, elevator, and restroom space. The office has equally spaced ribbon glazing on all four sides and a window-to-wall ratio of 63%.

Illuminance simulations were performed for all the regularly occupied spaces, based on diffuse and direct horizontal radiation inputs determined in Figure 2. For the entire project, the percentage of regularly occupied area that is daylighted is 81%. The percentage of regularly occupied floor area exceeds 75%, so project has earned 1 point under Option 2.

TABLE 5. Regularly occupied spaces in example office

Regularly occupied space ID	Floor area (ft^2)	Floor area with daylight illuminance of 300–3,000 lux
2nd-floor open office	9,000	7,200
3rd-floor conference room	500	420
3rd-floor private office 301	96	72
3rd-floor private office 302	120	88
3rd-floor open office	8,284	6,900
4th-floor open office	9,000	7,200
Total regularly occupied area (ft^2)	**27,000**	
Daylighted regularly occupied area (ft^2)	**21,880**	
Regularly occupied area that is daylighted	**81%**	

Figure 2. Diffuse and direct horizontal radiation inputs for New York City

New York City TMY3	
Daily illuminance intensity data	**September** • Lowest total sky cover for 9 A.M. on September 17 • Global horizontal irradiance = 618 Wh/m^2 • Diffuse horizontal irradiance = 98 Wh/m^2 • Direct horizontal irradiance = 618 – 98 = 520 Wh/m^2
	March • Lowest total sky cover for 9 A.M. was on March 21 • Global horizontal irradiance = 155 Wh/m^2 • Diffuse horizontal irradiance = 136 Wh/m^2 • Direct horizontal irradiance = 155 – 136 = 19 Wh/m^2
	Computer model will input following values: • Average diffuse horizontal irradiance = 117 Wh/m^2 • Average direct horizontal irradiance = 270 Wh/m^2

Example 2. Option 3

After construction of the New York City office building (Example 1) was completed in mid-June, the project team took daylight measurements in all regularly occupied spaces. A second set of daylight measurements was taken for the same spaces in October to determine the compliant floor areas in the building. The two measurements for each space were compared to determine the areas that were compliant at both times. Figures 3 and 4 display the measurement results for a third-floor private office, 301.

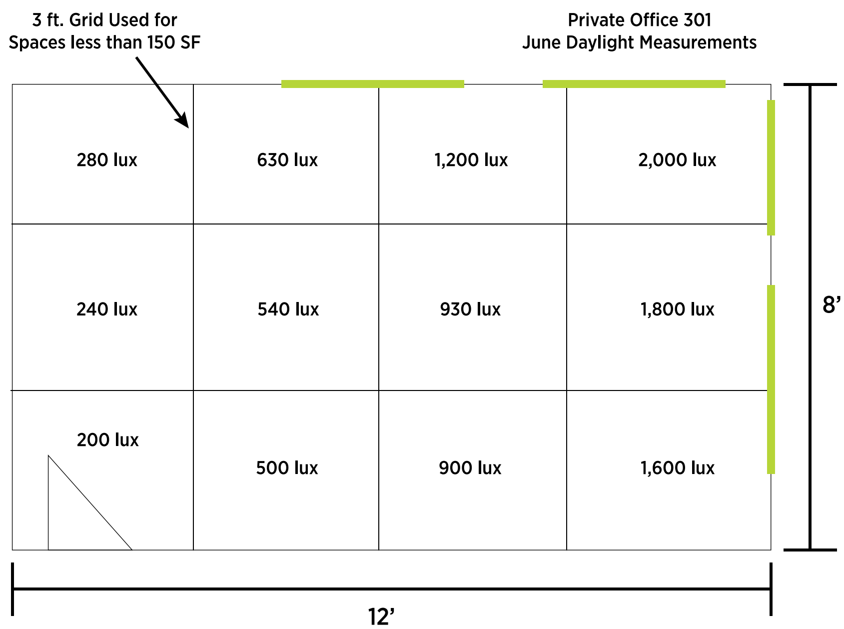


Figure 3. Measurements recorded in June

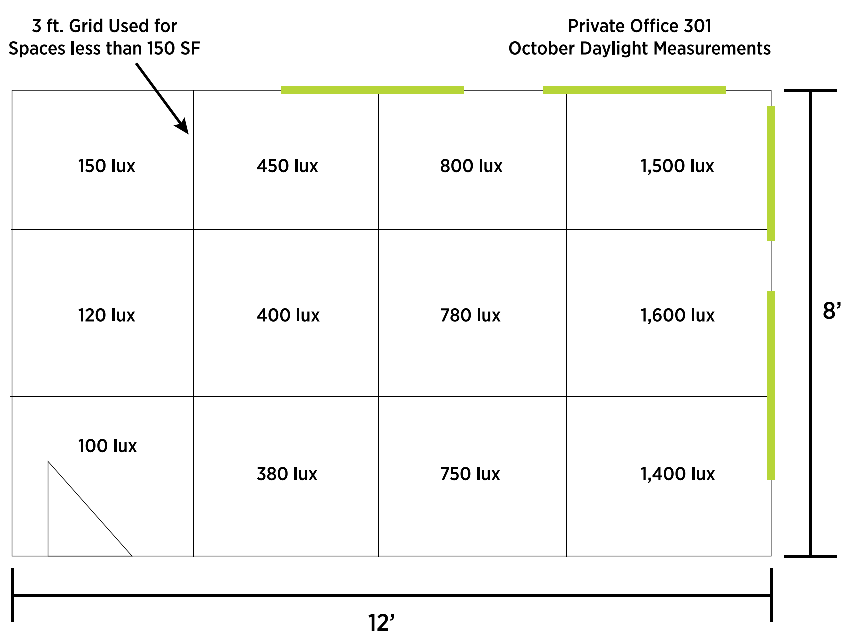


Figure 4. Measurements recorded in October

RATING SYSTEM VARIATIONS

Core and Shell
Project teams may assume surface reflectance for finishes in unfinished spaces as described in the credit requirements. Project teams must assume that all spaces except the core and restrooms are regularly occupied. In unfinished spaces, permanent interior obstructions may be excluded from the analysis.

Healthcare
Review all steps in *Step-by-Step Guidance*.

For Step 4, first identify the perimeter area (see EQ Credit Quality Views, *Further Explanation, Perimeter Areas*) for both the inpatient floors and non-inpatient floors. Next, identify all regularly occupied spaces in this area; this is the "regularly occupied area within the perimeter." Follow the rest of the steps for these spaces.

(For EQ Credit Quality Views, view compliance for the inpatient floor includes all regularly occupied spaces, not just the regularly occupied spaces in the perimeter area.)

PROJECT TYPE VARIATIONS

Auditoriums
Auditoriums must be included in the daylight requirements, but a lower illuminance level is acceptable; see recommended illuminance values in *The Lighting Handbook, Table 24.2*.

Conference rooms dedicated to video conferencing
Conference rooms that are dedicated to video conferencing may be excluded from the daylight requirements.

Gymnasiums
Gymnasiums must be included in the daylight requirements.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects	Option 1	Option 2	Option 3
Floor plans highlighting regularly occupied spaces (for Healthcare, regularly occupied perimeter area)	X	X	X	X
List of glare-control devices for all windows with their control mechanism	X	X	X	X
List of compliant spaces with their annual summary values for sDA and ASE		X		
Geometric plots from simulations.		X	X	
Narrative or output file describing daylight simulation program, simulation inputs, and weather file		X	X	
List of compliant spaces with their calculated illuminance values			X	
Floor plans or list of compliant spaces with measured illuminance values for each node				X
Calculations demonstrating percentage of compliant space between 300 lux and 3,000 lux				X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. Good daylighting and glare control reduce the need for electric lighting. Consider daylight contribution when designing the lighting system. Consider incorporating daylight sensors and dimmers to reduce lighting energy consumption, and account for these efficiency measures in the related prerequisite and credit.

EQ Credit Quality Views. Design strategies that enhance daylight penetration are also likely to increase the number of occupants with exterior views. Regularly occupied spaces must be consistently reported for both this credit and the related credit.

EQ Credit Interior Lighting. For projects that pursue Option 1 or Option 2 of this credit, ensure that same surface reflectance values used in daylight simulation models match those used in lighting quality calculations for the related credit.

CHANGES FROM LEED 2009

- The prescriptive compliance path has been eliminated.
- An additional simulation option is available. The new option incorporates two new metrics, spatial daylight autonomy and annual sunlight exposure, based on annual daylight computer simulation models.
- For Option 2, the illuminance simulation now relies on local weather data and uses a calculated illuminance intensity.
- For Option 3, measurements are required at two times of the year.
- The number of points available and thresholds for achievement have changed.
- Schools is no longer broken out by classroom and core learning spaces vs. other regularly occupied spaces.

REFERENCED STANDARDS

IES Lighting Measurements (LM) 83-12, Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE): webstore.ansi.org

***The Lighting Handbook, 10th edition,* Illuminating Engineering Society**: ies.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

annual sunlight exposure (ASE) a metric that describes the potential for visual discomfort in interior work environments. It is defined as the percentage of an analysis area that exceeds a specified direct sunlight illuminance level more than a specified number of hours per year. (Illuminating Engineering Society)

ASE$_{1,000,250}$ reports the percentage of sensors in the analysis area, using a maximum 2-foot spacing between points, that are found to be exposed to more than 1000 lux of direct sunlight for more than 250 hours per year, before any operable blinds or shades are deployed to block sunlight, considering the same 10 hour/day analysis period as sDA and using comparable simulation methods

automated dynamic façade systems are daylighting control devices whose position or light transmission level can be automatically changed by a control system to address sunlight penetration or perceived glare in the space. Acceptable automated dynamic façade systems include interior automated window blinds or shades; exterior automated louvers, shades, or blinds; or automatically controlled dynamic glazing. Automated methods of sunlight penetration or perceived glare control do not include manually operated interior or exterior façade shading systems; manually operated dynamic glazing; or fixed exterior overhangs, fins, shades, screens, awnings or louvers whose position on the fenestration cannot be automatically changed or adjusted. Automated dynamic façade systems are allowed to have manual override but must default back to automated operation after a predefined period of no longer than two hours. Dynamic glazing is further defined in ASHRAE Standard 90.1 and the International Energy Conservation Code (IECC)

clear glazing glass that is transparent and allows a view through the fenestration. Diffused glazing allows only daylighting.

direct sunlight an interior horizontal measurement of 1,000 lux or more of direct beam sunlight that accounts for window transmittance and angular effects, and excludes the effect of any operable blinds, with no contribution from reflected light (i.e., a zero bounce analysis) and no contribution from the diffuse sky component. (Adapted from (Illuminating Engineering Society)

movable furniture and partitions items that can be moved by the users without the need of tools or assistance from special trades and facilities management

permanent interior obstruction a structure that cannot be moved by the user without tools or assistance from special trades and facilities management. Examples include lab hoods, fixed partitions, demountable opaque full- or partial-height partitions, some displays, and equipment.

spatial daylight autonomy (**sDA**) a metric describing annual sufficiency of ambient daylight levels in interior environments. It is defined as the percentage of an analysis area (the area where calculations are performed, typically across an entire space) that meets a minimum daylight illuminance level for a specified fraction of the operating hours per year (i.e., the Daylight Autonomy value following Reinhart & Walkenhorst, 2001). The illluminance level and time fraction are included as subscripts, as in $sDA_{300,50\%}$. The sDA value is expressed as a percentage of area. (Illuminating Engineering Society)

$sDA_{300/50\%}$ the percentage of analysis points across the analysis area that meet or exceed this 300 lux value for at least 50% of the analysis period

INDOOR ENVIRONMENTAL QUALITY CREDIT

Quality Views

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1-2 points)

INTENT

To give building occupants a connection to the natural outdoor environment by providing quality views.

REQUIREMENTS

NEW CONSTRUCTION, CORE AND SHELL, SCHOOLS, RETAIL, DATA CENTERS, HOSPITALITY

Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area. View glazing in the contributing area must provide a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance.

Additionally, 75% of all regularly occupied floor area must have at least two of the following four kinds of views:

- multiple lines of sight to vision glazing in different directions at least 90 degrees apart;
- views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing;
- unobstructed views located within the distance of three times the head height of the vision glazing; and
- views with a view factor of 3 or greater, as defined in "Windows and Offices; A Study of Office Worker Performance and the Indoor Environment."

Include in the calculations any permanent interior obstructions. Movable furniture and partitions may be excluded.

Views into interior atria may be used to meet up to 30% of the required area.

WAREHOUSES AND DISTRIBUTION CENTERS

For the office portion of the building, meet the requirements above.

For the bulk storage, sorting, and distribution portions of the building, meet the requirements above for 25% of the regularly occupied floor area.

HEALTHCARE

For inpatient units (IPUs), meet the requirements above (1 point).

For other areas, configure the building floor plates such that the floor area within 15 feet (4.5 meters) of the perimeter exceeds the perimeter area requirement (Table 1), and meet the requirements above for the perimeter area (1 point).

TABLE 1. Minimum compliant perimeter area, by floor plate area

Floor plate area		Perimeter area	
(square feet)	**(square meters)**	**(square feet)**	**(square meters)**
Up to 15,000	Up to 1 400	7,348	682
20,000	1 800	8,785	816
25,000	2 300	10,087	937
30,000	2 800	11,292	1 049
35,000	3 300	12,425	1 154
40,000	3 700	13,500	1 254
45,000	4 200	14,528	1 349
50,000 and larger	4 600 and larger	15,516	1 441

BEHIND THE INTENT

Building occupants who can visually connect with outdoor environments while performing everyday tasks experience greater satisfaction, attentiveness, and productivity. Outside views that incorporate natural elements are more enticing and offer better visual respite. Workers seated at computers, who often develop eye strain or dry eyes from looking at their screens for extended periods without a break, find relief in attractive distance views.[1] In healthcare facilities, providing patients with views and access to nature can shorten hospital stays and reduce stress, depression, and the use of pain medication.[2]

Views to the outdoors also connect the occupants with natural environmental cues, such as diurnal changes from light to dark and the changes in light from season to season, which are important for maintaining natural circadian rhythms. Disruption of these rhythms can lead to long-term health care problems, including mental disorders.[3]

Designing for quality views involves consideration of building orientation and site design, facade, and interior layout. In particular, Healthcare projects may be required to rethink the fundamental building typology (see *Further Explanation, Special Considerations for Healthcare Projects*). Integrated design enables project teams to identify potential compromises. For example, glazing with frits, fibers, patterns, colors, or tints is often used to provide privacy, enhance aesthetics, and reduce glare and solar heat gain; however, these types of glazing distort and in some cases completely block the views to the exterior.

Four former exemplary performance paths have been incorporated as credit compliance options, expanding the credit to include consideration for the quality of views provided to building occupants. Specifically, glazing color, frit, and patterns have been restricted to ensure that quality views are being maintained. Additionally, the type of objects visible in the view (e.g., vegetation, sky, brick wall, busy street)—is now an important factor. Although the bar has been raised, four credit paths give teams flexibility in how their designed spaces may comply. Also, atriums may now account for up to 30% of the required area with access to quality views—a change based on industry recognition that atriums can not only increase daylight and views for interior spaces but also reduce the need for electrical lighting in spaces that would otherwise likely require it.

STEP-BY-STEP GUIDANCE

For **Healthcare**, see *Further Explanation, Rating System Variations.*

STEP 1. EVALUATE PROJECT SITE

During schematic design, review the project's surroundings to identify the presence of elements that meet the view quality requirements of this credit, such as parks, green roofs and walls, nearby buildings, and pedestrian and vehicle movement.

- Orient the building and locate glazing to capitalize on desirable views. For massing considerations for healthcare projects, see *Further Explanation, Special Considerations for Healthcare Projects*.
- Consider the energy and comfort implications of vision glazing. Explore ways to use exterior shading to minimize solar heat gain and glare while maintaining views.

STEP 2. DESIGN FOR TRANSPARENCY AND QUALITY VIEWS

During programming, consider how best to allocate interior space to maximize access to views. During design development, design enclosures and select furniture to minimize visual obstructions to perimeter glazing (see *Further Explanation, Quality View Design Considerations*).

- Consider using transparent partitions or providing interior glazing at eye level to ensure views for enclosed spaces.

1. *California Energy Commission, Windows and Offices: A Study of Office Worker Performance and Indoor Environment: Technical Report (2003), pp. 8–9, ff. 1–8, energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-09.PDF (accessed June 12, 2013); Oklahoma State University Healthy and Safety Office, You Can Do Something About Eyestrain (2011), ehs.okstate.edu/kopykit/eyestrain.htm (accessed June 12, 2013).*
2. *Ulrich, Roger, et al., "A Review of the Research Literature on Evidence-Based Healthcare Design," Health Environments Research and Design Journal 1(3) (2008), (http://www.herdjournal.com)*
3. *Kellert, Stephen R., Judith H. Heerwagen, and Martin L. Mador, Biophilic Design: The Theory, Science and Practice of Bringing Life into Buildings (New York: Wiley, 2008), p. 91.*

- In open-plan offices, select low partitions or incorporate glazed panels to provide views in multiple directions.
- Pay particular attention to maintaining views for spaces near the core. One successful strategy is to locate open-plan areas, including classrooms, at the perimeter, while placing private offices and unoccupied areas near the core.
- Consider using glare control devices that preserve the view to the exterior. Movable glare control devices do not need to be included in the calculations.

STEP 3. IDENTIFY REGULARLY OCCUPIED SPACES

Identify all regularly occupied spaces within the project (see *EQ Overview, Regularly versus nonregularly occupied spaces*). Highlight regularly occupied spaces on the floor plan or furniture plan and list all regularly occupied spaces and their respective floor areas (Table 2).

For Warehouses and Distribution Centers, identify which regularly occupied spaces are in the office portion of the building and which are in the bulk storage, sorting, and distribution portions of the building.

TABLE 2. Quality views tracking table

Regularly occupied space ID	Space type	Floor area (ft^2 or m^2)	Quality views: Floor area with direct line of sight to outdoors via vision glazing	Quality views: View types 1	Quality views: View types 2

Determine whether any regularly occupied spaces should be excluded from the views requirements (see *Further Explanation, Project Type Variations*). Spaces whose functional requirements prohibit the incorporation of glazing for direct access to views may be excluded. Spaces may not be excluded for security or noise concerns.

STEP 4. IDENTIFY SIGHT LINES TO EXTERIOR VIEWS

On floor plans or furniture plans, identify the locations of perimeter and interior glazing and all permanent interior obstructions.

