LEED®
Core Concepts Guide

An Introduction to LEED and Green Building

THIRD EDITION

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Contents

Imagine It

A letter from the President, CEO and Founding Chair

RICK FEDRIZZI
President, CEO and Founding Chair
U.S. Green Building Council

Imagine getting up on a warm spring morning and deciding it's the perfect day to ride your bike to work. Invigorated by your morning ride and eager to start the day, you head into your office. As you pass through a common area, you see a group of coworkers deep in a collaborative work session. They're seated around a gorgeous oak table hand-crafted by local artisans and made entirely of wood reclaimed from a tree that fell naturally in a nearby forest.

Imagine getting to your desk and sitting down without flipping a light switch—the huge floor-to-ceiling windows nearby provide plenty of natural springtime light, and if it gets cloudy this afternoon, sensors in your work area will kick on overhead lighting to an appropriate level of brightness. Meanwhile, your personal control of the temperature in your work area allows you to stay warm even as your neighbor, who has a higher cold tolerance, works at a temperature that's comfortable for him.

Imagine being surrounded by decorative elements that invoke nature and keep you connected to the natural world even while you're inside. Imagine an herb garden in the office cafeteria and an educational display in the office lobby—constant reminders for you and your company's visitors of just what it is that makes your building so special.

And imagine leaving the office to find that it has started raining. But not to worry, you just duck around the corner to one of the many bus stops nearby. You mount your bike to the rack on the front of the bus and climb aboard.

You settle into your seat at the end of a full day of work, feeling the positive effects of having spent your day in an environment filled with clean indoor air, with plenty of exposure to natural light. Your mind is clear and your energy and spirits high, knowing that your workday cost substantially less in energy and water use than it would have in a more traditional building.

This is what it feels like for me and my colleagues at the LEED Platinum U.S. Green Building Council headquarters in Washington, D.C. It is what it's like for the thousands upon thousands of people worldwide who work in LEED-certified office space. And if you tweak the details, it is what it's like for all the students nationwide who study in green schools and live in green dorms, and for the increasing number of families who live in green homes.

Now, imagine that designing, building, operating, marketing, supporting, or celebrating green buildings was at the heart of your everyday work. Imagine being a green building professional.

With the *LEED Core Concepts Guide*, you're on your way to just such a career. We hope you enjoy the journey, and we look forward to the innovations you'll bring as part of the green building community.

Section 1

Introduction to Green Buildings and Communities

Our built environment is all around us; it provides the setting for all our lives' events, big and small. And whether we notice it or not, our built environment plays a huge role in our natural environment, our economic environment, and our cultural environment. The built environment provides a context for facing and addressing humankind's greatest contemporary challenges.

Green building is fundamentally a process of continual improvement. It is a process by which today's "best practices" become tomorrow's standard practices, a rising foundation for ever-higher levels of performance. Green building can help us create more vital communities, more healthful indoor and outdoor spaces, and stronger connections to nature. The green building movement strives to effect a permanent shift in prevailing design, planning, construction, and operations practices, resulting in lower-impact, more sustainable, and ultimately regenerative built environments.

For the purposes of this guide, "built environment" refers to any environment that is man-made and provides a structure for human activity. These environments range from shelters and individual buildings to neighborhoods and vast metropolitan areas. This guide explains the reasons we must change traditional building practices. It presents fundamental concepts of green building and provides a summary of the application strategies that will help you be a more effective participant in the green building process.

The remainder of this section of the guide gives the rationale for green building and the related concept of sustainability. The core concepts of sustainable thinking are explored in Section 2. Section 3 looks at important components of the sustainable design and operations process. Section 4 reviews the application of green technologies and strategies. Section 5 offers more information on the programs of the U.S. Green Building Council (USGBC), particularly the Leadership in Energy and Environmental Design (LEED) certification system. Additional resources are listed in the Appendix, and educational opportunities to support your growth and success as a green building professional are available from USGBC at usgbc.org/education.

THE ENVIRONMENTAL IMPACTS OF BUILDINGS

Why is green building necessary? Buildings and communities, including the resources used to create them and the energy, water, and materials needed to operate them, have a significant effect on the environment and human health. In the United States, buildings account for:

- 14% of potable water consumption[1]
- 30% of waste output
- 40% of raw materials use[2]
- 38% of carbon dioxide emissions
- 24% to 50% of energy use
- 72% of electricity consumption[3]

1 J.F. Kenny, N.L. Barber, S.S. Hutson, K.S. Linsey, J.K. Lovelace, & M.A. Maupin. Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, (2009).

2 D.M. Roodman & N. Lenssen "A Building Revolution: How Ecology and Health Concerns Are Transforming Construction," Worldwatch Paper 124 (Worldwatch Institute, 1995).

3 Energy Information Administration, *EIA Annual Energy Outlook* (EIA, 2008).

THE CUMULATIVE EFFECT OF CONVENTIONAL PRACTICES IN THE BUILDING INDUSTRY HAS PROFOUND IMPLICATIONS FOR HUMAN HEALTH, THE ENVIRONMENT, AND THE ECONOMY:

- Clearing of land for development often destroys wildlife habitat
- Extracting, manufacturing, and transporting materials may pollute water and air, release toxic chemicals, and emit greenhouse gases
- Building operations require large inputs of energy and water and generate substantial waste streams
- Transportation to and from buildings by commuters and service providers compounds the harmful environmental effects associated with vehicle use, such as increased energy consumption and pollution

By building green, we can reduce that environmental damage. In many cases, green buildings can even enhance the health of the environment and the people who use them.