- Determine whether the perimeter and interior glazing qualifies as vision glazing (see *Further Explanation, Vision Glazing*).
- Identify permanent interior obstructions (see *Definitions*). Movable furniture and partitions as well as movable glare control devices may be included in the calculations, but this is not required.
- Consider performing an initial rough assessment before performing the detailed assessment of view quality. Determine whether the regularly occupied floor area with proximity to vision glazing is at least 75% of the total regularly occupied floor area (see *Further Explanation, Rating System Variations, Warehouses and Distribution Centers*).

STEP 5. ASSESS VIEW QUALITY

Identify which kinds of view will be used to demonstrate view quality. For each regularly occupied space or area of the floor plan, select two view types and add the selection to the tracking table. Eligible view types are as follows:

1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart
2. Views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing
3. Unobstructed views located within the distance of three times the head height of the vision glazing
4. Views with a view factor of 3 or greater, as defined in *Windows and Offices: A Study of Office Worker Performance and the Indoor Environment*[4]

4. *California Energy Commission, Windows and Offices: A Study of Office Worker Performance and Indoor Environment: Technical Report (2003), pp. 8–9, ff. 1–8, energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-09.PDF (accessed June 12, 2013).2.*

Review *Further Explanation, Quality View Design Considerations,* for tips on which view types make the most sense for the project.

The view types may be mixed and matched, but documentation will be simpler if the same view types are used consistently across spaces.

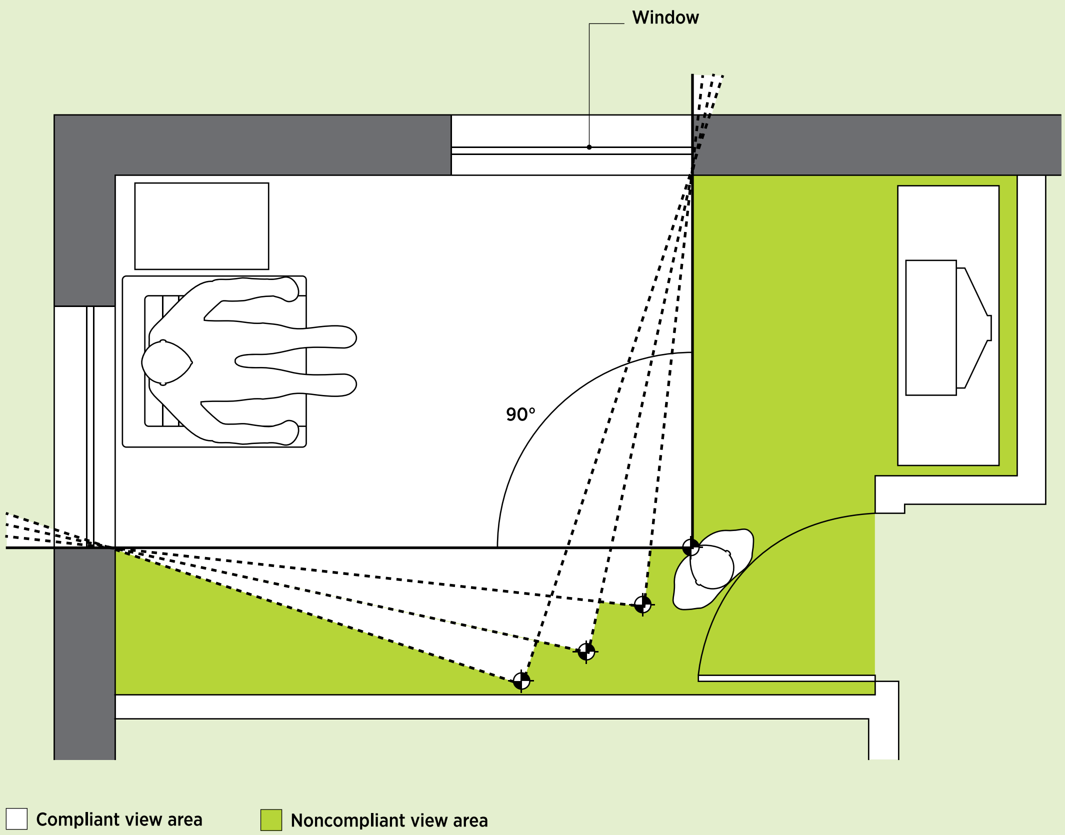
If the entire regularly occupied space or area does not meet the requirements of the selected view type, include only the regularly occupied floor area that complies. To assess the regularly occupied space for each view type selected, perform the following steps (also see *Further Explanation, Examples*).

View type 1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart

On the floor plan or furniture plans, draw two lines of sight to the vision glazing for each location within the space.

- The space or location qualifies if the lines of sight are at least 90 degrees apart and if they are not intercepted by any permanent interior obstructions. If necessary, draw sight lines on section or elevation plans to confirm that permanent interior obstructions do not block the lines of sight.
- It may be easiest to determine the boundary of qualifying areas to nonqualifying areas (Figure 1).

Figure 1. Identifying multiple lines of sight



View type 2. Views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing

In plan, label the qualifying features located at the vision glazing.

- Two features must be indicated.
- Movement (feature 2) includes such activities as people walking, cars driving on the street, and boats moving through the water. Movement of plants and trees from wind does not qualify.
- Account for any changes in exterior views as floor elevation changes.
- In plan, draw one line of sight to the vision glazing for each location in the space. The space or location qualifies if the line of sight is not intercepted by any permanent interior obstructions. If necessary, draw sight lines on section or elevation plans to confirm permanent interior obstructions do not block the lines of sight.

QUALITY VIEWS

EQ

View Type 3. Unobstructed views located within the distance of three times the head height of the vision glazing

In section, determine the head height of the vision glazing for each regularly occupied space. In plan, identify all regularly occupied floor area that is within three times the head height of the perimeter.

- The space or location qualifies if there are no permanent interior obstructions present in the area. No permanent interior obstructions are allowed, regardless of their height.
- Any regularly occupied floor area not in the identified area does not qualify.

View type 4. Views with a view factor of 3 or greater, as defined in *Windows and Offices: A Study of Office Worker Performance and the Indoor Environment*

On the floor plan or furniture plan, identify occupants' typical locations in each regularly occupied space (e.g., open-office workstation, enclosed office, conference room seat, counter). Indicate whether the location is the primary view location or a break view location (see *Further Explanation, View Factor*).

- Assess the view factor for each of these locations, based on either the primary view or the break view.
- In section or elevation, or through drawings or images, demonstrate how the view factor was determined.

STEP 6. CONFIRM COMPLIANCE

Complete the tracking table to confirm that at least 75% of the regularly occupied floor area has two qualifying view types.

For **Warehouses and Distribution Centers**, 75% of the regularly occupied floor area in the office portions of the building and 25% of the regularly occupied floor area in the bulk storage, sorting, and distribution portions of the building must meet two view types.

For **Healthcare**, see *Further Explanation, Rating System Variations*.

FURTHER EXPLANATION

CALCULATIONS

See the daylight and quality views calculator provided by USGBC.

Perimeter Area:

The perimeter area is all floor area within 15 feet (4.5 meters) of a perimeter wall that is capable of providing a view. Below-grade walls with areaways and walls that abut adjacent buildings are excluded. For portions of the perimeter wall with full-height glazing, the qualifying area may be extended beyond the 15-foot (4.5 meter) limit to twice the head height of the windows; both single-story and multistory spaces are eligible (see *Further Explanation, Example 7*).

QUALITY VIEW DESIGN CONSIDERATIONS

TABLE 3. Design considerations by view type

View type	Design considerations
1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart	Providing multiple lines of site to vision glazing in different directions could be advantageous for high-rise buildings with curtain wall exteriors, especially for open-office spaces. Interior atrium and exterior glazing provide views in several directions. Consider glazing characteristics that avoid excessive heat gain, to reduce energy use for cooling
2. Views that include at least two of following: • **(1) flora, fauna, or sky;** • **(2) movement; or** • **(3) objects at least 25 feet (7.5 meters) from exterior of glazing**	In dense urban environments, providing views of movement, flora, fauna, or sky, and objects at least 25 feet (7.5 meters) from exterior of building may prove difficult. Conversely, this criterion may be easy to achieve in low-rise buildings or buildings in suburban areas surrounded by open space and landscaping. Vertical landscaping may be effective strategy for achieving views of flora and fauna in dense urban environments.
3. Unobstructed views located within distance of three times head height of vision glazing	This option is easiest to achieve in buildings with large expanses of perimeter glazing. Layouts that include extensive open-office workstations or open areas with little interior obstructions along perimeter glazing are good candidates for this approach.
4. Views with view factor of 3 or greater	View factor must be determined by observation of available views for each workstation. This approach may allow greater flexibility in building orientation, window size, and surroundings, but without 3D modeling, team may be unable to determine view factor until substantial completion.

SPECIAL CONSIDERATIONS FOR HEALTHCARE PROJECTS

U.S. hospitals typically have a “plinth-tower” arrangement, with inpatient towers sitting on top of a diagnostic and treatment (D&T) block. In each tower, most of the perimeter is occupied by inpatient bed spaces, with windows. Many inpatient blocks are designed in a “racetrack” configuration, with a ring of patient rooms surrounding staff areas and family support areas. The nursing stations and other staff spaces are thus in the core of the building, without direct access to daylight and views.

In the D&T block, the perimeter is usually programmed for public spaces and circulation; the clinical areas, support spaces, and administrative offices are inside, leaving staff with limited access to daylight and views. In such designs, the deep floor plate of the D&T block has the benefit of reducing distance to critical adjacencies and provides uniform grids and bays for flexibility in future layout and servicing. Equipment lines all four walls and often is embedded into the ceiling and floor, eliminating opportunities for both windows and skylights. Fire code and privacy requirements also reduce opportunities and increase the initial cost associated with glazing in these areas.

EQ Credit Daylight and EQ Credit Quality Views encourage project teams to design the building for the benefit of both patients and staff.

Creative planning that retains the operational benefits of easy access to patients’ rooms while placing staff and public spaces on the perimeter is required for credit achievement. Courtyard and articulated floor plans[5] (e.g., C, F, E, or comb shapes) with double-loaded corridors, which place patient rooms on either side of a hallway, narrow the floor plate and improve access to both daylight and views. These designs can increase the initial cost because of the additional perimeter wall and additional glazing, but daylight can illuminate a greater proportion of the building, including nursing stations and other work areas. In T-shaped configurations with perimeter rooms, the windowless inside corner rooms can be used for storage, equipment, and vertical transportation. Nursing stations can be located closer to patient rooms, and wayfinding for visitors is easier.

Public spaces, diagnostic and treatment areas, and ambulatory units can be daylit either through an articulated plan or by inserting courtyards or light wells into a large block (Figure 18). Although the articulated plan is more widely used, the courtyard option both increases overall access to daylight and views and reduces travel time between departments. It also gives the facility flexibility to expand and contract department size when clinical practices shift and technology drives changes in spatial configurations.

5. *Guenther and Vittori, Sustainable Healthcare Architecture* (*New York: Wiley, 2008*).

VIEW FACTOR

View factor is a measure of the amount and quality of views within a 90-degree cone of vision from an individual workstation. View factor is rated from 0 (poor quality) to 5 (high quality).

To achieve this credit, teams may determine the view factor for either primary view, what an occupant would see while working on the phone or computer, or break view, what occupants would see while taking a short break by turning their heads or moving their chairs while remaining seated.

View factor is determined for each workstation by assessing the vertical and lateral viewing angle for either the primary or the break view (Figure 2). To determine view factor, first find the smaller of the vertical or lateral view angle. Use the angle to identify the preliminary view factor (Table 4). If the view angle falls within the gray zone, assess the content of the view. View angles in the gray zone are rated up one level when the view has very high vegetation content, and down one level if the view has no vegetation content.

Alternatively, use Figure 3, which demonstrates examples of different view factors, to visually assess the view factor of a given space.

TABLE 4. View factor

Preliminary view factor	View angle	
	Min–max (degrees)	Gray-zone range (degrees)
1	1–4	
1 or 2		4–5
2	5–9	
2 or 3		9–11
3	11–15	
3 or 4		15–20
4	20–40	
4 or 5		40–30
5	50–90	

Figure 2. Assessing view angles

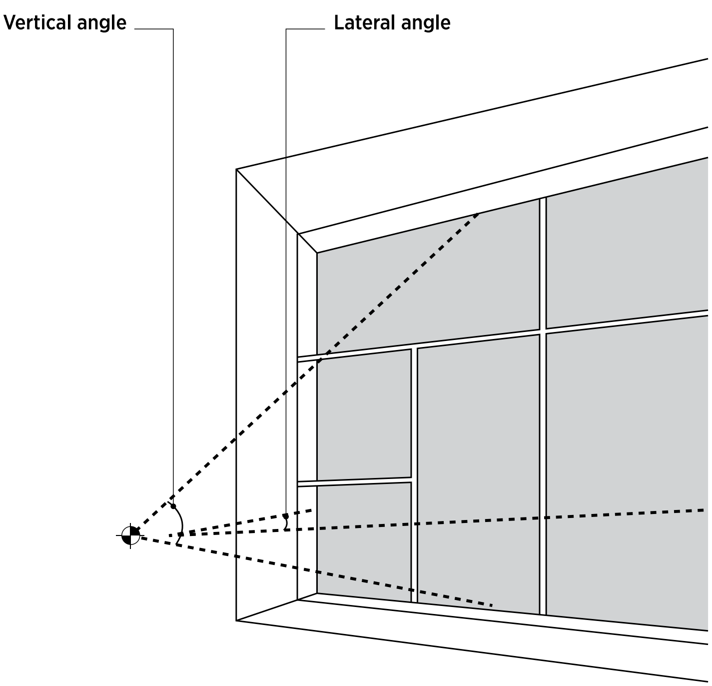
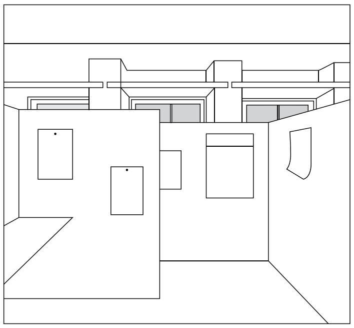
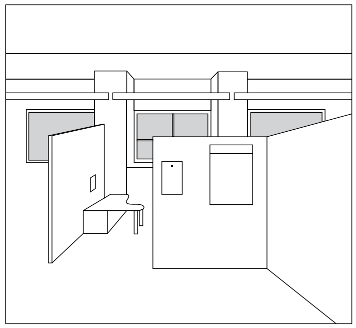


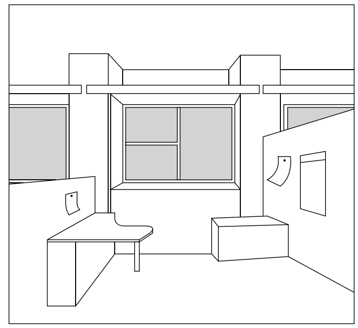
Figure 3. View factor illustrations. The following images illustrate the view quality associated with each view factor level.



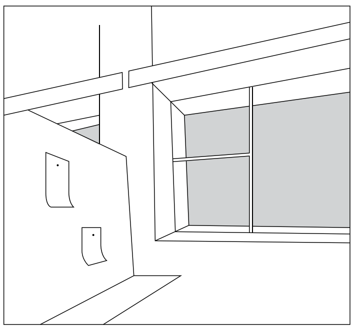
View Factor 1



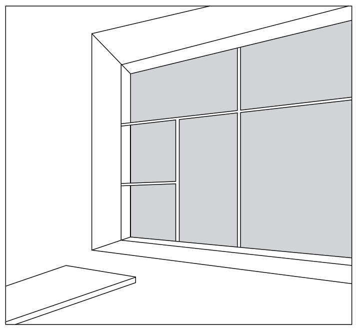
View Factor 2



View Factor 3



View Factor 4



View Factor 5

VISION GLAZING

Vision glazing is defined as that portion of exterior windows that permits views to the exterior (or an atrium). Vision glazing must have a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance (Figures 4–8). Some patterns are acceptable if they preserve the view.

The glazing does not have to be located between 30 and 90 inches (750 and 2 300 millimeters) above the finished floor.

Figures 4–7 illustrate examples of glazing solutions that are eligible for this credit.

Figure 4. Fritted glass with horizontal strips of clear glazing. The area between the upper and lower portions of fritted glass is acceptable vision glazing. Photo by Michael Spillers.

Figure 5. Fritted glass with vertical panels of clear glazing. The glazing between the fritted panels is acceptable vision glazing. Photo by Michael Spillers.

Figure 6. Frosted glass above, clear glazing below. The area below the frosted glazing is acceptable vision glazing. This space also has multiple views more than 90 degrees apart. Photo by Todd Reed.

Figure 7. Lightly tinted glazing. The gray tint darkens the view but does not distort color balance, so it is acceptable vision glazing.

Figure 8 is an example of glazing that is ineligible for this credit.

Figure 8. Partial-height partitions with frosted glass. Frosted glass is not acceptable because it interferes with occupants' views to the vision glazing. Photo by Marcus Sheffer.

EXAMPLES

Example 1. View type 1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart

A classroom is assessed for compliance with the requirement for view type 1. The classroom has a total floor area of 750 square feet (70 square meters) and no permanent interior obstructions. To identify compliant areas within the classroom, the team has identified representative points on the classroom floor plan with two lines of sight at least 90 degrees apart (Figure 9) and determined that 500 square feet (45 square meters) of the classroom complies with the requirement.