A study by the New Buildings Institute found that in green buildings, average energy use intensities (energy consumed per unit of floor space) are 24% lower than in typical buildings.[4] Additionally, the U.S. General Services Administration surveyed 12 green buildings in its portfolio and found these savings and improvements:

- 26% less energy usage
- 27% higher levels of occupant satisfaction
- 13% lower maintenance costs
- 33% lower emissions of carbon dioxide (CO_2)[5]

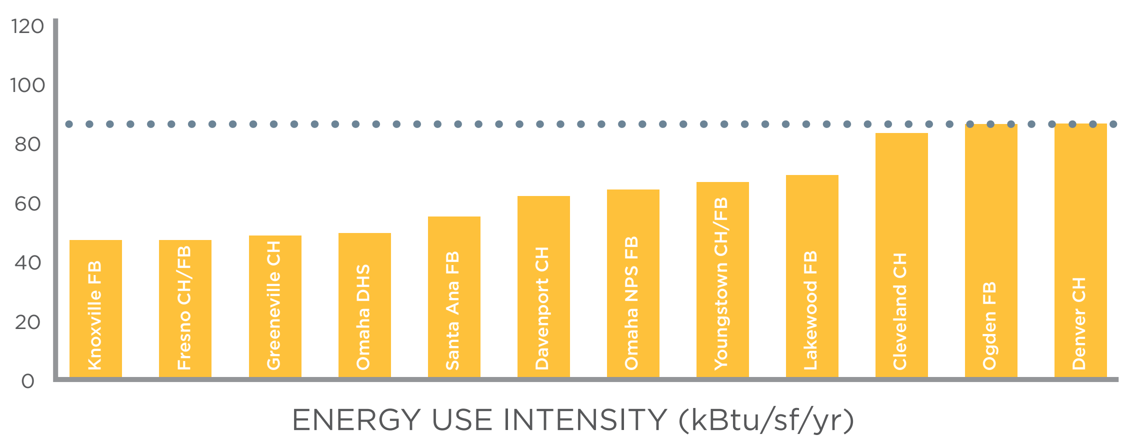


Figure 1.1. Energy Use Intensities for Sustainably Designed U.S. Government Buildings (Source: GSA 2008)
The dotted line indicates the national average energy use intensity.

4 Turner, C. & Frankel, Energy Performance of LEED® for New Construction Buildings (2008), newbuildings.org/sites/default/files/Energy_Performance_of_LEED-NC_Buildings-Final_3-4-08b.pdf.

5 Public Buildings Service, "Assessing Green Building Performance: A Post Occupancy Evaluation of 12 GSA Buildings" (General Services Administration, 2008), gsa.gov/graphics/pbs/GSA_Assessing_Green_Full_Report.pdf.

The study concluded that the federal government's green buildings outperform national averages in all measured performance areas—energy, operating costs, water use, occupant satisfaction, and carbon emissions. The agency attributed this performance to a fully integrated approach to sustainable design that addressed environmental, financial, and occupant satisfaction issues. This higher performance will last throughout a building's lifetime if the facility is also operated and maintained for sustainability.

WHAT IS GREEN BUILDING?

Sustainability is not a one-time treatment or product. Instead, green building is a process that applies to buildings, their sites, their interiors, their operations, and the communities in which they are situated. The process of green building flows throughout the entire life-cycle of a project, beginning at the inception of a project idea and continuing seamlessly until the project reaches the end of its life and its parts are recycled or reused.

In this guide, the term green building encompasses planning, design, construction, operations, and ultimately end-of-life recycling or renewal of structures. Green building pursues solutions that represent a healthy and dynamic balance between environmental, social, and economic benefits.

Sustainability and "green," often used interchangeably, are about more than just reducing environmental impacts. Sustainability means creating places that are environmentally responsible, healthful, just, equitable, and profitable. Greening the built environment means looking holistically at natural, human, and economic systems and finding solutions that support quality of life for all.

Triple bottom line is also often used to refer to the concept of sustainability. The term was coined by John Elkington, cofounder of the business consultancy SustainAbility, in his 1998 book ***Cannibals with Forks: the Triple Bottom Line of 21st Century Business***. First applied to socially responsible business, the term can characterize all kinds of projects in the built environment. The triple bottom line concept incorporates a long-term view for assessing potential effects and best practices for three kinds of resources:

- **PEOPLE (SOCIAL CAPITAL).** All the costs and benefits to the people who design, construct, live in, work in, and constitute the local community and are influenced, directly or indirectly, by a project
- **PLANET (NATURAL CAPITAL).** All the costs and benefits of a project on the natural environment, locally and globally
- **PROFIT (ECONOMIC CAPITAL).** All the economic costs and benefits of a project for all the stakeholders (not just the project owner)

The goal of the triple bottom line, in terms of the built environment, is to ensure that buildings and communities create value for all stakeholders, not just a restricted few. For example, an energy-efficient building that saves the owners money but makes the occupants sick is not sustainable, nor is a material that has a small carbon footprint but was made in a sweatshop, nor is an eco-resort that displaces threatened species or local people.

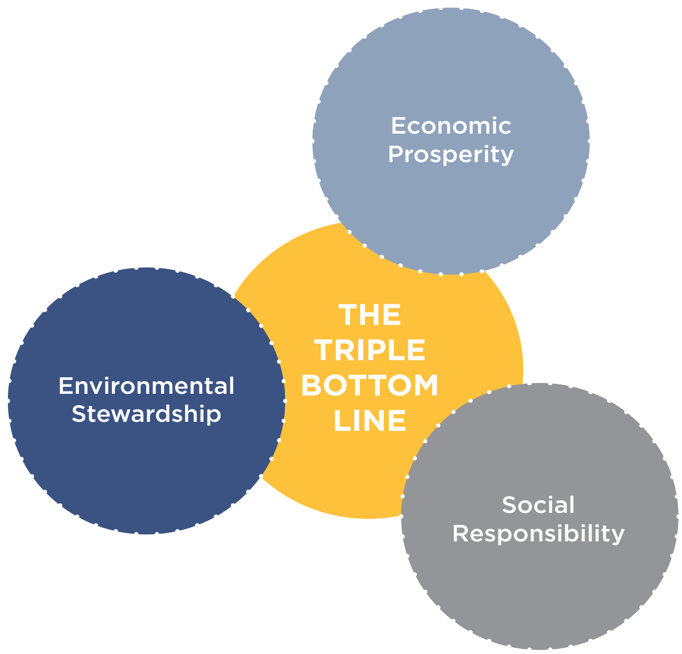


Figure 1.2. The Triple Bottom Line

A commitment to the triple bottom line means a commitment to look beyond the status quo. It requires consideration of whole communities and whole systems, both at home and around the world. Research is needed to determine the impacts of a given project and find new solutions that are truly sustainable. New tools and processes are required to help projects arrive at integrative, synergistic, sustainable solutions.

The triple bottom line requires a shift in perspective about both the costs and the benefits of our decisions. The term externalities is used by economists to describe costs or benefits incurred by parties who are not part of a transaction. For example, the purchase price of a car does not account for the wear and tear it will have on public roads or the pollution it will put into the environment. To shift the valuation process to account for such negative externalities, building professionals require new metrics. The green building process and rating systems have begun to encourage quantification of externalities. The focus has been first on environmental metrics, but the list is expanding to include indicators of social justice and public health.

Making buildings more healthful, more comfortable, and more conducive to productivity for their occupants has special significance in light of studies conducted by the U.S. Environmental Protection Agency (EPA), which found that people in the United States spend, on average, 90% of their time indoors.[6] Occupants of green buildings are typically exposed to far lower levels of indoor pollutants and have significantly greater satisfaction with air quality and lighting than occupants of conventional buildings. Research conducted at Carnegie Mellon University shows that these benefits can translate into a 2% to 16% increase in workers' and students' productivity. Even small increases in productivity can dramatically increase the value of a building.[7]

6 U.S. Environmental Protection Agency, The Inside Story: A Guide to Indoor Air Quality. U.S. EPA/Office of Air and Radiation. Office of Radiation and Indoor Air (6609J) Cosponsored with the Consumer Product Safety Commission, EPA 402-K-93-007. epa.gov/iaq/pubs/insidestory.html.

7 V. Loftness, V. Hartkopf, B. Gurtekin, and Y. Hua, "Building Investment Decision Support (BIDS™): Cost-Benefit Tool to Promote High Performance Components, Flexible Infrastructures and Systems Integration for Sustainable Commercial Buildings and Productive Organizations," Report on university research (AIA, 2005).

THE RISE OF THE GREEN BUILDING INDUSTRY

Many of the elements of green building are not new or even unique. Before the widespread availability of inexpensive fossil fuels for energy use and transportation, builders understood the principles of passive design, capturing sunlight and wind for natural lighting, heating, and cooling. In many ways, green building represents a return to simpler, low-tech solutions. At the same time, there are now many high-tech strategies available to improve the performance of the built environment. Green building is about finding the best combination of solutions to create built environments that seamlessly integrate the best of the old and the new in intelligent and creative ways.

The USGBC was formed in 1992, a time when the field was beginning to define itself, to promote and encourage green building. A member-based organization, USGBC engages hundreds of thousands of individuals. The mission of USGBC is "to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life."[8] USGBC supports achievement of this mission through education programs, advocacy, research, an extensive network of local chapters, and the LEED green building program.

Soon after it was formed, USGBC began developing LEED for rating and certifying sustainability in the building industry. Experts identified characteristics and performance levels that contributed to a definition of a green building. The first LEED green building rating system was launched in 2000. In the decade that followed, LEED expanded to include systems to address the entire life-cycle of the built environment from land-use planning to operations. It now provides rating systems for a wide array of building types, such as offices, schools, retail establishments, homes, and neighborhoods.

The Chesapeake Bay Foundation, an environmental advocacy, restoration, and education organization, is headquartered in Annapolis, Maryland. Photo credit: Robb Williamson

The trend toward green building practices in the United States has quickened in the past decade, contributing to a transformation in the market of building products and services, as well as the demand for skilled professionals. As more green products and technologies become available, green building will become more mainstream.

Federal, state, and local governments are among those adopting sustainable building practices and policies. For example, the largest federal property owners, the Department of Defense and General Services Administration have policies in place to pursue LEED certification in the new construction and major renovation rating system. Government agencies, utility companies, and manufacturers increasingly offer financial incentives for developers and owners to enhance the environmental performance of their buildings. The goal of LEED is market transformation—to fundamentally change how we design, build, and operate buildings and communities—through certification that honors levels of achievement in areas such

8 U.S Green Building Council, Strategic Plan 2013 - 2015 (USGBC, 2012).

as energy savings, water efficiency, CO_2 emissions reduction, improved indoor environmental quality, and stewardship of resources.

More information on USGBC and LEED is provided in Section 5.

GREEN BUILDING AND CLIMATE CHANGE

Although many environmental impacts are associated with buildings and addressed by rating systems such as LEED, climate change deserves special consideration because buildings and land-use are responsible for a large proportion of greenhouse gas emissions. To be effective, the policies that are emerging at the local, state, and federal levels to regulate greenhouse gas emissions must reflect a clear understanding of the connection between climate change and the built environment. Unfortunately, it is not enough for green building to lessen the effects that humans have on our climate. It must also prepare us for the inevitable consequences of climate change on our homes, communities, and society as a whole. A lower-carbon future will not only have higher-performing buildings but also require higher-performing communities.