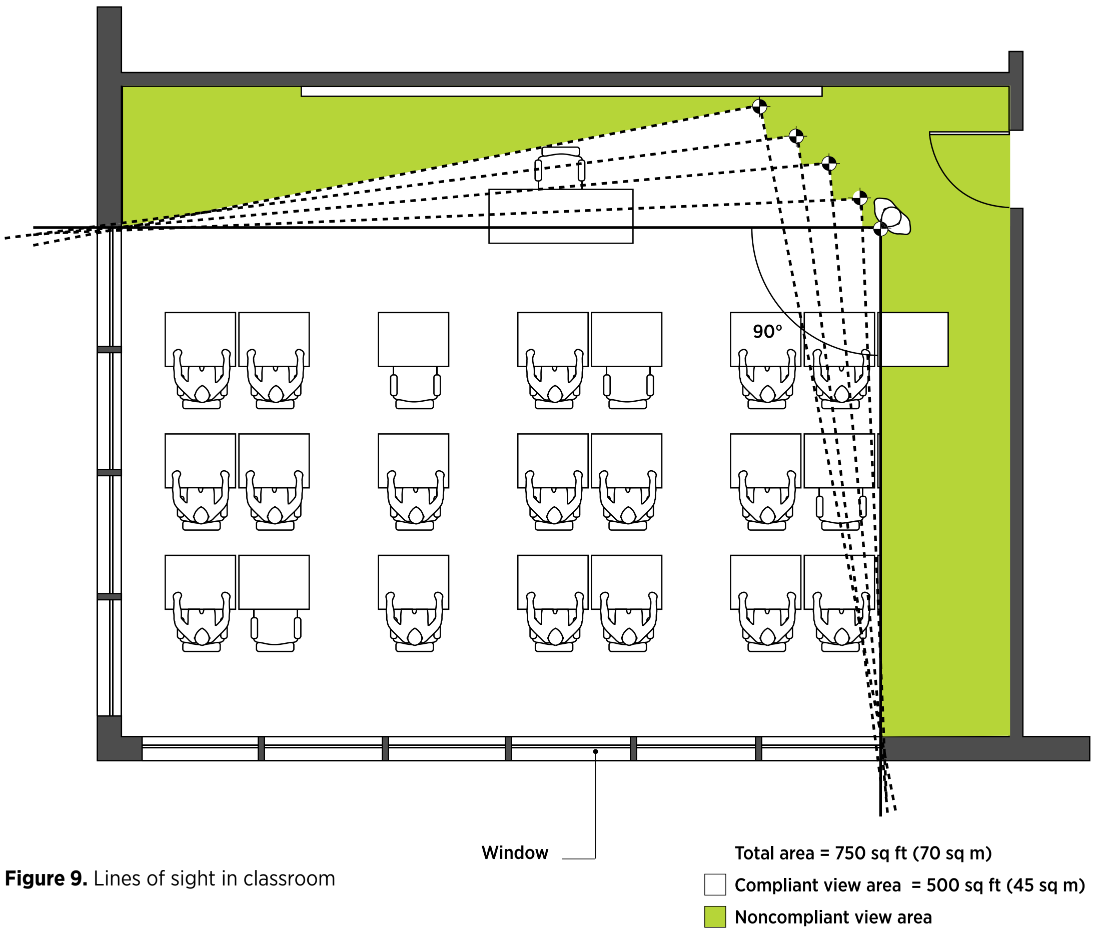


Figure 9. Lines of sight in classroom

Example 2. View type 2. Views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing

A regularly occupied space on the southeast side of the project building is assessed for compliance with requirements for view type 2. A section drawing of the building and adjacent properties is prepared to demonstrate that the space has views of trees close to the building and objects 25 feet (7.5 meters) from the exterior glazing (Figure 10). The section also shows that the space, which is an office, has no permanent interior obstructions, so this regularly occupied area meets the requirements.

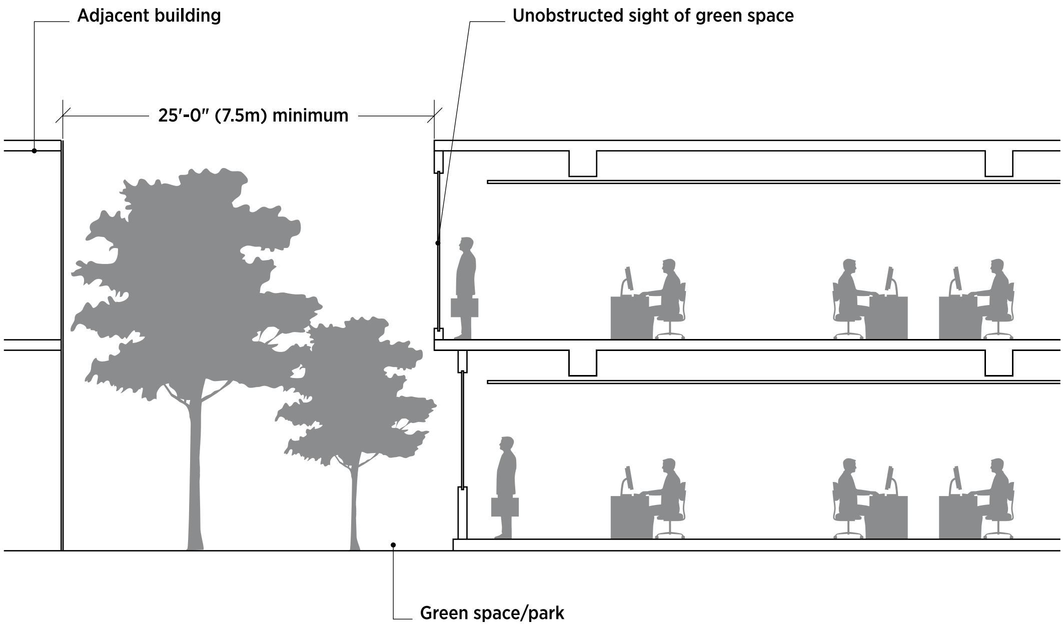


Figure 10. Flora within sight of space

Figures 11 illustrates a view with flora.

Figure 11. Planters outside a school. Photo by Marcus Sheffer.

Example 3. View type 3. Unobstructed views located within the distance of three times the head height of the vision glazing

An open-plan office space (Open Office 1) is assessed for compliance with the quality view requirement to have unobstructed views located within the distance of three times the head height of the vision glazing. A section view of the space is prepared to demonstrate that there are no permanent interior obstructions within 29 feet 3 inches (8.9 meters) of the vision glazing, which has a head height of 9 feet 9 inches (3 meters). The office space is compliant with the requirement (Figure 12).

In the same building, a similar open office space is also assessed for compliance. A section view of the space is prepared, but in this case, there are permanent interior obstructions within 29 feet 3 inches (8.9 meters) of the vision glazing, which has a head height of 9 feet 9 inches (3 meters). The fixed workstation with partitions and separate partition are both considered permanent interior obstructions. This open office space is not compliant with the requirement (Figure 12).

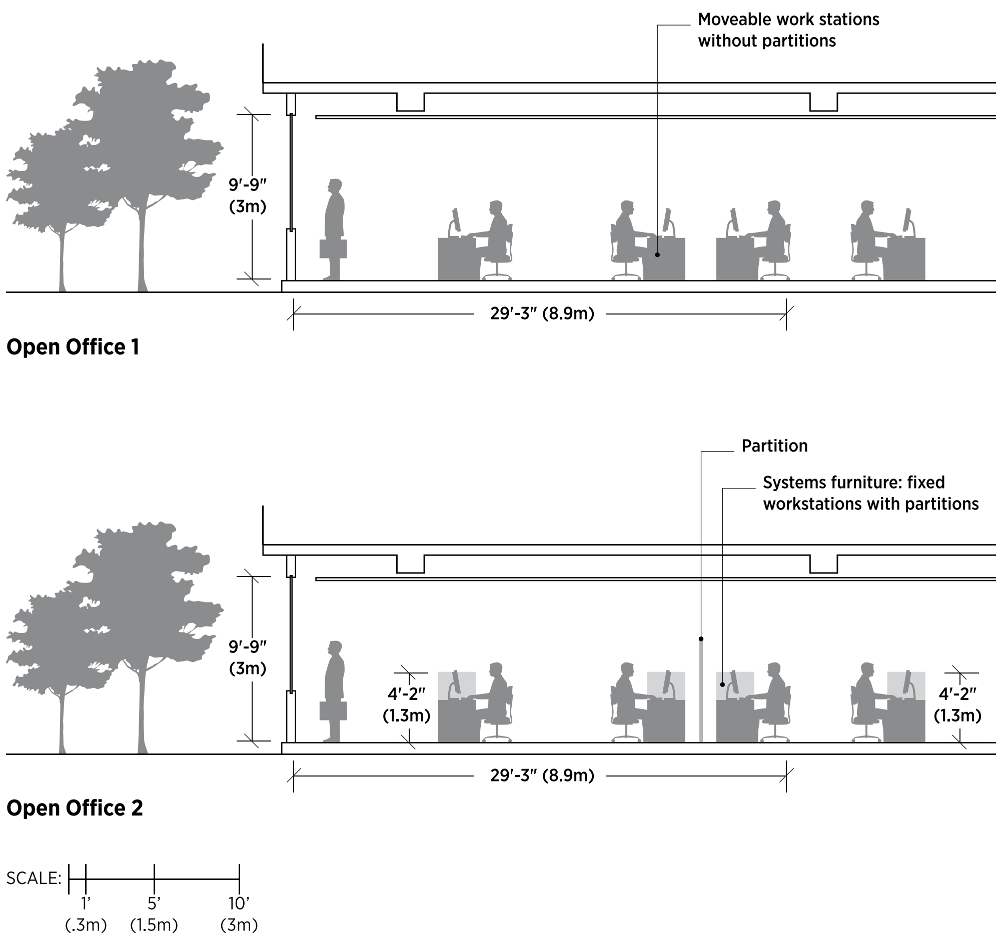


Figure 12. Compliant and noncompliant office spaces

Example 4. View type 4. Views with a view factor of 3 or greater, as defined in *Windows and Offices; A Study of Office Worker Performance and the Indoor Environment*

The primary view for a workstation in an open-plan office (Figure 13) is evaluated and assigned a view factor of 5, based on the view factor illustrations provided in Figure 3. The view factor is rated 5 because the workstation is directly in front of two large windows, with no obstructions or odd angles disrupting the view to the outdoors.

Figure 13. Workstation with view factor of 5. Photo by Marcus Sheffer.

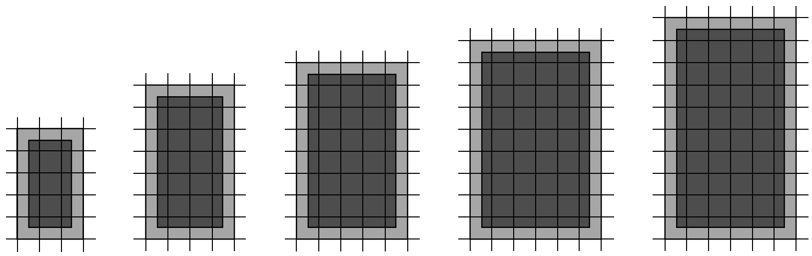
Example 5. Views into Atrium

Figure 14 illustrates how views into a sunlit interior space can be an alternative to views to the outdoors. This approach can be used for up to 30% of the regularly occupied floor area. The requirements for direct line of sight and two view types still apply.

Figure 14. View into atrium. The Christman Building: Photo by Gene Meadows.

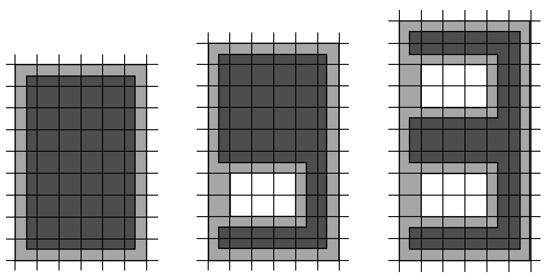
Example 6. Health care perimeter area examples

Figures 15 illustrates strategies that hospitals and other health care facilities can use to achieve compliance. The smaller the floor plate (Figure 15a), the greater the percentage of perimeter area. Courtyards also increase perimeter area (Figure 15b): all three floor plates have the same square footage, but the third has a much larger percentage of perimeter area because of the courtyard.



Floor Plate Area:	13,500 sq ft (1 254 sq m)	25,000 sq ft (2 323 sq m)	36,000 sq ft (3 345 sq m)	48,600 sq ft (4 515 sq m)	54,000 sq ft (5 017 sq m)
Compliant Perimeter Area (% of Area)	46.7	35.7	30.0	25.9	25.0

Impact of Floor Plate Area on Compliant Perimeter Area



Floor Plate Area:	48,600 sq ft (4 515 sq m)	48,600 sq ft (4 515 sq m)	48,600 sq ft (4 515 sq m)
Compliant Perimeter Area (% of Area)	25.9	38.9	51.9

Impact of Plan-enclosed Courtyards on Compliant Perimeter Area

Figure 15a. Effect of floor plate area on compliant perimeter area
Figure 15b. Effect of enclosed courtyards on compliant perimeter area

RATING SYSTEM VARIATIONS

Core and Shell

Develop a feasible tenant layout based on default occupancy (or other justifiable occupancy count) for use in analysis of quality views. Layouts should reflect the anticipated use of the unfinished spaces.

Warehouses and Distribution Centers

Follow all steps in Step-by-Step Guidance. Compliance for the office areas is calculated separately from compliance for the bulk storage, sorting, and distribution portions.

Healthcare

Review steps 1 and 2 in *Step-by-Step Guidance* and see *Further Explanation, Special Considerations for Healthcare Projects*.

Classify each floor of the building as inpatient or non-inpatient (see *Definitions*).

For the inpatient floors, in Step 3, identify all regularly occupied spaces (see *EQ Overview, Regularly Occupied Spaces*). Highlight them on the floor plan or furniture plan and list them with their floor areas (Table 1). Follow Steps 4 and 5. Confirm whether 75% of the inpatient regularly occupied floor area has two view types.

For the non-inpatient floors, calculate the perimeter area (see *Further Explanation, Calculations: Perimeter Area*). Because non-inpatient areas are often highly variable, each floor must be calculated separately. This component of the quality view calculation can be completed in the early stages of design, at block planning, so that project teams can determine whether massing decisions are likely to achieve the credit intent and adjust accordingly.

List the floor plate area and perimeter area (Table 5). Confirm that the perimeter area exceeds the values in Table 1 of the credit requirements.

TABLE 5. Tracking table for compliant perimeter area

Non-inpatient floor	Floor area (ft^2 or m^2)	Perimeter area (ft^2 or m^2)

Highlight the perimeter area on the floor plan or furniture plan and list all regularly occupied spaces within the highlighted area and their respective floor areas (Table 3) (see *EQ Overview, Regularly Occupied Spaces*). Follow Steps 4 and 5 in *Step-by-Step Guidance*. Confirm that 75% of the non-inpatient regularly occupied floor area has two view types.

TABLE 6. Healthcare quality views tracking table (non-inpatient, perimeter areas)

Regularly occupied space ID	Space type	Floor area (ft^2 or m^2)	Quality views		
			Floor area with direct line of sight to outdoors via vision glazing	View types	
				1	2

PROJECT TYPE VARIATIONS

Auditoriums

Auditoriums may be excluded from the view requirements.

Conference rooms dedicated to video conferencing

Conference rooms that are dedicated to video conferencing may be excluded from the view requirements.

Gymnasiums
Gymnasiums may be excluded from the view requirements.

Incomplete Spaces
See *Rating System Variations, Core and Shell.*

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach
Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects	View type			
		1: multiple lines of sight	2: exterior features	3: unobstructed views within 3H	4: view factor
List of all regularly occupied spaces, qualifying floor area in each space, and view features	X				
Sections, elevations, diagrams, renderings, or photos indicating sight lines to glazing do not encounter permanent interior obstructions.	X				
Floor plans or diagrams identifying regularly occupied spaces and the following:	X				
Multiple sight lines for each regularly occupied space		X			
Sight lines and exterior features labeled; provide multiple floor plans if view features change at varying building heights			X		
Sight lines and area indicating three times head height				X	
Area with view factor of 3 or greater					X
Sections, interior elevations, or other documentation that demonstrates the view factor assessment for the areas with a view factor of three or greater.					X
Method for determining view factor for each typical occupant location					X

RELATED CREDIT TIPS

EQ Credit Daylight. Window tints used for solar and glare control may hinder the quality of view by distorting the color of objects and light. Increasing the area of vision glazing may provide greater access to daylight.

EA Prerequisite Minimum Energy Performance. Increased window-to-wall ratio in design can alter energy performance and has a direct correlation to lighting design strategies to conserve energy. Increased glazing may contribute to heat gain and increased HVAC energy use, but daylighting reduces the need for electric lighting.

CHANGES FROM LEED 2009

- The exemplary performance requirements from LEED 2009 are now the basis for the credit requirements.
- Glazing must provide a clear view to the outdoors. The glazing does not have to be located between 30 and 90 inches (750 and 2300 millimeters) above the finished floor.
- Atriums now qualify for up to 30% of the total area.
- For Healthcare projects, the inpatient unit requirements now include nonperimeter area. The requirements for direct lines of sight in the perimeter area have been modified to align with other rating systems.

REFERENCED STANDARDS

***Windows and Offices: A Study of Office Worker Performance and the Indoor Environment*:** h-m-g.com

EXEMPLARY PERFORMANCE

New Construction, Core and Shell, Schools, Retail, Data Centers, Hospitality

Meet the requirements for 90% of all regularly occupied area.

Warehouses and Distribution Centers

Meet the requirements for 90% of the regularly occupied floor area in the office portion of the building, and for 50% of the regularly occupied floor area in the bulk storage, sorting, and distribution portions of the building.

Healthcare

For inpatient areas, meet the requirements for 90% of the regularly occupied floor area.

For noninpatient areas, exceed the area requirements in Table 1 by 10% or more.

DEFINITIONS

color rendering index a measurement from 0 to 100 that indictes how accurately an artificial light source, as compared with an incandescent light, displays hues. The higher the index number, the more accurately the light is rendering colors. Incandescent lighting has a color rendering index above 95; standard high-pressure sodium lighting (such as orange-hued roadway lights) measures approximately 25; many fluorescent sources using rare earth phosphors have a color rendering index of 80 and above. (Adapted from U.S. ENERGY STAR)

inpatient unit any medical, surgical, maternity, specialty, or intensive-care unit where an individual receives care for more than 23 hours

movable furniture and partitions items that can be moved by the users without the need of tools or assistance from special trades and facilities management

non-inpatient area a public space, diagnostic or treatment area, ambulatory unit, or any other space in a health care facility that is not for individuals who have been admitted for care

permanent interior obstruction a structure that cannot be moved by the user without tools or assistance from special trades and facilities management. Examples include lab hoods, fixed partitions, demountable opaque full- or partial-height partitions, some displays, and equipment.

vision glazing the glass portion of an exterior window that permits views to the exterior or interior. Vision glazing must allow a clear image of the exterior and must not be obstructed by frits, fibers, patterned glazing, or added tints that distort color balance.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Acoustic Performance

This credit applies to:

New Construction (1 point)
Schools (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1–2 points)

INTENT

To provide workspaces and classrooms that promote occupants' well-being, productivity, and communications through effective acoustic design.

REQUIREMENTS

NEW CONSTRUCTION, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

For all occupied spaces, meet the following requirements, as applicable, for HVAC background noise, sound isolation, reverberation time, and sound reinforcement and masking.

HVAC Background Noise

Achieve maximum background noise levels from heating, ventilating, and air conditioning (HVAC) systems per 2011 ASHRAE Handbook, HVAC Applications, Chapter 48, Table 1; AHRI Standard 885-2008, Table 15; or a local equivalent. Calculate or measure sound levels.

For measurements, use a sound level meter that conforms to ANSI S1.4 for type 1 (precision) or type 2 (general purpose) sound measurement instrumentation, or a local equivalent.

Comply with design criteria for HVAC noise levels resulting from the sound transmission paths listed in ASHRAE 2011 Applications Handbook, Table 6; or a local equivalent.

Sound Transmission

Meet the composite sound transmission class (STC_C) ratings listed in Table 1, or local building code, whichever is more stringent.

TABLE 1. Minimum composite sound transmission class ratings for adjacent spaces

Adjacency combinations		STC_c
Residence (within a multifamily residence), hotel or motel room	Residence, hotel or motel room	55
Residence, hotel or motel room	Common hallway, stairway	50
Residence, hotel or motel room	Retail	60
Retail	Retail	50
Standard office	Standard office	45
Executive office	Executive office	50
Conference room	Conference room	50
Office, conference room	Hallway, stairway	50
Mechanical equipment room	Occupied area	60

Reverberation Time

Meet the reverberation time requirements in Table 2 (adapted from Table 9.1 in the Performance Measurement Protocols for Commercial Buildings[1]).

TABLE 2. Reverberation time requirements

Room type	Application	T60 (sec), at 500 Hz, 1000 Hz, and 2000 Hz
Apartment and condominium	—	< 0.6
Hotel/motel	Individual room or suite	< 0.6
	Meeting or banquet room	< 0.8
Office building	Executive or private office	< 0.6
	Conference room	< 0.6
	Teleconference room	< 0.6
	Open-plan office without sound masking	< 0.8
	Open-plan office with sound masking	< 0.8
Courtroom	Unamplified speech	< 0.7
	Amplified speech	< 1.0
Performing arts space	Drama theaters, concert and recital halls	Varies by application
Laboratories	Testing or research with minimal speech communication	< 1.0
	Extensive phone use and speech communication	< 0.6
Church, mosque, synagogue	General assembly with critical music program	Varies by application
Library		< 1.0
Indoor stadium, gymnasium	Gymnasium and natatorium	< 2.0
	Large-capacity space with speech amplification	< 1.5
Classroom	—	< 0.6

1. *Adapted from ASHRAE (2007d), ASA (2008), ANSI (2002), and CEN (2007)*

Sound Reinforcement and Masking Systems

Sound Reinforcement

For all large conference rooms and auditoriums seating more than 50 persons, evaluate whether sound reinforcement and AV playback capabilities are needed.

If needed, the sound reinforcement systems must meet the following criteria:

- Achieve a speech transmission index (STI) of at least 0.60 or common intelligibility scale (CIS) rating of at least 0.77 at representative points within the area of coverage to provide acceptable intelligibility.
- Have a minimum sound level of 70 dBA.
- Maintain sound-level coverage within +/–3 dB at the 2000 Hz octave band throughout the space.

Masking Systems

For projects that use masking systems, the design levels must not exceed 48 dBA. Ensure that loudspeaker coverage provides uniformity of +/–2 dBA and that speech spectra are effectively masked.

SCHOOLS

HVAC Background noise

Achieve a background noise level of 35 dBA or less from heating, ventilating, and air-conditioning (HVAC) systems in classrooms and other core learning spaces. Follow the recommended methodologies and best practices for mechanical system noise control in ANSI Standard S12.60–2010, Part 1, Annex A.1; the 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Sound and Vibration Control, with errata; AHRI Standard 885–2008; or a local equivalent.

Sound Transmission

Design classrooms and other core learning spaces to meet the sound transmission class (STC) requirements of ANSI S12.60–2010 Part 1, or a local equivalent. Exterior windows must have an STC rating of at least 35, unless outdoor and indoor noise levels can be verified to justify a lower rating.

HEALTHCARE

Design the facility to meet or exceed the sound and vibration criteria outlined below, which are adapted from the 2010 FGI Guidelines for Design and Construction of Health Care Facilities (“2010 FGI Guidelines”) and the reference document on which it is based, Sound and Vibration Design Guidelines for Health Care Facilities (“2010 SV Guidelines”).

OPTION 1. SPEECH PRIVACY, SOUND ISOLATION, AND BACKGROUND NOISE (1 POINT)

Speech Privacy and Sound Isolation

Design sound isolation to achieve speech privacy, acoustical comfort, and minimal annoyance from noise-producing sources. Consider sound levels at both source and receiver locations, the background sound at receiver locations, and the occupants’ acoustical privacy and acoustical comfort needs. Speech privacy is defined as “techniques…to render speech unintelligible to casual listeners” (ANSI T1.523-2001, Telecom Glossary 2007).

Design the facility to meet the criteria outlined in the sections of Table 1.2-3, Design Criteria for Minimum Sound Isolation Performance between Enclosed Rooms, and Table 1.2-4 Speech Privacy for Enclosed Room and Open-Plan Spaces (in the 2010 FGI Guidelines and 2010 SV Guidelines).

Calculate or measure sound isolation and speech privacy descriptors achieved for representative adjacencies as necessary to confirm compliance with the criteria in the 2010 FGI Guidelines, Sections1.2-6.1.5 and 1.2-6.1.6, and the 2010 SV Guidelines (including the appendix).

Background Noise

Consider background noise levels generated by all building mechanical-electrical-plumbing systems, air distribution systems and other facility noise sources under the purview of the project building design-construction team.

Design the facility to meet the 2010 FGI Guidelines, Table 1.2-2 Minimum-Maximum Design Criteria for Noise in representative interior rooms and spaces.

Calculate or measure sound levels in representative rooms and spaces of each type to confirm compliance with criteria in the above-referenced table using a sound level meter that conforms to ANSI S1.4 for type 1 (precision) or type 2 (general purpose) sound measurement instrumentation. For spaces not listed in Table 1.2-2, refer to ASHRAE 2011 Handbook, Chapter 48, Sound and Vibration Control, Table 1.

OPTION 2. ACOUSTICAL FINISHES AND SITE EXTERIOR NOISE (1 POINT)

Meet the requirements for acoustical finishes and site exterior noise.

Acoustical Finishes

Specify materials, products systems installation details, and other design features to meet the 2010 FGI Guidelines, Table 1.2-1, Design Room Sound Absorption Coefficients (including associated sections of the appendix) and the 2010 SV Guidelines.

Calculate or measure the average sound absorption coefficients for representative unoccupied rooms of each type in the building to confirm conformance with the requirements.

Site Exterior Noise

Minimize the effect on building occupants of site exterior noise produced by road traffic, aircraft flyovers, railroads, on-site heliports, emergency power generators during maintenance testing, outdoor facility MEP and building services equipment, etc. Also minimize effects on the surrounding community from all facility MEP equipment and activities as required to meet (1) local applicable codes or (2) Table 1.2-1 of the 2010 FGI Guidelines, Table 1.2-1, and the 2010 SV Guidelines, Table 1.3-1, whichever is more stringent.

Comply with the 2010 FGI Guidelines for the following noise sources:

- heliports, A1.3-3.6.2.2;
- generators, 2.1-8.3.3.1;
- mechanical equipment, 2.1-8.2.1.1; and
- building services, A2.2-5.3

Measure and analyze data to determine the exterior noise classification (A, B, C, or D) of the facility site. See the 2010 FGI Guidelines, Categorization of Health Care Facility Sites by Exterior Ambient Sound, Table A1.2a, and the 2010 SV Guidelines, Table 1.3-1.

Design the building envelope composite STC rating based on the 2010 FGI Guidelines, Categorization of Health Care Facility Sites by Exterior Ambient Sound, and show conformance with requirements.

For exterior site exposure categories B, C, or D, calculate or measure the sound isolation performance of representative elements of the exterior building envelope to determine the composite sound transmission class (STCc) rating for representative façade sections. Measurements should generally conform to ASTM E966, Standard Guide for Field Measurements of Airborne Sound Insulation of Building Façades and Façade Elements, current edition.

BEHIND THE INTENT

This credit challenges project teams to address best practices in acoustic design as an indoor environmental quality imperative that complements other green building practices.

Research by the Center for the Built Environment (CBE) of 34,000 building inhabitants[2] showed that LEED buildings outperform standard design in all areas of indoor environmental quality except acoustics (Figure 1). Acoustic performance typically is considered during the design process, the study found, yet teams are just beginning to understand the trade-offs with other green building practices, such as open floor planning, highly efficient HVAC systems, and efficient lighting strategies.

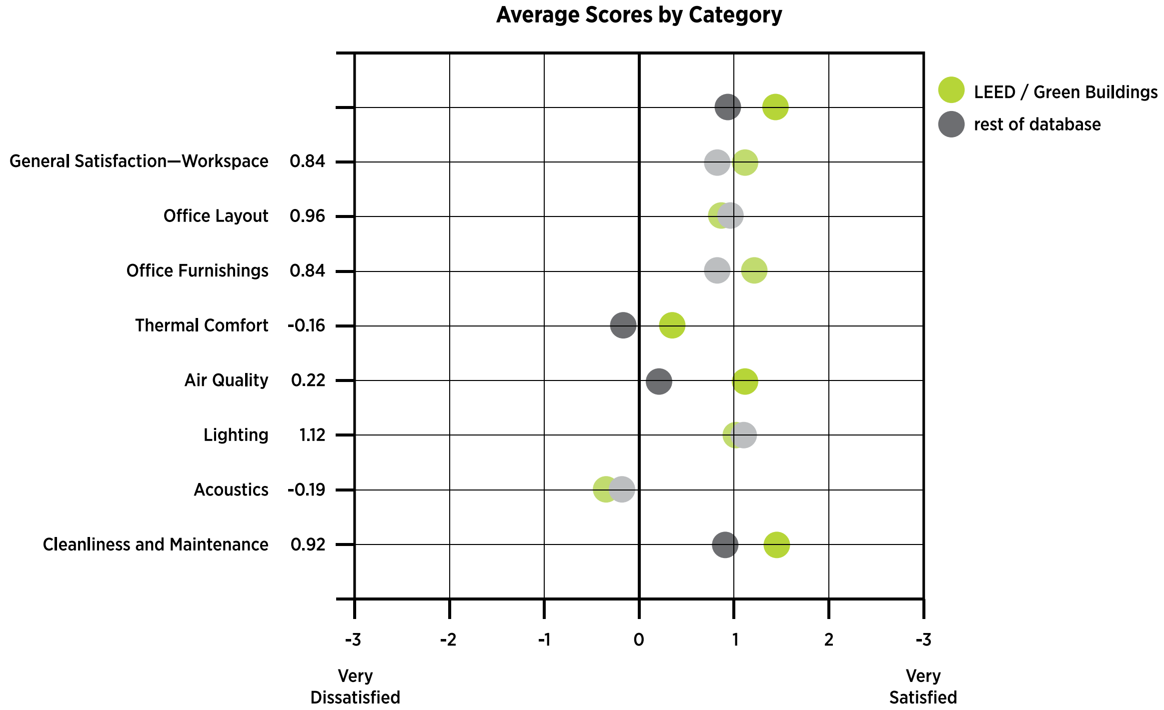


Figure 1. Occupants' satisfaction in conventional versus LEED-certified buildings. Used with permission from the Center for the Built Environment, UC Berkeley.

LEED 2009 covered acoustics in the Schools and Healthcare rating systems, partly because it critically affects learning and healing environments. Now an acoustics credit is available to all new construction projects, challenging project teams to balance acoustical design strategies with considerations for daylighting, thermal comfort, and other performance areas that must be considered when planning systems and indoor spaces. In all project types, well-designed acoustics can enhance the environmental quality of the space by facilitating communication, increasing productivity, improving the well-being of workers, or aiding in noise control and speech privacy.

2. *Huizenga, C., et al. 2005. LEED Post-occupancy Evaluation: Taking Responsibility for the Occupants. cbe.berkeley.edu/research/pdf_files/Huizenga_Greenbuild2005.pdf (accessed June 12, 2013).*

The benefits of open collaboration spaces should be balanced with acoustic design. In schools, where communication between students and teachers affects the learning process, acoustic performance is essential (see EQ Prerequisite Minimum Acoustic Performance). In Healthcare projects, the acoustic environment affects patients' privacy and recuperation. Careful sound isolation supports confidential personal health discussions among patients, their families, and caregivers; it also allows health care workers to communicate more effectively with each other. Better acoustics do matter: research links poor acoustic performance to sleep disturbance,[3,4] increased blood pressure and heart rates, and stress.[5]

STEP-BY-STEP GUIDANCE

NEW CONSTRUCTION, DATA CENTERS, WAREHOUSES AND DISTRIBUTION CENTERS, HOSPITALITY

STEP 1. DEFINE ACOUSTIC NEEDS FOR EACH SPACE

Identify occupied spaces and determine the following:

- Activities or user groups within each space and adjacencies
- Privacy or sound sensitivity requirements

STEP 2. REVIEW ACOUSTIC CRITERIA

Evaluate how the four performance areas addressed by this credit affect each applicable space:

- **HVAC background noise levels.** Engineers or acoustic experts will need to analyze background noise levels coming from HVAC equipment.
- **Sound isolation.** Designers will need to specify materials to meet sound transmission class ratings.
- **Reverberation time.** Designers will need to specify sound-absorbing treatments and/or revisit room size to address reverberation time.
- **Sound reinforcement and masking systems.** Designers will need to analyze STI or CIS, sound level and sound-level coverage for spaces with sound reinforcement systems. Designers will also need to analyze sound level, loudspeaker coverage, and speech spectra for spaces with masking systems.

Prepare a log or spreadsheet to record pertinent acoustic information for each space.

Determine how the acoustic requirements fit into the design process so that each can be addressed by the responsible party at the appropriate time.

STEP 3. ADDRESS HVAC BACKGROUND NOISE

Identify equipment and air distribution elements that could contribute to HVAC background noise in occupied spaces. The following steps refer to the referenced standard, 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control ("Chapter 48").

- When selecting and designing HVAC systems, consider basic acoustic design techniques (e.g., Chapter 48, page 48.8).
- Consider specific source design considerations (e.g., Chapter 48, pages 48.1–48.41 and 48.8–48.30).
- Compile acoustic performance data at specific operating points from the HVAC equipment manufacturer's data. This information may inform the HVAC background noise criteria used for compliance.
- Consider source-receiver paths when locating occupied spaces, and HVAC equipment. For example, noise-generating HVAC equipment could be placed above a corridor rather than above a conference room. Review Chapter 48, Table 6, and address each applicable transmission path.

3. *Aaron, J.N., et al., "Environmental Noise as a Cause of Sleep Disruption in an Intermediate Respiratory Care Unit," SLEEP 19(9) (1996): 707–10.*
4. *Novaes, M.A., et al., "Stressors in ICU: Patients' Evaluation," Intensive Care Medicine 23(12): 1282–5.*
5. *Baker, C.F., "Discomfort to Environmental Noise: Heart Rate Responses of SICU Patients," Critical Care Nursing Quarterly 15(2) (1992): 75–90*

STEP 4. VERIFY HVAC BACKGROUND NOISE

Determine noise criteria (NC), room criteria (RC), A-weighted sound pressure levels, or C-weighted sound pressure levels for each occupied space through one or more of the following methods (see *Further Explanation, Selecting a Sound Rating Method*). Consider sound pressure levels from HVAC equipment only; plumbing, lighting, and electrical may be excluded.

- Calculate sound pressure levels per Chapter 48 and follow the steps outlined in the HVAC Noise-Reduction Design Procedures section of the handbook. Calculations may be done in the design phase.
- Calculate sound pressure levels per AHRI Standard 885–2008, Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets. Follow the steps outlined in Section 6, Calculation Procedures for Estimating Sound Levels in Occupied Spaces. Calculations may be done in the design phase.
- Measure sound pressure levels per Chapter 48. Follow field measurement guidelines from the Determining Compliance section. Follow guidelines from the Room Noise Measurements sections. The measurements must be performed postconstruction and should be done in furnished spaces with HVAC systems operating in typical conditions and while no occupants are present. Noises from sources other than HVAC systems should be minimized or turned off during testing.

A local standard, procedure, or handbook that is equivalent to one of the above methods may also be used.

Prepare a narrative that describes the methods followed and a summary report with measurements or calculations.

Demonstrate compliance with the overall sound pressure limits listed in Chapter 48, page 48.3, Table 1, or AHRI Standard 885-2008, Table 15, for applicable spaces.

STEP 5. VERIFY NOISE REDUCTION METHODS FOR SOUND TRANSMISSION PATHS

In a narrative and associated drawings or details, highlight each transmission path from Chapter 48, Table 6, that is applicable to the project and the specific noise reduction measures selected.

STEP 6. IDENTIFY ADJACENCIES FOR SOUND ISOLATION REQUIREMENTS

Identify occupied spaces and their adjacency combinations. Review Table 1 from the credit requirements and the local building code to determine the applicable composite sound transmission class (STC_C) rating.

Identify all assemblies (e.g., wall, floor-ceiling, roof-ceiling, door, window) that serve to acoustically isolate each occupied space.

STEP 7. VERIFY SOUND ISOLATION

Verify that the assemblies for each occupied space meet the sound isolation requirements. Demonstrate compliance through published data, calculation, or measurement, as follows:

- **Published data.** Select walls, doors, and windows with published manufacturer's data
- **Calculation.** Perform averaging calculations that allow a trade-off between higher STC of walls and lower STC ratings of doors, windows, and penetrations (see *Further Explanation, Determining Composite Sound Transmission Class*). Calculations may be done in the design phase.
- **Measurement.** Measure noise isolation class (NIC) for all assemblies per Annex A.3 of ANSI S12.60–2010 and compare the results with the sound isolation requirements. A NIC rating within 3 points of the specified STC rating may be considered compliant. Measurements cannot be performed until after the substantial completion of construction.

Assemblies with similar construction details may be grouped together. Any significant variance in opening areas, such as window or door ratios, should be evaluated separately.