The built environment, including buildings and transportation systems, accounts for more than two-thirds of all greenhouse gas emissions.[9] Greenhouse gas emissions come from many components of the built environment, including building systems and energy use, transportation, water use and treatment, land-cover change, materials, and construction. By improving the efficiency of buildings and communities, we can significantly reduce greenhouse gas emissions.

However, focusing on building design and construction alone will not achieve the emissions reduction that scientists believe is required to mitigate climate change. Building location is equally important. For example, a typical code-compliant 135,000-square-foot office building in a car-oriented suburban location will be responsible for approximately 8,375 tons (T) of carbon, or 11.8 T per person. Because this building is in the suburbs, emissions from transportation—people driving to and from work—make up half the total emissions associated with the project.

9 Energy Information Administration, *Annual Energy Outlook 2008* (EIA, 2008), eia.doe.gov/oiaf/aeo/pdf/0383(2008).pdf.

Common Sources of Federal Greenhouse Gas Emissions

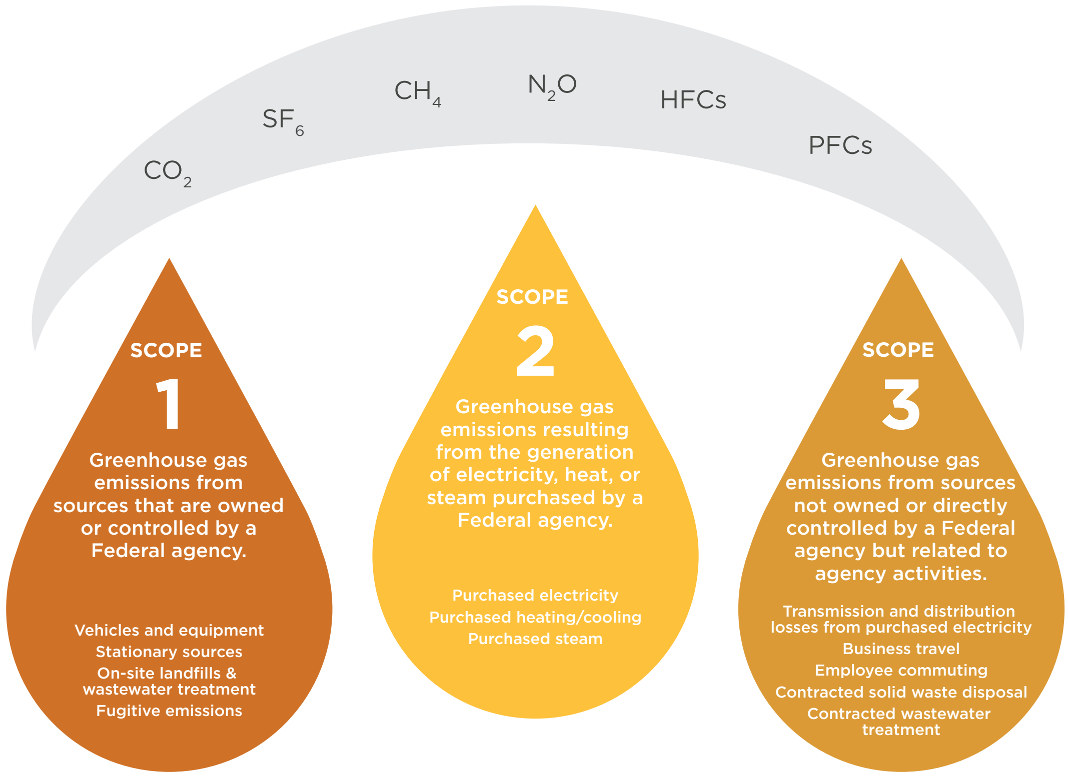


Figure 1.3. Common Sources of Greenhouse Gas Emissions from Federal Facilities as Called Out by Executive Order 13514.

When that same building is moved to a location that is accessible via public transportation, bicycling, or walking, its total emissions decrease. The emissions from transportation are much less, and the relative amount from the building systems increases.

When the building is designed and maintained as a green building with improved energy and water performance, the total emissions fall to 3,233 T, or 4.6 T per person. This example demonstrates the important link between buildings and land use and the need to address both to achieve meaningful reductions in greenhouse gas emissions.

Figure 1.4. Building Location without Supporting Infrastructure and Services

Figure 1.5. Building Location with Infrastructure and Services

Carbon emissions provide a useful metric for many aspects of green buildings and communities, including energy, water, solid waste, materials, and transportation, but green building involves more than reducing greenhouse gas emissions. It is important to set goals for other issues as well, such as indoor air quality, human health, and habitat protection. This comprehensive goal-setting process encourages programs and policies that will lead to sustainable communities. The goal-setting process will be discussed in Section 3.

ENERGY CONSUMPTION: BUILDING-ASSOCIATED TRANSPORTATION VERSUS OPERATIONS

For an average office building in the United States, 30 percent more energy is expended by office workers commuting to and from the building than is consumed by the building itself for heating, cooling, lighting, and other energy uses. Even for an office building built to modern energy codes (ASHRAE 90.1–2010), more than twice as much energy is used by commuters than by the building.[10]

Flexibility and adaptability are increasingly important attributes of green projects. Although the long-term effects of climate change are uncertain, we know that sea levels will be higher, temperatures higher, droughts longer and more widespread, and flooding more intense. How different regions will experience these changes will vary considerably, and building professionals will have to assess the likely threats to their communities and respond accordingly.