Compile a list of each occupied space. For each space, list the maximum STC rating, the design STC rating or measured results, and data or calculations to support the values.

STEP 8. IDENTIFY SPACE REVERBERATION TIME REQUIREMENTS

Use Table 2 in the credit requirements to determine reverberation time requirements for each occupied space in the project. For spaces that vary by application or are not listed in the table, use criteria from referenced standards, or use values for the space type with the closest functional use.

STEP 9. IMPLEMENT REVERBERATION TIME MITIGATION STRATEGIES

Use sound-absorptive materials or other strategies to limit the reverberation times for each occupied space as appropriate for the room type.

Consider the following surfaces when specifying materials:

- Sound-absorptive materials can be applied to any planar surface in the space. Although applying treatment to the walls is typically effective, a sound-absorptive ceiling is generally more cost-effective.
- Absorptive wall surfaces or vertical acoustic panels in spaces that require hard surfaces, such as laboratories
- Soft or upholstered backs and seats for spaces with seating
- Window curtains, ceiling baffles, or other acoustic finishes

Determine sound-absorption coefficients for absorptive materials. Use manufacturers' documentation or Table 3 for common materials.

TABLE 3. Sound absorption coefficients for common materials

	Coefficient (α)				Coefficient (α)		
Material	**500HZ**	**1000HZ**	**2000HZ**	**Material**	**500Hz**	**1000Hz**	**2000HZ**
Walls				**Floor**			
Brick, unglazed	.03	.04	.05	Concrete or Terrazzo	.015	.02	.02
Brick, unglazed, painted	.02	.02	.02	Linoleum, asphalt, rubber, or cork tile on concrete	.03	.03	.03
Plaster, gypsum, or lime, smooth finish on tile or brick	.02	.03	.04	Wood	.10	.07	.06
Plaster, gypsum, or lime, rough or smooth finish on lath	.06	.05	.04	Wood parquet in asphalt on concrete	.07	.06	.06
Concrete block, light, porous	.31	.29	.39	Carpet, heavy, on concrete	.14	.37	.60
Concrete block, dense, painted	.06	.07	.09	Same, on 40 oz hairfelt or foam rubber	.57	.69	.71
Gypsum boards. 1/2-inch nailed to 2x4s, 16 inches o.c.	.05	.04	.07	Same, with impermeable latex backing on 40 oz hairfelt or foam rubber	.39	.34	.48
Plywood paneling, 3/8-inch thick	.17	.09	.10	Marble or glaze tile	.01	.01	.02
Large panes of heavy plate glass	.04	.03	.02	**Fabrics**			
Ordinary window glass	.18	.12	.07	Light velour, 10 oz per sq yd, hung straight, in contact with walll	.11	.17	.24
Misc				Medium velour, 14 oz per sq yd, draped to half area	.49	.75	.70
Chairs, metal or wood seats, each, unoccupied	.22	.39	.38	Heavy velour, 18 oz per sq yd, draped to half area	.55	.72	.70

STEP 10. VERIFY THAT REVERBERATION TIME REQUIREMENTS ARE MET

Calculate or measure the reverberation time for each occupied space (see *Further Explanation, Reverberation Time*).

- Reverberation time must be verified at 500, 1,000, and 2,000 Hz.
- Retain calculations and measurements for credit documentation.
- Spaces with identical size and material treatments may be documented together. To reduce documentation burden, calculations and measurements can also be based on acoustically critical spaces or room types, or on worst-case combinations of room assemblies.

STEP 11. SELECT SOUND REINFORCEMENT AND MASKING SYSTEMS, IF NEEDED

Determine whether the project will have any sound reinforcement or masking systems (see *Further Explanation, Sound Reinforcement,* and *Masking Systems*). This credit does not require that sound reinforcement or masking systems be implemented, but it does require that any installed system meet specific criteria.

- For each space using sound reinforcement, select sound reinforcement strategies that meet the speech intelligibility, sound level, and sound-level coverage credit requirements (see *Further Explanation, Meeting Sound Reinforcement Credit Requirements*).
- For each space using masking systems, select a system that meets the credit requirements for sound level and system uniformity (see *Further Explanation, Selecting a Sound Rating Method*).
- Document the needs that are addressed through a sound reinforcement or masking system, or the rationale for not including these systems.

SCHOOLS

STEP 1. IDENTIFY ALL CLASSROOMS AND OTHER CORE LEARNING SPACES

See EQ Prerequisite Minimum Acoustic Performance. Spaces addressed for this credit should be consistent with those addressed for the prerequisite.

STEP 2. REVIEW ACOUSTIC CRITERIA

Review the acoustic design documentation developed for EQ Prerequisite Minimum Acoustic Performance and append it as necessary for the HVAC background noise and sound isolation requirements of this credit.

- **HVAC background noise.** Using the results from Step 4 of the HVAC background noise section in the prerequisite, confirm that all classroom and core learning spaces comply with a 35 dBA maximum.
- **Sound isolation.** Designers must specify materials to meet sound transmission class ratings.

Prepare a log or spreadsheet to record the pertinent acoustic information for each space.

Determine how the acoustic requirements will be integrated into the design process so that they can be addressed by the responsible party at the appropriate time.

STEP 3. ADDRESS HVAC BACKGROUND NOISE

Follow the step-by-step guidance for HVAC background noise in EQ Prerequisite Minimum Acoustic Performance, and verify that background noise does not exceed 35 dBA in any applicable space. The credit threshold will likely require the adoption of a layered strategy that combines several best practices for low-noise mechanical design. Teams are encouraged to engage mechanical designers or acoustic experts familiar with the referenced standards who can calculate HVAC background noise levels during design development.

STEP 4. IDENTIFY ADJACENCIES

Identify the types of spaces that are adjacent to each core learning space. Review ANSI S12.60–2010, Section 5.4.2, Table 4, to understand the types of adjacent spaces and determine the applicable required STC ratings.

- Review ANSI S12.60–2010, Section 5.4.2.3, to determine which adjacencies require composite wall STC ratings (which account for doors, windows, and other penetrations).
- Review Section 5.4.2.4 to identify the STC ratings for interior door assemblies and their associated window glazing.
- Windows in core learning spaces must have a minimum STC rating of 35 in lieu of the ratings in Section 5.4.2.

STEP 5. DESIGN FOR MAXIMIZING SOUND ISOLATION

Identify all assemblies (e.g., wall, floor-ceiling, roof-ceiling, door, window) that serve to acoustically isolate each core learning space.

STEP 6. VERIFY SOUND ISOLATION

Verify that the assemblies for each core learning space meet the sound isolation requirements listed in ANSI S12.60–2010, Part 1, Section 5.4.2, Indoor-to-Indoor Attenuation of Airborne Sound and Table 4. Demonstrate compliance through published data, calculation, or measurement, as follows:

- **Published data.** Select walls, doors, and windows with published manufacturer's data
- **Calculation.** If necessary, perform averaging calculations according to Sections 5.4.2.3 and 5.4.2.4 of the ANSI standard (see *Further Explanation, Determining Composite Sound Transmission*). Calculations may be done in the design phase.

- **Measurement.** Measure noise isolation class (NIC) for all assemblies per Annex A.3 of ANSI S12.60–2010 and compare with the sound isolation requirements. A NIC rating within 3 points of the specified STC rating may be considered compliant. Measurements cannot be performed until after the substantial completion of construction.

Assemblies may be grouped together based on similar construction details. Any significant variance in opening areas, such as window or door ratios, should be evaluated separately.

Compile a list of each core learning space. For each space, list the maximum STC rating, the design STC rating or measured results, and data or calculations to support the values.

HEALTHCARE

STEP 1. IDENTIFY OCCUPIED SPACES

Create a table of all occupied spaces in the project and the function of each space.

STEP 2. SELECT OPTION

Determine whether the project will pursue one or both options.

- Option 1 includes requirements related to interior spaces and partitions.
- Option 2 has requirements for interior finishes, the building envelope, and exterior noise sources.

Both Options 1 and 2 may involve multiple design strategies:

- Separating patient rooms from treatment areas, media areas, and staff areas
- Including buffer spaces in the building program
- Using partial-height barriers in open-plan areas and isolating partitions in closed-plan areas
- Installing sound-absorptive finishes
- Addressing mechanical system noise and medical equipment noise
- Installing ambient background noise or electronic masking systems
- Installing interior vision panels
- Installing close-fit doors with gaskets where appropriate

Both options reference the 2010 FGI Guidelines for Design and Construction of Health Care Facilities (“2010 FGI Guidelines”) and the Sound and Vibration Design Guidelines for Health Care Facilities (“2010 SV Guidelines”) (see *Further Explanation, Using 2010 FGI Guidelines and 2010 SV Guidelines*).

Option 1. Speech Privacy, Sound Isolation, and Background Noise

STEP 1. IDENTIFY ADJACENCIES AND ISOLATION REQUIREMENTS

In the table of occupied spaces and functions, note adjacencies. Review the 2010 FGI Guidelines, Table 1.2-3, to determine the applicable composite sound transmission class (STC) ratings. Consider adjacencies for interior spaces only; exterior adjacency is addressed elsewhere.

STEP 2. DESIGN FOR SOUND ISOLATION

Identify all demising wall assemblies and floor-ceiling assemblies that acoustically separate each applicable occupied space, including patient rooms, intensive-care units, examination rooms, treatment rooms, toilet rooms, consultation rooms, MRI rooms, corridors, and public space.

For all applicable assemblies, use products with sound isolation properties that meet the STC ratings in the 2010 FGI Guidelines, Table 1.2-3.

STEP 3. VERIFY SOUND ISOLATION

Verify that the assemblies for each occupied space meet the sound isolation requirements. Demonstrate compliance through published data, calculation, or measurement, as follows:

- **Published data.** Select walls, doors, and windows with published manufacturer’s data
- **Calculation.** Perform averaging calculations that allow a trade-off between higher STC of walls and lower STC ratings of doors, windows, and penetrations (see *Further Explanation, Determining Composite Sound Transmission Class*). Calculations may be done in the design phase.

- **Measurement.** Measure noise isolation class (NIC) for all assemblies per Annex A.3 of ANSI S12.60–2010 and compare with the sound isolation requirements. A NIC rating within three points of the specified STC rating may be considered compliant. Measurements cannot be performed after the substantial completion of construction.

Assemblies may be grouped together based on similar construction details. Any significant variance in opening areas, such as window or door ratios, should be evaluated separately.

Compile a list of each occupied space. For each space, list the maximum STC rating, the design STC rating or measured results, and data or calculations to support the values.

STEP 4. IDENTIFY SPEECH PRIVACY REQUIREMENTS

In the table developed for Step 1, identify whether each space is fully enclosed or open to other spaces, and work with the owner to determine the level of speech privacy desired in each space and required to comply with the Health Insurance Portability and Accountability Act (HIPAA) and other privacy protection statutes.

- Classify speech privacy goals as “normal,” “confidential,” or “secure” based on the sensitivity of expected conversations. Open-plan spaces typically permit limited opportunities for speech privacy, so activities that require speech privacy may be assigned to adjacent enclosed spaces.
- Enclosed rooms that require confidential levels may include admitting areas, psychiatric and psychological interviewing and testing rooms, hematology labs, clinical areas, examination rooms, consultation rooms, and private offices where speech privacy is critical to the services performed.
- Secure speech privacy, the highest level, is generally defined as the total inaudibility of speech in adjacent spaces. This level of privacy may be required in special clinical areas, such as hearing test booths, speech therapy rooms, and special psychiatric suites.
- Engage an expert familiar with speech privacy to select the speech privacy rating method that will be used to evaluate compliance and to provide design assistance. Refer to the 2010 FGI Guidelines, page 27, Appendix A1.2-6.1.6.1, for further discussion of the four methods (privacy index, articulation index, speech transmission index, and speech intelligibility index).

STEP 5. DESIGN FOR SPEECH PRIVACY

Two approaches to providing adequate speech privacy are common. The first is to reduce sound transmission between spaces by installing improved partition assemblies (for enclosed rooms) and partial-height partitions and sound-absorptive room finishes (for open-plan spaces). The second is to provide an adequate level of continuous background sound.

STEP 6. VERIFY SPEECH PRIVACY PERFORMANCE

Evaluate each occupied space for speech privacy and compare to the speech privacy goals in the 2010 FGI Guidelines, Table 1.2-4 for the selected method. Seek expert guidance on the appropriate calculation or site measurement methodology, or review the standards referenced in 2010 FGI Guidelines, page 27, Appendix A1.2-6.1.6.1.

Retain copies of testing or calculation procedures for documentation.

STEP 7. ADDRESS BACKGROUND NOISE

Identify all equipment that could contribute to background noise in occupied spaces.

- Requirements of this credit apply to all elements within the project scope that have the potential to generate audible noise in occupied rooms. Examples include all building mechanical, electrical, plumbing systems, and air distribution elements.
- Consider source-receiver paths when locating occupied spaces and HVAC equipment. For example, an air-handling unit could be placed above a corridor rather than above a patient’s room. Control ambient noise, including mechanical system noise, by selecting quiet fans that rotate at slow speeds, changing filters on a regular basis, locating sound attenuators at variable air volume terminal boxes where needed, installing vibration isolators on rotating and vibrating equipment, providing duct attenuation, designing ductwork to minimize “cross-talk” from one room to another, and controlling airflow velocity in the ductwork to minimize turbulence noise.
- Compile acoustic performance data at the specific operating points from the equipment manufacturers’ data. This information may inform the background noise criteria used for compliance (see *Further Explanation, Selecting a Sound Rating Method*).
- Because of the sensitive nature of these projects’ occupants, electrical, lighting, and plumbing noise sources are considered in the background noise requirements for Healthcare but not for the other BD+C rating systems.

STEP 8. SELECT ROOM NOISE RATING METHOD

Review the 2010 FGI Guidelines, Table 1.2-2, to determine the applicable background noise criteria for each space. The referenced standard lists four measures for background noise: noise criteria (NC), room criteria (RC), room criteria neutral (RC(N), and A-weighted decibel (dBA). To demonstrate achievement of the credit, project teams must verify compliance for one metric for each space. For space types not listed in the table, refer to 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Table 1 (see *Further Explanation, Selecting a Sound Rating Method*).

STEP 9. VERIFY HVAC BACKGROUND NOISE

Determine sound pressure levels for each occupied space and verify compliance for each applicable room type using the 2010 FGI Guidelines, Table 1.2-2. Consider sound pressure levels from HVAC, plumbing, lighting, and electrical equipment. Demonstrate compliance through calculation or measurement, as follows:

- Engage an acoustics expert to complete the necessary calculations manually or through computer simulation. Early calculations, during design, may allow teams to iteratively evaluate alternative or layered strategies.
- Consider measuring sound levels if the mechanical designer or acoustics expert on the project team is familiar with best practice acoustic design and construction strategies. Ensure that the meter used conforms to credit requirements.

Option 2. Acoustic Finishes and Site Exterior Noise

STEP 1. IDENTIFY SOUND ABSORPTION REQUIREMENTS

Review the 2010 FGI Guidelines, Table 1.2-1, to determine the applicable sound absorption criteria for each space listed in the table created for Step 1.

STEP 2. IDENTIFY SURFACES FOR ACOUSTIC TREATMENT

Catalog the area of planar surfaces in each space and identify locations where absorptive finishes can be applied.

- Acoustically absorptive finishes are typically applied to floors, ceilings, or walls as soft or perforated materials. Fabric-covered furniture or partition systems may be considered part of the permanent room layout.
- For spaces with noisy plenum equipment, sound transmission paths that travel through the ceiling plenum, or partitions that do not extend to the underside of the deck above, consider incorporating ceiling materials with ceiling attenuation class (CAC) ratings of 35 or greater.
- Cushion-backed flooring materials may reduce footfall and cart-rolling noise.
- Additional acoustic finishes may be applied as window curtains, ceiling baffles, or other elements.

Balance the application of acoustic treatments with other performance criteria. For example, criteria for daylighting penetration may affect how acoustic ceilings are applied. Areas with stringent sanitation needs may also restrict the placement of acoustically absorptive materials on the floors or lower walls.

STEP 3. SELECT ACOUSTIC TREATMENTS

Specify and install finish materials with a high noise reduction coefficient (NRC) rating to satisfy the credit requirements. Typically, acoustically absorptive materials have NRC ratings of 0.70 or higher. Collect manufacturer's documentation to verify the NRC of each acoustic finish material. Record the area of each acoustic finish material for credit documentation.

STEP 4. VERIFY SOUND ABSORPTION COEFFICIENT

Calculate the average sound absorption coefficient (α) for each space type, using Equation 1, and confirm that each room complies with the applicable sound absorption.

EQUATION 1. Average room sound absorption coefficient

$$\alpha_{average} = \left\{ \frac{(NCR_1 \times area_1) + (NCR_2 \times area_2) + (NCR_n \times area_n)}{area_{total}} \right\}$$

Account for all room surfaces (walls, floors, and ceilings) in the calculation.

STEP 5. IDENTIFY SOURCES OF EXTERIOR NOISE

Early in the design process, assess the project site for exterior noise sources, both on- and off-site. Off-site sources may include major transit corridors, industry or manufacturing facilities, outdoor venues, rail lines, and air traffic lanes. On-site sources may include heliports, emergency power generators, and outdoor mechanical and building services equipment.

Predicted noise sources may also be identified through neighborhood maps or aerial photographs that show adjacent site uses. Consider marking existing off-site and anticipated on-site noise sources on a map, where adjacencies to project buildings or residential neighbors can be identified. These zones can then be highlighted for special consideration for noise mitigation.

STEP 6. DESIGN USING BEST PRACTICES AND REQUIREMENTS

Ensure that the design meets the 2010 SV Guidelines acoustic requirements for heliports, generators, mechanical equipment, and building services, as described in the credit requirements. Several referenced sections affect programmatic functions of the project; therefore, teams are encouraged to evaluate criteria early in planning and design. Other sections define criteria for equipment specification and adjacency limits that must be resolved during design development and construction.

Evaluate each section and define how a combination of architectural and engineering strategies will be used to satisfy the requirements.

STEP 7. CLASSIFY SITE NOISE EXPOSURE LEVEL

Through observation or measurement, determine the project's exterior noise exposure category per 2010 FGI Guidelines, Table A1.2-a or the 2010 SV Guidelines, Table 1.3-1. For additional information on exterior noise exposure categories, see 2010 FGI Guidelines, Section A1.2-6.1.2, and 2010 SV Guidelines, Section 1.3.