GREEN BUILDING OVER TIME

Green projects must be prepared to adapt to future change and be designed and operated to stand the test of time. Continuous monitoring is required to identify needed improvements and users' changing needs. Project teams must look far ahead to determine what stressors a project is likely to encounter and then build resilience into the system.

10 H. Levin. Driving to Green Buildings: *The Transportation Energy Intensity of Buildings. Environmental Building News,* 16:9 (2007). buildinggreen.com

For example, where water supply depends on local snowpack, planning and design efforts might focus on water conservation, water storage, and alternative sources of water in anticipation that the snowpack will shrink. Where summer heat is already high, green builders will have to consider what will happen with even hotter temperatures and ensure that the cooling strategies of buildings can handle higher degree-days and still maintain air quality, which will be exacerbated at higher temperatures. These strategies and others will be discussed in Section 4.

The performance of most systems degrades with time, and thus a building's total emissions footprint incrementally increases over time unless care is taken to maintain the systems properly. Figure 1.6 illustrates building performance by looking at the total amount of carbon emissions over a building's life-cycle.

Building commissioning helps project teams ensure that systems are designed efficiently, are installed appropriately, and operate as intended. Commissioning is the process of verifying and documenting that a building and all its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements. However, even if initial performance is optimal, emissions will rise as performance falls over time. This trend can be periodically reversed through retrocommissioning, a tune-up that identifies inefficiencies and restores high levels of performance. Commissioning and retrocommissioning will be reviewed in further detail in Section 4.

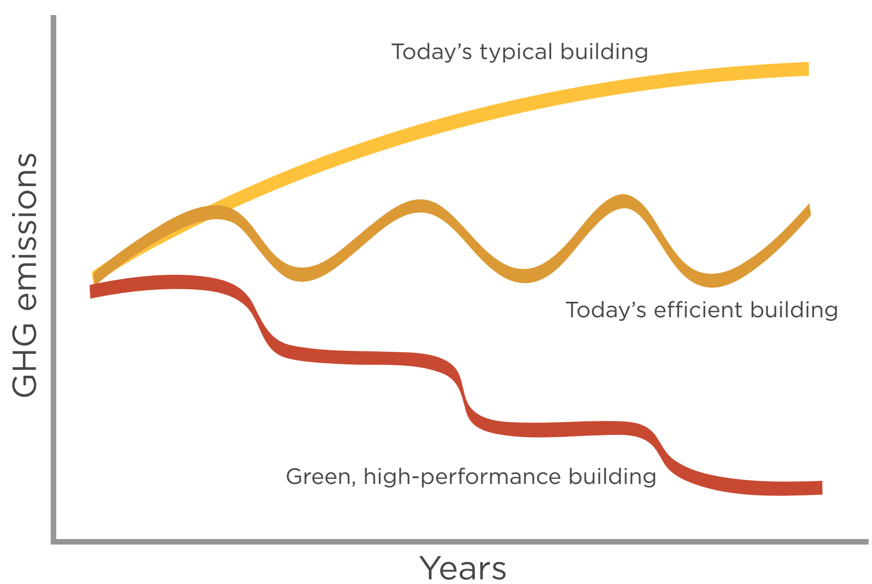


Figure 1.6. Carbon Emissions Related to Building Performance Over Time

Green building professionals strive to follow a path of continuous improvement. Because projects must be designed for the future, their operators need to participate in the design process and obtain the information they will need to monitor and maintain the building's performance. Operators also benefit from monitoring and verification systems, which enable facilities personnel to identify and resolve issues that arise over time and even enhance a building's performance throughout the life of the project.

A chief goal of green building practitioners is to find new uses for existing structures. Adaptive reuse is the practice of redesigning and using a structure for a use that is significantly different from the building's original use. Buildings can also be designed to prevent future obsolescence; for example, a flexible floor plan can accommodate offices today and apartments tomorrow. This avoids the environmental consequences of extracting materials for a new building and disposing of demolition waste. The adapted building reuses a site that is already served by infrastructure and avoids the conversion of farmland or forest to development. Designing a project to meet both current and evolving needs is one key to sustainability.

Adaptability is also critical for land use and municipal infrastructure, such as roads. Once road networks are established, they can remain fixed for centuries. In Rome, for example, the roadways that existed in ancient times have become today's automobile roads. This issue is particularly important as we move toward a lower-carbon future. Alternative transportation, including availability of public transportation, is essential for reducing carbon emissions. However, options for alternative and public transit, including bicycling and walking, depend on the proximity of destinations, connectivity of the community, and design of surroundings. Roads that are designed for only motor vehicles do not provide the flexibility or adaptability of a transportation network designed for diverse travel modes.

Buildings that protect the history and character of a place also promote sustainability. A project team can take advantage of the community's past by reusing materials with historic value. Linking the present with the past reinforces a sense of place and helps create attractive communities with viable commercial centers. Sustainable design ensures that buildings and communities will survive and thrive for generations, no matter what the future holds.

GREEN BUILDING AND LOCATION

> *A place for everything, everything in its place.*
>
> **Benjamin Franklin**

Location is a critical element of green building: it can define appropriate strategies, yet it can also limit how green a project can actually be. Depending on the environmental issues that are most critical in a particular area, location can influence a project team's priorities. Location includes these factors:

- **NATURAL CONTEXT.** Climate, sun, wind, orientation, soils, precipitation, local flora and fauna.
- **INFRASTRUCTURAL CONTEXT.** Available resources, materials, skills, and connections to utilities, roads and transit.
- **SOCIAL CONTEXT.** Connections to the community and other destinations, local priorities, cultural history and traditions, local regulations and incentives.

PROJECT CASE STUDY

NORTHWEST GARDENS

LEED GOLD

Northwest Gardens (NWG) is a transit-rich affordable housing development adjacent to downtown Fort Lauderdale, FL. The location of the NWG neighborhood on an urban infill site is ideal for the LEED for Neighborhood Development (LEED ND) program. The community boasts sufficient density to support nearby mass transit, accessible via a gridded street network of compact blocks. The project contains 394 dwelling units located in 44 multi-family buildings in addition to several retail and office buildings. The Housing Authority for the City of Fort Lauderdale (HACFL) welcomed the idea of using LEED ND and engaged their development partner Carlisle Development Group to further improve the community. Together, they expanded programs to install energy efficient street lighting and added pocket parks, community gardens, fruit trees, bioswales and additional walking paths throughout the community. Each of the homes is pursuing LEED for Homes Certification for improvements in energy use, water consumption and indoor air quality. To learn more about Northwest Gardens visit usgbc.org/projects/northwest-gardens

Courtesy of The Housing Authority of the City of Fort Lauderdale

Selecting a location is one of the earliest decisions made in a project, and this decision defines many of the opportunities and constraints that the project team will encounter. It can determine whether a project can take advantage of sunlight, have access to public transportation and other services, and protect habitats. As discussed earlier in this section, a building whose occupants must drive long distances may contribute to greenhouse gas emissions, as well as destruction of natural habitat for infrastructure development.

To design sustainably for place, a team can start with a project site and determine what uses are most appropriate there. Alternatively, the team can start with a function and find the best place to put it. In either case, the goals of the project must be clear and the needs and resources must be clearly identified so that the building can be carefully integrated into its context and support a thriving and sustainable local community.

Project teams with a goal of sustainability develop a deep understanding of the place and context in which their projects are built. They go beyond a cursory site assessment and study the land and its history. They look for ways to make connections to the immediate site, the surrounding watershed, or ecological features and promote their healthy evolution. They also engage the community's traditions, strengths, and needs in order to ascertain how the project can contribute to social and economic well-being and growth.

GREEN BUILDING COSTS AND SAVINGS

At first glance, the additional work and alternative materials needed to build green may seem like a burdensome cost, but closer attention reveals this perception to be misleading. If sustainability is viewed as an expensive add-on to a building, we would mistake efforts to reduce energy costs or improve indoor environmental quality as comparable to specifying a better grade of countertop or a more impressive front door. Under this approach, any improvement beyond a minimally code-compliant baseline looks like an added cost.

If, however, we consider energy improvements part of an overall process, we often find that the added costs are balanced by long-term savings. The initial expenditures continue to pay back over time, like a good investment. The best returns on these investments are realized when green building is integrated into the process at the earliest stages rather than as a last-minute effort. For instance, specification of more costly, high-performance windows may allow for the use of a smaller, lower-cost heating, ventilation, and air-conditioning (HVAC) system. More fundamentally, if we view sustainable design as part of the necessary functional requirements for building an energy-efficient structure and providing a safe, healthful environment, we can compare the cost of the green building with that of other buildings in the same class, rather than against an artificially low baseline.

A landmark study by the firm Davis Langdon found no significant difference between the average cost of a LEED-certified building and other new construction in the same category: there are expensive green buildings, and there are expensive conventional buildings. Certification as a green building was not a significant indicator of construction cost.[11]

11 L.F. Matthiessen and P. Morris, "Cost of Green Revisited: Reexamining the Feasibility and Cost Impact of Sustainable Design in the Light of Increased Market Adoption" (Davis Langdon, 2007), davislangdon.com.

Interestingly, the public dramatically overestimates the marginal cost of green building. A 2007 public opinion survey conducted by the World Business Council for Sustainable Development found that respondents believed, on average, that green features added 17% to the cost of a building, whereas a study of 146 green buildings found an actual average marginal cost of less than 2%.[12]

Green building is, however, a significant predictor of tangible improvements in building performance, and those improvements have considerable value. Studies have shown that certified green buildings command significantly higher rents. A University of California–Berkeley study analyzed 694 certified green buildings and compared them with 7,489 other office buildings, each located within a quarter-mile of a green building in the sample. The researchers found that, on average, certified green office buildings rented for 2% more than comparable nearby buildings. After adjusting for occupancy levels, they identified a 6% premium for certified buildings. The researchers calculated that at prevailing capitalization rates, this adds more than $5 million to the market value of each property.[13]

BEYOND GREEN

Initially, green buildings were intended to reduce damage to the environment and human health caused by creating and maintaining buildings and neighborhoods. As the concept of sustainability was applied to the built environment, it has become clear that doing less damage is not enough.

Leaders in the field now speak about buildings and communities that are regenerative, meaning that these sustainable environments evolve with living systems and contribute to the long-term renewal of resources and life. Some practitioners have begun to explore what it would mean to move beyond "sustainable" and participate as a positive developmental force in our ecosystems and communities. The focus is on building a comprehensive understanding of the place in which the project is located, recognizing the site's patterns and flow of life. Accordingly, such projects contribute to the healthy coevolution of humans and all life in that place. They thrive on diversity, for example, and clean the air rather than pollute it. Regenerative projects and communities involve stakeholders and require interactivity.

Figure 1.7. Regenerative Design

12 G. Kats et al., *Green Buildings and Communities: Costs and Benefits* (Good Energies, 2008).

13 P. Eichholtz, N. Kok, and J.M. Quigley, "Doing Well by Doing Good? Green Office Buildings" (Institute of Business and Economic Research, University of California–Berkeley, 2008), mistra.org/download/18.39aa239f11a8dd8de6b800026477/IBER+Green+Office+Buildings+NKok+et+al.pdf.