Assign a site classification based on the worst-case conditions, from A (quiet) through D (very noisy), through either observation or measurement, as follows:

- On a site visit, identify development patterns around the project, their approximate sound levels, and adjacency to major transportation corridors (air, rail, highway).
- Conduct one-week monitoring of day-night sound levels (in dB) and average hourly nominal maximum A-weighted sound levels (dBA).

Most teams will be able to classify their sites based on observation. However, teams that wish to claim a site classification lower than the default category should analyze measured site noise levels.

STEP 8. DESIGN ENVELOPE USING STC PERFORMANCE CRITERIA

Based on the site's exterior noise exposure category identified in Step 7, determine the required STC rating for exterior building envelope assemblies according to the 2010 FGI Guidelines, Table A1.2a. To meet the STC rating performance criteria, consider the following strategies:

- Select exterior envelope assemblies based on STC ratings provided by manufacturers.
- Noisy sites may require thicker wall materials and highly insulated fenestration.
- Wall assembly STC ratings should exceed the STC rating requirement if any low-STC rated assemblies or elements are used for fenestrations, doors, or other openings.
- Balance the use of low–STC-rated assemblies and elements with the need to provide daylighting and views to occupied perimeter spaces.

STEP 9. VERIFY COMPLIANCE

If the project is located on a B, C, or D site, provide calculations or measurements to verify that assembly STC ratings meet the applicable 2010 FGI Guidelines requirements. Sites categorized as A or Minimal have limited exterior noise and can skip this step.

- For guidance on calculations, see the 2010 SV Guidelines, Section A1.3, and *Further Explanation, Determining Composite Sound Transmission Class*.
- Conform to the measurement methods outlined in ASTM E966, Standard Guide for Field Measurements of Airborne Sound Insulation of Building Facades and Facade Elements. Project teams wishing to pursue this method are encouraged to engage an expert familiar with testing protocol.

FURTHER EXPLANATION

CALCULATIONS

Reverberation Time

Equation 2 must be calculated separately for each frequency: 500, 1,000, and 2,000 Hz. The calculation should include all finish materials in the room.

EQUATION 2. Total sound absorption for room

$$A = (\alpha S + \alpha S + \alpha S + \ldots\ldots \alpha_n S_n)$$

where

α is the sound absorption coefficient for a material at a specific frequency
S is the total surface area for that material in square feet (or square meters).

Reverberation times must be calculated for all rooms at each of the three frequencies; all must meet the specified T60 requirement in Table 2 in the credit requirements.

EQUATION 3. Reverberation time (IP)

$$RT = 0.049 \times \frac{V}{A}$$

where

V is the room volume in cubic feet
A is the total sound absorption in the room (from Equation 1).

EQUATION 4. Reverberation time (SI)

$$RT = 0.161 \times \frac{V}{A}$$

where

V is the room volume in cubic meters
A is the total sound absorption in the room (from Equation 1).

REVERBERATION TIME MEASUREMENTS

For reverberation time measurements, refer to the following references:

- ASHRAE Performance Measurement Protocols for Commercial Buildings, Chapter 9.
- ANSI Standard S12.60–2010, Annex A.4. For all projects except Schools, the reverberation time limits from Table 2 in the credit requirements should be used in lieu of the limits in the ANSI standard.

DETERMINING COMPOSITE SOUND TRANSMISSION CLASS (STC) RATINGS

Composite sound transmission class (STC) rating is a weighted value for the capacity of a partition to attenuate airborne sound. STC rating is calculated by averaging the transmission loss through an entire assembly.

In design, consider both the acoustic performance and ratio of partition materials. Because sound has a tendency to travel through the weakest element (that with the lowest STC rating), carefully evaluate the use of penetrations, openings, or fenestration in assemblies with a high STC rating requirement.

Ensure compliance with the standard through an evaluation of wall and floor sections and specification of tested window and door assemblies. STC ratings are typically reported by manufacturers on product data sheets and other documentation (such as the 2010 FGI Guidelines and 2010 SV Guidelines) that show tested results based on standard wall materials.

SOUND REINFORCEMENT

Sound reinforcement may be needed for meeting, open office, public, or presentation spaces that seat more than 50 people, depending on their function (see *Definitions, AV Playback Capabilities,* and *Definitions, Sound Reinforcement*). For smaller spaces and for spaces with simple geometry, simple amplification systems may meet the credit criteria.

For spaces with unique architecture or "live" acoustic environments, systems with advanced balancing and signal processing may be required. Balancing the sound reinforcement system helps provide appropriate coverage throughout the space. The balancing requirements and methodology depend on the type of sound system strategy implemented and the sound reinforcement system equipment available. Signal-processing equipment can help improve sound system fidelity and uniformity of coverage.

MEETING SOUND REINFORCEMENT REQUIREMENTS

For each space with a sound reinforcement system, verify compliance with the speech intelligibility (the extent to which a listener can hear and comprehend spoken words over other noise), sound level, and uniformity of coverage requirements. This involves evaluating the relationship of the room acoustic environment, sound reinforcement system design and location, background noise level, and the listeners' locations.

For more information on the performance criteria, see the following:

- For speech intelligibility, CIS criterion, see the Speech Intelligibility White Paper by 3M.[6] The speech transmission index (STI) varies from 0 (totally unintelligible) to 1.0 (perfectly intelligible). The common intelligibility scale (CIS) relates to STI with the following equation: CIS = 1 + log (STI).
- For sound-level and uniformity of coverage, refer to ANSI/INFOCOMM 1M–2009, Audio Coverage Uniformity in Enclosed Listener Areas.

Compliance with the criteria can be determined through basic calculations, acoustic modeling software, or with measurements. If the space is not compliant, consider one or a combination of the following options:

- Revising the room's acoustic treatment strategy (typically by increasing the distribution and amount of treatment)
- Revising the sound reinforcement strategy (adjusting the type of sound reinforcement system or location and the type and aiming of loudspeakers)
- Lowering the background noise level in the room
- Adjusting the sound output as needed to increase the output level while maintaining uniform coverage

MASKING SYSTEMS

Sound masking is a technology that uses artificially produced sound to cover or mask unwanted environmental noise. These systems may be appropriate in open-floor layouts where full height partitions do not exist between workspaces. Sound-masking systems can mitigate the perception that open offices are noisy and distracting places to work.

Our hearing system tends to notice specific sounds when they are above ambient noise levels. Therefore, very

6. *http://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSufSevTsZxtUoY_vN82eevUqevTSevTSevTSeSSSSSS--&fn=Speech*

quiet spaces with isolated areas of activity may be balanced by targeted sound-masking systems.

Project teams using sound masking should consider their use as a supplement to architectural finishes or other passive strategies for sound isolation. Masking systems need to be carefully designed and calibrated so that their coverage is uniform and even and the sound spectrum (not just overall loudness) is appropriate for masking the intended environmental noise. A system should not sound "hissy" or "rumbly," and the level should be low enough that it does not cause listening fatigue. A system's use time period also needs to be evaluated. Consider incorporating "ramping" in the masking system design, whereby the equipment gradually increases noise levels throughout the day or when a space is occupied.

A commonly applied rule is to control no more than 1,000 square feet (93 square meters) per zone, though project teams may consult with sound-masking system experts to identify appropriate control strategies.

For more information on sound masking and how it can improve workplaces, see "Sound Matters," available at *gsamatters.com.*

MEETING MASKING SYSTEM REQUIREMENTS

Typically, a sound masking system's specification includes the required frequency spectrum (or spectra), which could be assessed to make sure that the maximum masking noise levels are at or below 48 dBA. See ASTM E1130 for an example of a speech spectrum.

Make sure the system will be measured or evaluated after installation to confirm that it operates as designed. Consider specifying the procedures and reporting methods from ASTM Standard E1573.

SELECTING A SOUND RATING METHOD

The referenced standards for this credit present HVAC background noise level guidelines based on space type. The guidelines use the following sound rating methods:

- Noise criteria (NC)
- Room criteria (RC) or room criteria neutral (RCN)
- A-weighted decibel (dBA)
- C-weighted decibel (dBC)
- RC Mark II rating method

The methods are described in the 2011 ASHRAE Handbook, HVAC Applications, Chapter 48, Noise and Vibration Control. Teams must demonstrate compliance with one of the background noise rating methods for each space. The selection of rating method depends on the project requirements for acoustic quality but may be affected by the availability of data for HVAC components' sound levels.

In each method, sound levels must be calculated or measured across a range of audible frequencies. NC and RC methods are more sensitive to the balance of sound frequencies, whereas dBA reports the maximum sound level within a frequency range.

USING 2010 FGI GUIDELINES AND 2010 SV GUIDELINES

The 2010 SV Guidelines are the referenced standard for all acoustics issues in the 2010 FGI Guidelines; they contain design suggestions and background information regarding acoustic and privacy design for all types of health care facilities. The guidelines were commissioned by FGI and prepared by the ad hoc Joint Subcommittee on Speech Privacy and Healthcare Acoustics TC-AA.NS.SC, a technical subcommittee of the Acoustical Society of America, the Institute of Noise Control Engineers, and the National Council of Acoustical Consultants.

INTERNATIONAL TIPS

The International Electrotechnical Commission (2013) IEC 61672-1:2013 Electroacoustics – Sound Level Meters – Part 1: Specifications are considered to be an equivalent to ANSI S1.4. Project teams in Europe may use measuring equipment which is in line with IEC 61672-1:2013.

CAMPUS

Group Approach
Submit separate documentation for each building.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

New Construction, Data Centers, Warehouses and Distribution Centers, Hospitality		All projects
HVAC background noise	Occupied spaces' sound level values	X
	Calculation, measurement narrative, or manufacturers' data	X
	Noise reduction narrative	X
Sound isolation	STC ratings for space adjacencies	X
	Calculation, measurement narrative, or manufacturers' data	X
Reverberation time	Reverberation time criteria for each room	X
	Calculation, measurement narrative, or manufacturers' data	X
Sound reinforcement and masking systems	List of all large conference rooms and auditoriums	X
	Explanation of sound reinforcement methodology (if installed)	X
	Explanation of sound reinforcement system components and specifications (if installed)	X
	Explanation of masking system components and specifications narrative (if installed)	X

Schools		All projects
Background noise	See EQ Prerequisite Minimum Acoustic Performance	X
Sound isolation	STC calculation or measurement method	X
	List of STC ratings	X
	STC rating assembly source data	X

Healthcare		Option 1	Option 2
Speech privacy and sound isolation	List of spaces, adjacencies, STC ratings	X	
	List of spaces, privacy index values	X	
	Calculation or simulation results, or report of field measurements	X	
Room noise levels	List of spaces, design criteria, values	X	
	Lab test reports and simulation results, or report of field measurements	X	
Acoustical finishes	Documentation of wall, ceiling, and floor finishes with associated NRC values		X
	Calculated average sound absorption coefficients for representative room types		X
Site exterior noise	Exterior building envelope STC rating		X
	Site noise exposure category narrative		X
	Mitigation narrative for each 2010 FGI guideline		X
	Special neighborhood considerations narrative		X

RELATED CREDIT TIPS

Schools

EQ Prerequisite Minimum Acoustic Performance. This credit has additional performance thresholds for HVAC background noise and additional criteria for STC.

CHANGES FROM LEED 2009

New Construction, Data Centers, Warehouses and Distribution Centers, Hospitality

This is a new credit.

Schools

- The background noise level limit has decreased from 40 dBA to 35 dBA.
- The referenced ANSI S12.60 standard has been updated from 2002 to 2010.
- AHRI Standard 885–2008 has been added as a referenced standard for background noise.
- Equivalent local codes may now be used in place of the national codes specified in the credit requirements.

Healthcare

The credit name has changed from Acoustic Environment.

REFERENCED STANDARDS

ASHRAE 2011, HVAC Applications Handbook, Chapter 48, Noise and Vibration Control: ashrae.org

AHRI Standard 885–2008: ahrinet.org

ANSI S1.4, Performance Measurement Protocols for Commercial Buildings: ashrae.org

2010 Noise and Vibration Guidelines for Health Care Facilities:
http://speechprivacy.org/joomla//index.php?option=com_content&task=view&id=33&Itemid=43

ANSI/ASA S12.60–2010 American National Standard Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1, Permanent Schools: asastore.aip.org

FGI Guidelines for Design and Construction of Health Care Facilities, 2010 edition: www.fgiguidelines.org

ANSI T1.523–2001, Telecom Glossary 2007: ansi.org

E966, Standard Guide for Field Measurements of Airborne Sound Insulation of Building Facades and Facade Elements: astm.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

classroom or core learning space a space that is regularly occupied and used for educational activities. In such space, the primary functions are teaching and learning, and good speech communication is critical to students' academic achievement. (Adapted from ANSI S12.60)

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

sound-level coverage a set of uniformity criteria that ensure consistent intelligibility and directionality of audible frequencies for all occupants within a space

speech privacy a condition in which speech is unintelligible to casual listeners (ANSI T1.523–2001)

speech spectra the distribution of acoustic energy as a function of frequency for human speech

Innovation (IN)

OVERVIEW

Sustainable design strategies and measures are constantly evolving and improving. New technologies are continually introduced to the marketplace, and up-to-date scientific research influences building design strategies. The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies.

Occasionally, a strategy results in building performance that greatly exceeds what is required in an existing LEED credit. Other strategies may not be addressed by any LEED prerequisite or credit but warrant consideration for their sustainability benefits. In addition, LEED is most effectively implemented as part of a cohesive team, and this category addresses the role of a LEED Accredited Professional in facilitating that process.

INNOVATION CREDIT

Innovation

This credit applies to:

New Construction (1–5 points)
Core and Shell (1–5 points)
Schools (1-5 points)
Retail (1–5 points)
Data Centers (1–5 points)
Warehouses and Distribution Centers (1–5 points)
Hospitality (1–5 points)
Healthcare (1–5 points)

INTENT

To encourage projects to achieve exceptional or innovative performance.

REQUIREMENTS

To achieve all five innovation points, a project team must achieve at least one pilot credit, at least one innovation credit and no more than two exemplary performance credits.

OPTION 1. INNOVATION (1 POINT)

Achieve significant, measurable environmental performance using a strategy not addressed in the LEED green building rating system.

Identify the following:

- the intent of the proposed innovation credit;
- proposed requirements for compliance;
- proposed submittals to demonstrate compliance; and
- the design approach or strategies used to meet the requirements.

AND/OR

OPTION 2. PILOT (1 POINT)

Achieve one pilot credit from USGBC's LEED Pilot Credit Library

AND/OR

OPTION 3. ADDITIONAL STRATEGIES

Innovation (**1-3 points**)

- Defined in Option 1 above.

Pilot (1–3 points)

- Meet the requirements of Option 2.

Exemplary Performance (1–2 points)

- Achieve exemplary performance in an existing LEED v4 prerequisite or credit that allows exemplary performance, as specified in the LEED Reference Guide, v4 edition. An exemplary performance point is typically earned for achieving double the credit requirements or the next incremental percentage threshold.

BEHIND THE INTENT

Sustainable design comes from innovative strategies and thinking. Institutional measures that reward such thinking—such as the achievement of this credit—benefit our environment. Recognition of exceptional efforts will spur further innovation.

When project teams innovate and go beyond LEED requirements, they not only achieve measurable environmental benefits beyond those specified by the LEED rating system, they also have the opportunity to explore cutting-edge pilot credits and contribute to the development of future LEED credits. When they can demonstrate that the project exceeds the standard level of performance associated with one or more LEED credits, their innovations can be adopted by other teams in the future.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY INNOVATIVE STRATEGIES

Innovation may begin at a project's conception, but it can enter at any step of the process and come from any member of the project team.

- During initial meetings or design charrettes, explore opportunities to incorporate innovative strategies, achieve exemplary performance for existing LEED credits, and develop pilot credits, based on the project scope.
- Review the project goals and targeted credits to determine whether the project is likely to meet any exemplary performance criteria.
- Identify any environmental strategies included in the project that are not addressed by existing LEED credits.
- Discuss pilot credits, green housekeeping, public education, and other opportunities for innovation.

STEP 2. DEVELOP INNOVATION POINT STRATEGY

Projects may earn up to 5 points through a combination of the following:

- Innovation (up to 4 points). This option is appropriate for strategies that are not addressed by any existing credits in the LEED rating system under which the project will be certified.
- Pilot credits (up to 4 points). This option requires project teams to achieve, document, and provide feedback on pilot credit strategies developed by USGBC members and committees.
- Exemplary performance (up to 2 points). This option is achieved by demonstrating performance that greatly exceeds the level or scope required by existing LEED prerequisites or credits.
    - One point is reserved for Pilot Credits and one for Innovation. To use all five points, projects must use at least one pilot credit and one innovation credit.

Innovation (up to 4 points)

STEP 1. CONFIRM CREDIT ELIGIBILITY

For innovations that are not addressed by existing LEED credits, confirm that the proposed strategy meets the following three basic criteria:

- The project must demonstrate a quantitative improvement in environmental performance by identifying or establishing a baseline of standard performance and comparing that benchmark with the final design performance.
- The strategy must be comprehensive. Measures that address a limited portion of a project or are not comprehensive in other ways are not eligible. The project team must demonstrate that the proposed innovation credit applies to the entire project being certified under LEED and has at least two components (i.e., it is not limited to use of a single product).
- The strategy must be significantly better than standard sustainable design practices.

Points can also be earned by achieving selected credits from other LEED rating systems.

Strategies must demonstrate a comprehensive approach, have significant, measurable environmental benefits, and be better than standard practice (see *Further Explanation, Suggested Topics for Innovation Credits* and *Ineligible Strategies*).

STEP 2. DEVELOP DOCUMENTATION

Document credit eligibility as outlined above, and note any project-specific strategies.

STEP 3. IMPLEMENT CREDIT

Develop and execute the innovative strategy or program in a manner that yields a meaningful environmental benefit. Retain documentation and calculations to validate the project team's approach and implementation.

Pilot credits (up to 4 points)

STEP 1. SELECT CREDIT

Select a credit from the LEED Pilot Credit Library on the USGBC website. The Pilot Credit Library includes credit intent, requirements, submittals, and feedback questions for each pilot credit.

- Pilot credits open and close at varying intervals. Check the USGBC website for a current list of available pilot credit strategies.
- Pilot credits are specific to the rating systems. Review the list on the USGBC website to identify pilot credits for the applicable rating system.

STEP 2. REGISTER PILOT CREDIT

Register for the selected pilot credit through the Pilot Credit Library.

- Since pilot credit availability changes over time, register for a credit as soon as the project team decides to pursue it, rather than waiting until documentation review.
- Once a project has registered for a pilot credit, the project team may continue to pursue it even if it is closed to new registrants.

STEP 3. IMPLEMENT CREDIT

Follow the steps to implement the credit as outlined in the pilot credit. Visit the LEEDuser forums for the selected pilot credit to ask questions or get advice on strategy.

STEP 4. PROVIDE FEEDBACK

Complete the credit's feedback survey, found on the USGBC website. Include any information that might be helpful in future revisions of the credit.

STEP 5. DOCUMENT CREDIT

Complete all credit-specific documentation as outlined in the pilot credit.

- Some pilot credits have documentation forms or calculators.
- Pilot credits may be attempted in any review stage and can be replaced before the next review if the initial credit is not accepted.

Exemplary Performance (up to 2 points)

STEP 1. IDENTIFY TARGET EXEMPLARY PERFORMANCE CREDITS

During design, review exemplary performance criteria and select credits for which exemplary performance will be pursued. Credits that allow exemplary performance through a predetermined approach are noted throughout this reference guide.

STEP 2. CONFIRM IMPLEMENTATION

Document design elements and specifications requirements to ensure that the selected exemplary performance criteria are met. Provide the required documentation as noted in the base credit.

FURTHER EXPLANATION

SUGGESTED TOPICS FOR INNOVATION CREDITS

Project teams are encouraged to explore the full range of innovative opportunities in their buildings. Refer to the online Innovation Catalog for examples of successful innovation credits. The examples do not constitute preapproval of any Innovation strategy, however, and Innovation credit awarded for a project today does not imply automatic approval for similar strategies in the future. A team seeking formal preapproval should submit a project credit interpretation request (CIR).

The following example was submitted for an Innovation credit:

Public education. Provide an educational program on the environmental and human health benefits of green building practices and how building occupants or the public can help improve green performance within the LEED space (such as recycling and appropriate use of efficient fixtures and equipment). The program must be actively instructional and include at least two instructional initiatives that have ongoing components, such as a signage program, case study, guided tours, educational outreach program through periodic events covering green building topics, and/or a website or electronic newsletter.

INELIGIBLE STRATEGIES

Innovation credits are not awarded for the use of a particular product or design strategy if the technology aids in the achievement of an existing LEED credit, even if the project is not attempting to earn that credit.

Innovation strategies that are closed pilot credits are not available unless they are listed in the online Innovation Catalog.

No strategy can achieve more than 1 point under Innovation. That is, a single strategy cannot be double-counted for both exemplary performance and innovation (or both exemplary performance and a pilot credit, or both a pilot credit and innovation).

The innovation strategy must be specific to the LEED project under review.

RATING SYSTEM VARIATIONS

Core and Shell

Core and Shell projects pursuing Innovation credits must implement a comprehensive strategy, often applied to the whole building, including both the core and shell and any common areas, as well as the tenant spaces.

For example, to earn an Innovation credit for a green housekeeping program, base building management of the Core and Shell project must either control the cleaning of both the base building and tenant spaces, or it must enforce the credit requirements through a legally binding sales agreement or tenant lease for areas outside its control.

CAMPUS

Group Approach

All buildings in the group may be documented as one. Documentation for campus-wide strategies must represent the total combined performance for all buildings and site areas.

Campus Approach

Eligible. Documentation for campus-wide strategies must represent the total combined performance for all master site buildings and site areas, but strategies that apply to individual buildings must be documented for every building.

REQUIRED DOCUMENTATION

Documentation	Innovation	Pilot credit	Exemplary performance
Innovation narrative	X		
Supporting documentation	X	X	X
Pilot credit registration		X	
Pilot credit survey		X	
Pilot credit specific submittals		X	
Exemplary performance credit and level			X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

The maximum number of exemplary performance strategies eligible for IN credits has changed from three to two.

REFERENCED STANDARDS

None.

DEFINITIONS

None.

INNOVATION CREDIT

LEED Accredited Professional

This credit applies to:

New Construction (1 point)
Core and Shell (1 point)
Schools (1 point)
Retail (1 point)
Data Centers (1 point)
Warehouses and Distribution Centers (1 point)
Hospitality (1 point)
Healthcare (1 point)

INTENT

To encourage the team integration required by a LEED project and to streamline the application and certification process.

REQUIREMENTS

At least one principal participant of the project team must be a LEED Accredited Professional (AP) with a specialty appropriate for the project.

BEHIND THE INTENT

A LEED Accredited Professional (LEED AP) with specialty can be a valuable resource in the LEED certification process. The presence of a LEED AP with specialty helps project team members understand the rating system, the importance of interactions among the prerequisites and credits, and the LEED application process.

STEP-BY-STEP GUIDANCE

STEP 1. ENGAGE LEED AP WITH SPECIALTY

Identify a project team member who is a LEED AP with specialty, or engage a LEED AP with specialty to support the project and participate in the certification process.

- Select a team member with a LEED AP Building Design & Construction (LEED AP BD+C) credential.
- The LEED AP with specialty identified for this credit must have an active credential at the time of certification review (see *Further Explanation, Maintaining a LEED Credential*).
- LEED APs without specialty (legacy LEED APs) do not qualify for this credit.

FURTHER EXPLANATION

MAINTAINING A LEED CREDENTIAL

The LEED AP with specialty credential can be maintained through either of the following methods:

- Retaking and passing the LEED accreditation exam
- Earning 30 continuing education hours per credentialing period

A credential is considered active (and eligible for this credit) only if the credential holder has completed his or her credential maintenance through the GBCI Credential Maintenance Program. For more information, visit USGBC's website.

CAMPUS

Group Approach

Eligible. All buildings in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Required
Full name and specialty credential of LEED AP	x

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

LEED APs without specialty (legacy LEED APs) are no longer eligible for this credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

Regional Priority (RP)

OVERVIEW

Because some environmental issues are particular to a locale, volunteers from USGBC chapters and the LEED International Roundtable have identified distinct environmental priorities within their areas and the credits that address those issues. These Regional Priority credits encourage project teams to focus on their local environmental priorities.

USGBC established a process that identified six RP credits for every location and every rating system within chapter or country boundaries. Participants were asked to determine which environmental issues were most salient in their chapter area or country. The issues could be naturally occurring (e.g., water shortages) or man-made (e.g., polluted watersheds) and could reflect environmental concerns (e.g., water shortages) or environmental assets (e.g., abundant sunlight). The areas, or zones, were defined by a combination of priority issues—for example, an urban area with an impaired watershed versus an urban area with an intact watershed.

The participants then prioritized credits to address the important issues of given locations. Because each LEED project type (e.g., a data center) may be associated with different environmental impacts, each rating system has its own RP credits.

The ultimate goal of RP credits is to enhance the ability of LEED project teams to address critical environmental issues across the country and around the world.

REGIONAL PRIORITY CREDIT

Regional Priority

This credit applies to:

New Construction (1–4 points)
Core and Shell (1–4 points)
Schools (1–4 points)
Retail (1–4 points)
Data Centers (1–4 points)
Warehouses and Distribution Centers (1–4 points)
Hospitality (1–4 points)
Healthcare (1–4 points)

INTENT

To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities.

REQUIREMENTS

Earn up to four of the six Regional Priority credits. These credits have been identified by the USGBC regional councils and chapters as having additional regional importance for the project's region. A database of Regional Priority credits and their geographic applicability is available on the USGBC website, http://www.usgbc.org/rpc.

One point is awarded for each Regional Priority credit achieved, up to a maximum of four.

BEHIND THE INTENT

LEED projects are designed, built, and operated in many different contexts. Climate, population density, and local regulations can differ significantly from one location to another, making certain environmental issues more critical than others. Examples include water conservation in arid climates versus rainwater management in wet climates.

LEED projects can be more transformative if teams recognize their location's priority environmental issues and address them through design, construction, and operation choices. LEED encourages a focus on regional issues through RP credits—existing LEED credits that USGBC volunteers have determined to be especially important in a given area. For every location in the U.S., six credits are prioritized. The ultimate intent is to motivate project teams to earn the credits that address an area's priority issues.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY APPLICABLE RP CREDITS

Review the credits flagged for regional priority in the project's area (see USGBC's website). Consider how achievement of these credits will affect the project.

STEP 2. DETERMINE PERFORMANCE REQUIRED TO EARN RP POINTS

- For credits with multiple thresholds (e.g., percentage improvement in energy efficiency), points are awarded at particular levels of achievement.
- If such a credit is flagged as RP for the project's location, confirm the threshold the project must meet to earn the bonus point.

FURTHER EXPLANATION

None.

REQUIRED DOCUMENTATION

Documentation
No additional documentation is required to earn Regional Priority credits. Document compliance for the selected credits, and the related RP bonus points for their achievement will be awarded automatically.

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

The RP credits for a given region may be different than they were for LEED 2009.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

APPENDICES

APPENDIX 1. USE TYPES AND CATEGORIES

TABLE 1. Use Types and Categories

Category	Use type
Food retail	Supermarket
	Grocery with produce section
Community-serving retail	Convenience store
	Farmers market
	Hardware store
	Pharmacy
	Other retail
Services	Bank
	Family entertainment venue (e.g., theater, sports)
	Gym, health club, exercise studio
	Hair care
	Laundry, dry cleaner
	Restaurant, café, diner (excluding those with only drive-thru service)
Civic and community facilities	Adult or senior care (licensed)
	Child care (licensed)
	Community or recreation center
	Cultural arts facility (museum, performing arts)
	Education facility (e.g., K—12 school, university, adult education center, vocational school, community college)
	Government office that serves public on-site
	Medical clinic or office that treats patients
	Place of worship
	Police or fire station
	Post office
	Public library
	Public park
	Social services center
Community anchor uses (BD+C and ID+C only)	Commercial office (100 or more full-time equivalent jobs)

Adapted from Criterion Planners, INDEX neighborhood completeness indicator, 2005.

APPENDIX 2. DEFAULT OCCUPANCY COUNTS

Use Table 1 to calculate default occupancy counts. Only use the occupancy estimates if occupancy is unknown.

For the calculation, use gross floor area, not net or leasable floor area. Gross floor area is defined as the sum of all areas on all floors of a building included within the outside faces of the exterior wall, including common areas, mechanical spaces, circulation areas, and all floor penetrations that connect one floor to another. To determine gross floor area, multiply the building footprint (in square feet or square meters) by the number of floors in the building. Exclude underground or structured parking from the calculation.

TABLE 1. Default Occupancy Numbers

	Gross square feet per occupant		Gross square meters per occupant	
	Employees	Transients	Employees	Transients
General office	250	0	23	0
Retail, general	550	130	51	12
Retail or service (e.g., financial, auto)	600	130	56	12
Restaurant	435	95	40	9
Grocery store	550	115	51	11
Medical office	225	330	21	31
R&D or laboratory	400	0	37	0
Warehouse, distribution	2,500	0	232	0
Warehouse, storage	20,000	0	1860	0
Hotel	1,500	700	139	65
Educational, daycare	630	105	59	10
Educational, K–12	1,300	140	121	13
Educational, postsecondary	2,100	150	195	14

Sources:

- ANSI/ASHRAE/IESNA Standard 90.1–2004 (Atlanta, GA, 2004).
- 2001 Uniform Plumbing Code (Los Angeles, CA)
- California Public Utilities Commission, 2004–2005 Database for Energy Efficiency Resources (DEER) Update Study (2008).
- California State University, Capital Planning, Design and Construction Section VI, Standards for Campus Development Programs (Long Beach, CA, 2002).
- City of Boulder Planning Department, Projecting Future Employment—How Much Space per Person (Boulder, 2002).
- Metro, 1999 Employment Density Study (Portland, OR 1999).
- American Hotel and Lodging Association, Lodging Industry Profile Washington, DC, 2008.
- LEED for Core & Shell Core Committee, personal communication (2003 - 2006).
- LEED for Retail Core Committee, personal communication (2007)
- OWP/P, Medical Office Building Project Averages (Chicago, 2008).
- OWP/P, University Master Plan Projects (Chicago, 2008).
- U.S. General Services Administration, Childcare Center Design Guide (Washington, DC, 2003).

APPENDIX 3. RETAIL PROCESS LOAD BASELINES

TABLE 1A. Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Broiler, underfired	Gas	Cooking	30%	16,000 Btu/h/ft^2 peak input	35%	12,000 Btu/h/ft^2 peak input
Combination ovens, steam mode (P = pan capacity)	Elec	Cooking	40% steam mode	0.37P+4.5 kW	50% steam mode	0.133P+0.6400 kW
Combination ovens, steam mode	Gas	Cooking	20% steam mode	1,210P+35,810 Btu/h	38% steam mode	200P+6,511 Btu/h
Combination ovens, convection mode	Elec	Cooking	65% convection mode	0.1P+1.5 kW	70% convection mode	0.080P+0.4989 kW
Combination ovens, convection mode	Gas	Cooking	35% convection mode	322P+13,563 Btu/h	44% convection mode	150P+5,425 Btu/h
Convection oven, full-size	Elec	Cooking	65%	2.0 kW	71%	1.6 kW
Convection oven, full-size	Gas	Cooking	30%	18,000 Btu/h	46%	12,000 Btu/h
Convection oven, half-size	Elec	Cooking	65%	1.5 kW	71%	1.0 kW
Conveyor oven, > 25-inch belt	Gas	Cooking	20%	70,000 Btu/h	42%	57,000 Btu/h
Conveyor oven, ≤ 25-inch belt	Gas	Cooking	20%	45,000 Btu/h	42%	29,000 Btu/h
Fryer	Elec	Cooking	75%	1.05 kW	80%	1.0 kW
Fryer	Gas	Cooking	35%	14,000 Btu/h	50%	9,000 Btu/h
Griddle (based on 3 ft model)	Elec	Cooking	60%	400 W/ft^2	70%	320 W/ft^2
Griddle (based on 3 ft model)	Gas	Cooking	30%	3,500 Btu/h/ft^2	38%	2,650 Btu/h/ft^2
Hot food holding cabinets (excluding drawer warmers and heated display) 0 < V < 13 ft^3 (V = volume)	Elec	Cooking	na	40 W/ft^3	na	21.5V Watts
Hot food holding cabinets (excluding drawer warmers and heated display) 13 ≤ V < 28 ft^3	Elec	Cooking	na	40 W/ft^3	na	2.0V + 254 Watts
Hot food holding cabinets (excluding drawer warmers and heated display) 28 ft^3 ≤ V	Elec	Cooking	na	40 W/ft^3	na	3.8V + 203.5 Watts
Large vat fryer	Elec	Cooking	75%	1.35 kW	80%	1.1 kW

TABLE 1A (CONTINUED). Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)						
	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Large vat fryer	Gas	Cooking	35%	20,000 Btu/h	50%	12,000 Btu/h
Rack oven, double	Gas	Cooking	30%	65,000 Btu/h	50%	35,000 Btu/h
Rack oven, single	Gas	Cooking	30%	43,000 Btu/h	50%	29,000 Btu/h
Range	Elec	Cooking	70%		80%	
Range	Gas	Cooking	35%	na	40% and no standing pilots	na
Steam cooker, batch cooking	Elec	Cooking	26%	200 W/pan	50%	135 W/pan
Steam cooker, batch cooking	Gas	Cooking	15%	2,500 Btu/h/pan	38%	2,100 Btu/h/pan
Steam cooker, high production or cook to order	Elec	Cooking	26%	330 W/pan	50%	275 W/pan
Steam cooker, high production or cook to order	Gas	Cooking	15%	5,000 Btu/h/pan	38%	4,300 Btu/h/pan
Toaster	Elec	Cooking	na	1.8 kW average operating energy rate	na	1.2 kW average operating energy rate
Ice machine, IMH (ice-making head, H = harvest ice), H ≥ 450 lb/day	Elec	Ice	6.89 – 0.0011H kWh/100 lb ice	na	$37.72 \cdot H^{-0.298}$ kWh/100 lb ice	na
Ice machine, IMH (ice-making head), H < 450 lb/day	Elec	Ice	10.26 – 0.0086H kWh/100 lb ice	na	$37.72 \cdot H^{-0.298}$ kWh/100 lb ice	na
Ice machine RCU (remote condensing unit, w/o remote compressor), H < 1,000 lb/day	Elec	Ice	8.85 – 0.0038H kWh/100lb ice	na	$22.95 \cdot H^{-0.258} + 1.00$ kWh/100 lb ice	na
Ice machine RCU (remote condensing unit), 1600 > H ≥ 1000 lb/day	Elec	Ice	5.10 kWh/100 lb ice	na	$22.95 \cdot H^{-0.258} + 1.00$ kWh/100 lb ice	na
Ice machine RCU (remote condensing unit), H ≥ 1600 lb/day	Elec	Ice	5.10 kWh/100 lb ice	na	-0.00011*H + 4.60 kWh/100 lb ice	na
Ice machine SCU (self-contained unit), H < 175 lb/day	Elec	Ice	18.0 – 0.0469H kWh/100 lb ice	na	$48.66 \cdot H^{-0.326} + 0.08$ kWh/100 lb ice	na
Ice machine self-contained unit, H ≥ 175 lb/day	Elec	Ice	9.80 kWh/100 lb ice	na	$48.66 \cdot H^{-0.326} + 0.08$ kWh/100 lb ice	na