Regenerative projects support the health of the local community and regional ecosystems, generate electricity and send the excess to the grid, return water to the hydrologic system cleaner than it was before use, serve as locations for food production and community networking, regenerate biodiversity, and promote many other relationships that link the projects to the whole system of life around them.

Regenerative projects strive toward "net-zero"—using no more resources than they can produce. For example, net-zero energy projects use no more energy from the grid than they generate on site. These projects may be connected to the grid, drawing electricity from it at night and contributing energy from on-site renewable energy systems during the day, such that their total energy cost is zero. Other projects strive for carbon neutrality, emitting no more carbon emissions than they can either sequester or offset. Still other projects are designed to achieve a more even water balance: they use no more water than that which falls on site as precipitation, or they produce zero waste by recycling, reusing, or composting all materials.

Not all projects can achieve those levels of performance. Nevertheless, on average, green buildings save energy, use less water, generate less waste, and provide more healthful, more comfortable indoor environments. Specific strategies will be discussed in Section 4 of this guide.

Getting to green and beyond requires more than learning about new technologies and strategies. It requires more than learning to apply LEED checklists. Achieving true sustainability requires a new approach to creating and caring for the built environment.

GREEN BUILDING EXPERTISE

Green building requires new skills and new knowledge, as well as new attitudes and new mindsets. In a linear and hierarchical practice, each participant does his or her part and passes the job on to the next in line. There is little interaction, and people are compartmentalized by discipline or profession. By contrast, the green building process is interdisciplinary, iterative, and collaborative. Teamwork and critical thinking are valued. Everyone needs to learn to ask the right questions and to participate in developing the solutions. Feedback loops are built into the entire process.

The new skills required for a green building practice are not just knowledge of new strategies, materials, or equipment, although these are necessary. Green building practitioners need to learn how teams work, how to facilitate or participate in a productive discussion, how to work with people with different backgrounds and skills, and how to think outside their normal comfort zones when developing ideas. They need to be able to understand an ecologist's report on the proposed site, or better still, participate in walking the site and contributing to the assessment. They need to be able to question one another—Why should something be done the way it always has been done it in the past?—and then consider, what if...?

These are not skills and knowledge that most practitioners traditionally receive during their professional education and training. Most architects, engineers, landscape architects, planners, and business managers learn skills on the job and through trial and error, such as by facilitating meetings with team members and stakeholders. These opportunities will be explored in greater depth in Section 3. Additionally, training programs can help build these skills by combining experience with more formal classes, workshops, and online education. University curricula are beginning to incorporate these skills, but it may be several years before green expertise becomes the norm.

This guide is intended to set the foundation needed to develop green building expertise. A fresh perspective will change the way you look at the buildings we all live and work in, the ones we walk past, and the ones we revere as beacons of innovation in our communities. It will challenge you to imagine the next green building project to which you'll contribute.

Section 2

Sustainable Thinking

Green building will change the way you think. Buildings that seem to be individual, static objects will reveal themselves as fluid parts of an environmental system that changes over time. Professionals who appeared only distantly related will become partners in a dynamic process that incoporates perspectives from different fields.

> *No problem can be solved from the same level of consciousness that created it.*
>
> Albert Einstein

This section reviews three major concepts that are integral to green building and sustainability: systems thinking, life-cycle thinking, and integrative processes. In systems thinking, the built environment is understood as a series of relationships in which each part affects many other parts. Systems include materials, resources, energy, people, and information, as well as the complex interactions and flows between these elements across space and through time. Green building also requires taking a life-cycle approach, looking at all stages of a project, product, or service. It requires asking, where do building materials and resources come from? Where will they go once their useful life ends? What effects do they have on the world along the way? Questions such as these encourage practitioners to ensure that buildings are adaptable and resilient and perform as expected while minimizing harmful consequences. Finally, to achieve results that are based on whole systems across their entire life-cycle, building professionals must adopt an integrative process. This approach emphasizes connections and communication among professionals and stakeholders throughout the life of a project. It breaks down disciplinary boundaries and rejects linear planning and design processes that can lead to inefficient solutions. Although the term "integrative design" is most often applied to new construction or renovations, an integrative process is applicable to any phase in the life-cycle of a building.

In green building, solutions are examined through different perspectives, scales, and levels of detail, and then refined. The lens of each discipline involved in a project contributes to an overall view that leads to more effective designs. For example, sustainable neighborhood design strategies might be analyzed by land-use planners, traffic engineers, civil engineers, infrastructure designers, public health experts, and developers. The more each team member understands the perspectives and strategies of the others, the more integrated the design. The iterative pattern of an integrative process can be used throughout the project as details come into focus. Far from being time consuming, the process can actually save time by encouraging communication up front and bringing people together for highly productive collaborative work sessions.

INTEGRATIVE DESIGN MEETS THE REAL WORLD

In the article "Integrated Design Meets the Real World," the authors note that users of an integrated approach "... got better at the process over time, especially when they were able to work with the same team members more than once. Once they'd gone through the process, they found it valuable, and many couldn't imagine doing design any other way."[14]

This section addresses problem-solving approaches that can be applied throughout the green building process. Subsequent sections will explore how green building professionals can begin to incorporate these ideas into projects and professional pursuits.

SYSTEMS THINKING

Sustainability involves designing and operating systems to survive and thrive over time. To understand sustainable systems, we must further understand what we mean by systems.

A system is an assemblage of elements or parts that interact in a series of relationships to form a complex whole that serves particular functions or purposes. The theory behind systems thinking has had a profound effect on many fields of study, such as computer science, business, psychology, and ecology. Donella Meadows, Jørgen Randers, and Dennis Meadows, pioneers in the study of systems and sustainability, describe this discipline in their book *The Limits to Growth*.