TABLE 1A (CONTINUED). Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)						
	Baseline energy usage for energy modeling path				**Levels for prescriptive path**	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Ice machine, water-cooled ice-making head, H ≥ 1436 lb/day (must be on chilled loop)	Elec	Ice	4.0 kWh/100 lb ice	na	3.68 kWh/100 lb ice	na
Ice machine, water-cooled ice-making head, 500 lb/day < H < 1436 (must be on chilled loop)	Elec	Ice	5.58 – 0.0011H kWh/100 lb ice	na	5.13 – 0.001H kWh/100 lb ice	na
Ice machine, water-cooled ice-making head, H < 500 lb/day (must be on chilled loop)	Elec	Ice	7.80 – 0.0055H kWh/100 lb ice	na	7.02 – 0.0049H kWh/100 lb ice	na
Ice machine water-cooled once-through (open loop)	Elec	Ice	Banned	Banned	Banned	Banned
Ice machine, water-cooled SCU (self-contained unit), H < 200 lb/day (must be on chilled loop)	Elec	Ice	11.4 – 0.0190H kWh/100 lb ice	na	10.6 – 0.177H kWh/100 lb ice	na
Ice machine, water-cooled self-contained unit, H ≥ 200 lb/day (must be on chilled loop)	Elec	Ice	7.6 kWh/100 lb ice	na	7.07 kWh/100 lb ice	na
Chest freezer, solid or glass door	Elec	Refrig	0.45V + 0.943 kWh/day	na	≤ 0.270V + 0.130 kWh/day	na
Chest refrigerator, solid or glass door	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.125V + 0.475 kWh/day	na
Glass-door reach-in freezer 0 < V < 15 ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.607V + 0.893 kWh/day	na
Glass-door reach-in freezer 15 ≤ V < 30 ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.733V – 1.00 kWh/day	na
Glass-door reach-in freezer, 30 ≤ V < 50 ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.250V + 13.50 kWh/day	na
Glass-door reach-in freezer, 50 ≤ V ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.450V + 3.50 kWh/day	na
Glass-door reach-in refrigerator, 0 < V < 15 ft^3	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.118V + 1.382 kWh/day	na
Glass-door reach-in refrigerator, 15 ≤ V < 30 ft^3	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.140V + 1.050 kWh/day	na
Glass-door reach-in refrigerator, 30 ≤ V < 50 ft^3	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.088V + 2.625 kWh/day	na

TABLE 1A (CONTINUED). Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)						
	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Glass-door reach-in refrigerator, 50 ≤ V ft³	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.110V + 1.500 kWh/day	na
Solid-door reach-in freezer, 0 < V < 15 ft³	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.250V + 1.25 kWh/day	na
Solid-door reach-in freezer, 15 ≤ V < 30 ft³	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.400V – 1.000 kWh/day	na
Solid-door reach-in freezer, 30 ≤ V < 50 ft³	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.163V + 6.125 kWh/day	na
Solid-door reach-in freezer, 50 ≤ V ft³	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.158V + 6.333 kWh/day	na
Solid-door reach-in refrigerator, 0 < V < 15 ft³	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.089V + 1.411 kWh/day	na
Solid-door reach-in refrigerator, 15 ≤ V < 30 ft³	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.037V + 2.200 kWh/day	na
Solid-door reach-in refrigerator, 30 ≤ V < 50 ft³	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.056V + 1.635 kWh/day	na
Solid-door reach-in refrigerator, 50 ≤ V ft³	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.060V + 1.416 kWh/day	na
Clothes washer	Gas	Sanitation	1.72 MEF	na	2.00 MEF	na
Door-type dish machine, high temp	Elec	Sanitation	na	1.0 kW	na	0.70 kW
Door-type dish machine, low temp	Elec	Sanitation	na	0.6 kW	na	0.6 kW
Multitank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.6 kW	na	2.25 kW
Multitank rack conveyor dish machine, low temp	Elec	Sanitation	na	2.0 kW	na	2.0 kW
Single-tank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.0 kW	na	1.5 kW
Single-tank rack conveyor dish machine, low temp	Elec	Sanitation	na	1.6 kW	na	1.5 kW
Undercounter dish machine, high temp	Elec	Sanitation	na	0.9 kW	na	0.5 kW
Undercounter dish machine, low temp	Elec	Sanitation	na	0.5 kW	na	0.5 kW

The energy efficiency, idle energy rates, and water use requirements, where applicable, are based on the following test methods:

ASTM F1275 Standard Test Method for Performance of Griddles

ASTM F1361 Standard Test Method for Performance of Open Deep Fat Fryers

ASTM F1484 Standard Test Methods for Performance of Steam Cookers

ASTM F1496 Standard Test Method for Performance of Convection Ovens

ASTM F1521 Standard Test Methods for Performance of Range Tops

ASTM F1605 Standard Test Method for Performance of Double-Sided Griddles

ASTM F1639 Standard Test Method for Performance of Combination Ovens

ASTM F1695 Standard Test Method for Performance of Underfired Broilers

ASTM F1696 Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, ASTM Door-Type Commercial Dishwashing Machines

ASTM F1704 Standard Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems

ASTM F1817 Standard Test Method for Performance of Conveyor Ovens

ASTM F1920 Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines

ASTM F2093 Standard Test Method for Performance of Rack Ovens

ASTM F2140 Standard Test Method for Performance of Hot Food Holding Cabinets

ASTM F2144 Standard Test Method for Performance of Large Open Vat Fryers

ASTM F2324 Standard Test Method for Prerinse Spray Valves

ASTM F2380 Standard Test Method for Performance of Conveyor Toasters

ARI 810-2007: Performance Rating of Automatic Commercial Ice Makers

ANSI/ASHRAE Standard 72–2005: Method of Testing Commercial Refrigerators and Freezers with temperature setpoints at 38°F for medium-temp refrigerators, 0°F for low-temp freezers, and -15°F for ice cream freezers

TABLE 1B. Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Broiler, underfired	Gas	Cooking	30%	50.5 kW/m²	35%	37.9 kW/m²
Combination oven, steam mode (P = pan capacity)	Elec	Cooking	40% steam mode	0.37P + 4.5 kW	50% steam mode	0.133P + 0.6400 kW
Combination oven, steam mode	Gas	Cooking	20% steam mode	(1 210P + 35 810)/3 412 kW	38% steam mode	(200P + 6 511)/ 3 412 kW
Combination oven, convection mode	Elec	Cooking	65% convection mode	0.1P + 1.5 kW	70% convection mode	0.080P + 0.4989 kW
Combination oven, convection mode	Gas	Cooking	35% convection mode	(322P + 13 563)/3 412 kW	44% convection mode	(150P + 5 425)/ 3 412 kW
Convection oven, full-size	Elec	Cooking	65%	2.0 kW	71%	1.6 kW
Convection oven, full-size	Gas	Cooking	30%	5.3 kW	46%	3.5 kW
Convection oven, half-size	Elec	Cooking	65%	1.5 kW	71%	1.0 kW
Conveyor oven, > 63.5-cm belt	Gas	Cooking	20%	20.5 kW	42%	16.7 kW
Conveyor oven, < 63.5-cm belt	Gas	Cooking	20%	13.2 kW	42%	8.5 kW
Fryer	Elec	Cooking	75%	1.05 kW	80%	1.0 kW
Fryer	Gas	Cooking	35%	4.1 kW	50%	2.64 kW
Griddle (based on 90-cm model)	Elec	Cooking	60%	4.3 kW/m²	70%	3.45 kW/m²

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Griddle (based on 90-cm model)	Gas	Cooking	30%	11 kW/m²	33%	8.35 kW/m²
Hot food holding cabinets (excluding drawer warmers and heated display) 0 < V < 0.368 m³ (V = volume)	Elec	Cooking	na	1.4 kW/m³	na	(21.5*V)/0.0283 kW/m³
Hot food holding cabinets (excluding drawer warmers and heated display) 0.368 ≤ V < 0.793 m³	Elec	Cooking	na	1.4 kW/m³	na	(2.0*V + 254)/0.0283 kW/m³
Hot food holding cabinets (excluding drawer warmers and heated display) 0.793 m³ ≤ V	Elec	Cooking	na	1.4 kW/m³	na	(3.8*V + 203.5)/0.0283 kW/m³
Large vat fryer	Elec	Cooking	75%	1.35 kW	80%	1.1 kW
Large vat fryer	Gas	Cooking	35%	5.86 kW	50%	3.5 kW
Rack oven, double	Gas	Cooking	30%	19 kW	50%	10.25 kW
Rack oven, single	Gas	Cooking	30%	12.6 kW	50%	8.5 kW
Range	Elec	Cooking	70%	na	80%	na
Range	Gas	Cooking	35%	na	40% and no standing pilots	na
Steam cooker, batch cooking	Elec	Cooking	26%	200 W/pan	50%	135 W/pan
Steam cooker, batch cooking	Gas	Cooking	15%	733 W/pan	38%	615 W/pan
Steam cooker, high production or cook to order	Elec	Cooking	26%	330 W/pan	50%	275 W/pan
Steam cooker, high production or cook to order	Gas	Cooking	15%	1.47 kW/pan	38%	1.26 kW/pan
Toaster	Elec	Cooking	na	1.8 kW average operating energy rate	na	1.2 kW average operating energy rate
Ice machine IMH (ice-making head, H = ice harvest) H ≥ 204 kg/day	Elec	Ice	0.0015 – 5.3464E^{-07} kWh/kg ice	na—	≤ 13.52*H$^{-0.298}$ kWh/100 kg ice	na
Ice machine IMH (ice making head) ice-making head, H < 204 kg/day	Elec	Ice	0.2262 – 4.18E^{-04} kWh/kg ice	na	≤ 13.52*H$^{-0.298}$ kWh/100 kg ice	na
Ice machine, RCU (remote condensing unit, w/o remote compressor) H < 454 kg/day	Elec	Ice	0.1951 – 1.85E^{-04} kWh/kg ice	na	≤ 111.5835*H$^{-0.258}$ + 2.205 kWh/100 kg ice	na

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Ice machine RCU (remote condensing unit) 726 > H ≥ 454 kg/day	Elec	Ice	0.1124 kWh/kg ice	na	≤ $111.5835 {}^{*}H^{-0.258}$ + 2.205 kWh/100 kg ice	na
Ice machine RCU (remote condensing unit) H ≥ 726 kg/day	Elec	Ice	0.1124 kWh/kg ice	na	≤ -0.00024H + 4.60 kWh/100 kg ice	na
Ice machine SCU (self contained unit), H < 79 kg/day	Elec	Ice	0.3968 – $2.28E^{-03}$ kWh/kg ice	na	$236.59 {}^{*}H^{-0.326}$ + 0.176 kWh/100 kg ice	na
Ice machine SCU (self-contained unit), H ≥ 79 kg/day	Elec	Ice	0.2161 kWh/kg ice	na	$236.59 {}^{*}H^{-0.326}$ + 0.176 kWh/100 kg ice	na
Ice machine, water-cooled ice-making head, H ≥ 651 kg/day (must be on a chilled loop)	Elec	Ice	0.0882 kWh/kg ice	na	≤ 8.11 kWh/100 kg ice	na
Ice machine, water-cooled ice-making head, 227 ≤ H < 651 kg/day (must be on a chilled loop)	Elec	Ice	0.1230 – $5.35E^{-05}$ kWh/kg ice	na	≤ 11.31 – 0.065H kWh/100 kg ice	na
Ice machine, water-cooled ice-making head, H < 227 kg/day (must be on a chilled loop)	Elec	Ice	0.1720 – $2.67E^{-04}$ kWh/kg ice	na	≤ 15.48 – 0.0238H kWh/100 kg ice	na
Ice machine, water-cooled once-through (open loop)	Elec	Ice	Banned	Banned	Banned	Banned
Ice machine water-cooled SCU (self-contained unit) H < 91 kg/day (must be on a chilled loop)	Elec	Ice	0.2513 – $29.23E^{-04}$ kWh/kg ice	na	≤ 23.37 – 0.086H kWh/100 kg ice	na
Ice machine, water-cooled SCU (self-contained unit) H ≥ 91 kg/day (must be on a chilled loop)	Elec	Ice	0.1676 kWh/kg ice	na	15.57 kWh/100 kg ice	na
Chest freezer, solid or glass door	Elec	Refrig	15.90V + 0.943 kWh/day	na	9.541V + 0.130 kWh/day	na
Chest refrigerator, solid or glass door	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 4.417V + 0.475 kWh/day	na
Glass-door reach-in freezer, 0 < V < 0.42 m^3	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 21.449V + 0.893 kWh/day	na
Glass-door reach-in freezer, 0.42 ≤ V < 0.85 m^3	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 25.901V – 1.00 kWh/day	na
Glass-door reach-in freezer, 0.85 ≤ V < 1.42 m^3	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 8.834V + 13.50 kWh/day	na
Glass-door reach-in freezer, 1.42 ≤ V m^3	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 15.90V + 3.50 kWh/day	na

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Glass-door reach-in refrigerator, 0 < V < 0.42 m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 4.169V + 1.382 kWh/day	na
Glass-door reach-in refrigerator, 0.42 ≤ V < 0.85 m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 4.947V + 1.050 kWh/day	na
Glass-door reach-in refrigerator, 0.85 ≤ V < 1.42 m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 3.109V + 2.625 kWh/day	na
Glass-door reach-in refrigerator, 1.42 ≤ V m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 3.887V + 1.500 kWh/day	na
Solid-door reach-in freezer, 0 < V < 0.42 m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 8.834V + 1.25 kWh/day	na
Solid-door reach-in freezer, 0.42 < V < 0.85 m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 4.819V – 1.000 kWh/day	na
Solid-door reach-in freezer, 0.85 ≤ V < 1.42 m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 5.760V + 6.125 kWh/day	na
Solid-door reach-in freezer, 1.42 ≤ V m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 5.583V + 6.333 kWh/day	na
Solid-door reach-in refrigerator, 0 < V < 0.42 m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 3.145V + 1.411 kWh/day	na
Solid-door reach-in refrigerator, 0.42 ≤ V < 0.85 m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 1.307V + 2.200 kWh/day	na
Solid-door reach-in refrigerator, 0.85 ≤ V < 1.42 m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 1.979V + 1.635 kWh/day	na
Solid-door reach-in refrigerator, 1.42 ≤ V m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 2.120V + 1.416 kWh/day	na
Clothes washer	Gas	Sanitation	1.72 MEF		2.00 MEF	
Door-type dish machine, high temp	Elec	Sanitation	na	1.0 kW	na	0.70 kW
Door-type dish machine, low temp	Elec	Sanitation	na	0.6 kW	na	0.6 kW
Multitank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.6 kW	na	2.25 kW
Multitank rack conveyor dish machine, low temp	Elec	Sanitation	na	2.0 kW	na	2.0 kW
Single-tank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.0 kW	na	1.5 kW

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)						
	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Single-tank rack conveyor dish machine, low temp	Elec	Sanitation	na	1.6 kW	na	1.5 kW
Undercounter dish machine, high temp	Elec	Sanitation	na	0.9 kW	na	0.5 kW
Undercounter dish machine, low temp	Elec	Sanitation	na	0.5 kW	na	0.5 kW

The energy efficiency, idle energy rates, and water use requirements, where applicable, are based on the following test methods:

ASTM F1275 Standard Test Method for Performance of Griddles

ASTM F1361 Standard Test Method for Performance of Open Deep Fat Fryers

ASTM F1484 Standard Test Methods for Performance of Steam Cookers

ASTM F1496 Standard Test Method for Performance of Convection Ovens

ASTM F1521 Standard Test Methods for Performance of Range Tops

ASTM F1605 Standard Test Method for Performance of Double-Sided Griddles

ASTM F1639 Standard Test Method for Performance of Combination Ovens

ASTM F1695 Standard Test Method for Performance of Underfired Broilers

ASTM F1696 Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, ASTM Door-Type Commercial Dishwashing Machines

ASTM F1704 Standard Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems

ASTM F1817 Standard Test Method for Performance of Conveyor Ovens

ASTM F1920 Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines

ASTM F2093 Standard Test Method for Performance of Rack Ovens

ASTM F2140 Standard Test Method for Performance of Hot Food Holding Cabinets

ASTM F2144 Standard Test Method for Performance of Large Open Vat Fryers

ASTM F2324 Standard Test Method for Prerinse Spray Valves

ASTM F2380 Standard Test Method for Performance of Conveyor Toasters

ARI 810-2007: Performance Rating of Automatic Commercial Ice Makers

ANSI/ASHRAE Standard 72–2005: Method of Testing Commercial Refrigerators and Freezers with temperature setpoints at 3°C for mediumtemp refrigerators, -18°C for low-temp freezers, and -26°C for ice cream freezers.

TABLE 2. Supermarket refrigeration prescriptive measures and baseline for energy cost budget			
Item	**Attribute**	**Prescriptive Measure**	**Baseline for Energy Modeling Path**
Commercial Refrigerator and Freezers	Energy Use Limits	ASHRAE 90.1-2010 Addendum g. Table 6.8.1L	ASHRAE 90.1-2010 Addendum g. Table 6.8.1L
Commercial Refrigeration Equipment	Energy Use Limits	ASHRAE 90.1-2010 Addendum g. Table 6.8.1M	ASHRAE 90.1-2010 Addendum g. Table 6.8.1M

TABLE 3. Walk-in coolers and freezers prescriptive measures and baseline for energy cost budget

Item	Attribute	Prescriptive Measure	Baseline for Energy Modeling Path
Envelope	Freezer insulation	R-46	R-36
	Cooler insulation	R-36	R-20
	Automatic closer doors	Yes	No
	High-efficiency low- or no-heat reach-in doors	40W/ft (130W/m) of door frame (low temperature), 17W/ft (55W/m) of door frame (medium temperature)	40W/ft (130W/m) of door frame (low temperature), 17W/ft (55W/m) of door frame (medium temperature)
Evaporator	Evaporator fan motor and control	Shaded pole and split phase motors prohibited; use PSC or EMC motors	Constant-speed fan
	Hot gas defrost	No electric defrosting	Electric defrosting
Condenser	Air-cooled condenser fan motor and control	Shaded pole and split phase motors prohibited; use PSC or EMC motors; add condenser fan controllers	Cycling one-speed fan
	Air-cooled condenser design approach	Floating head pressure controls or ambient subcooling	10°F (-12°C) to 15°F (-9°C) dependent on suction temperature
Lighting	Lighting power density (W/sq.ft.)	0.6 W/sq.ft. (6.5 W/sq. meter)	0.6 W/sq.ft. (6.5 W/sq. meter)
Commercial Refrigerator and Freezers	Energy Use Limits	na	Use an Exceptional Calculation Method if attempting to take savings
Commercial Refrigerator and Freezers	Energy Use Limits	na	Use an Exceptional Calculation Method if attempting to take savings

TABLE 4. Commercial kitchen ventilation prescriptive measures and baseline for energy cost budget

Strategies	Prescriptive Measure	Baseline
Kitchen hood control	ASHRAE 90.1-2010 Section 6.5.7.1, except that Section 6.5.7.1.3 and Section 6.5.7.1.4 shall apply if the total kitchen exhaust airflow rate exceeds 2,000 cfm (960 L/s) (as opposed to 5,000 cfm (2,400 L/s) noted in the ASHRAE 90.1-2010 requirements)	ASHRAE 90.1-2010 Section 6.5.7.1 and Section G3.1.1 Exception (d) where applicable