A system can be physically small (an ant hill) or large (the entire universe), simple and self-contained (bacteria in a Petri dish) or complex and interacting with other systems (the global trading system or a forest ecosystem). Systems rarely exist in isolation; even the bacteria in the Petri dish are affected by the light and temperature of the laboratory. The boundaries of a system depend on what we are looking at, and most systems are actually systems within systems. For example, the human body is made up of many interlinking internal systems, such as the musculoskeletal system, which interact with external systems, such as the natural environment.

> Our training taught us to see the world as a set of unfolding behavior patterns, such as growth, decline, oscillation, overshoot. It has taught us to focus not so much on single pieces of a system, as on connections. We see the elements of demography, economy, and the environment as *one planetary system*, with innumerable interconnections. We see stocks and flows and feedbacks and interconnections, all of which influence the way the system will behave in the future and influence the actions we might take to change its behavior.[15]

14 A. Wendt and N. Malin, Integrated Design Meets the Real World, *Environmental Building News* 19(5) (2010), buildinggreen.com/articles/IssueTOC.cfm?Volume=19&Issue=5.

15 Donella H. Meadows, Dennis L. Meadows, Jorgen Randers, and William W. Behrens III. (1972). The Limits to Growth. New York: Universe Books.

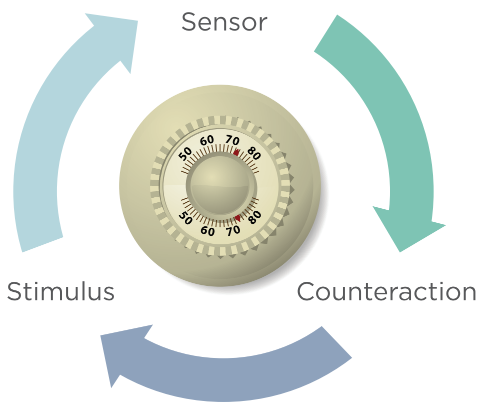
Many systems in the modern world are designed as open systems, into which materials and resources are constantly brought in from the outside, used in some way, and then released outside the system in some form of waste. For example, in most urban American communities, water, food, energy, and materials are imported into the city from sources outside the municipal boundaries. In fact, many of our materials and resources are imported from around the world. After they have been used inside the city, they are released as waste in the form of sewage, solid waste, and pollution. In nature, there are no open systems; dead and decaying matter become food for something else, and everything goes somewhere. There is no "away." By slowing the passing of materials and resources through the system and linking elements to form new relationships and functions, we can begin to mimic nature and design closed systems, which are more sustainable.

When designing buildings and communities, we must understand both the individual elements of the system and their relationships to each other as a whole. One decision may have a ripple effect. For example, improvements in the building envelope, the boundary between the exterior and interior elements of a building, can change the requirements for the mechanical system. Using better insulation or more efficient windows might allow for a smaller heating system. At the same time, reducing air infiltration can raise concerns about the indoor air quality. Envelope design can also be used to increase daylight into the space, affecting lighting design, heating, and air-conditioning as well as improving the quality of the indoor space. But envelopes designed for increased daylighting without consideration of glare and heat gain can create uncomfortable and less productive spaces. Even the interior finishes and furnishings can change the effectiveness of natural daylighting and ventilation strategies.

> *Optimizing components in isolation tends to pessimize the whole system—and hence the bottom line. You can actually make a system less efficient, simply by not properly linking up those components … If they're not designed to work with one another, they'll tend to work against one another.*
>
> Paul Hawken, Amory Lovins, and L. Hunter Lovins *Natural Capitalism*

The concept of feedback loops helps explain how systems work. Feedback loops are the information flows within a system that allow that system to organize itself. For example, when a thermostat indicates that the temperature in a room is too warm, it sends a signal to turn on the air-conditioning. When the room is sufficiently cooled, the thermostat sends a signal for the air-conditioning to stop.

This type of feedback loop is called a negative feedback loop because embedded in the system's response to a change is a signal for the system to stop changing when that response is no longer needed. Negative feedback loops enable a system to self-correct and stay within a particular range of function or performance. Thus, they keep systems stable.



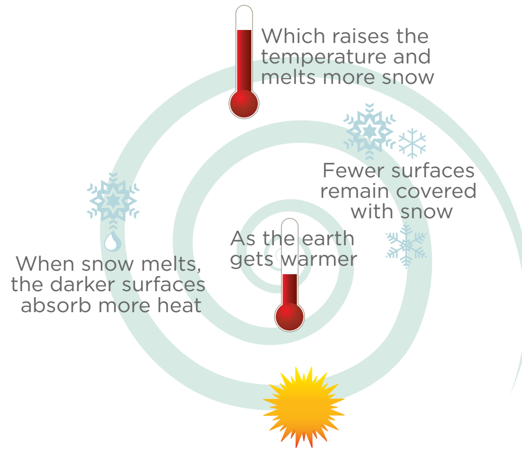


Figure 2.1. Negative Feedback Loop

Figure 2.2. Positive Feedback Loop

POSITIVE FEEDBACK LOOPS, on the other hand, are self-reinforcing: the stimulus causes an effect, and the effect produces even more of that same effect. Population growth is a positive feedback loop. The more babies who are born, the more people there will be in the population to have more babies. Therefore, the population can be expected to rise until acted upon by another force, such as an epidemic or shortage of resources.

In the built environment, roads and infrastructure built out to the urban fringe often result in a positive feedback loop of increased development. This suburban growth can sprawl far from the urban core, requiring more roads and encouraging additional growth, as well as using more resources (energy, water, sewage systems, materials) to support that growth.

Climate change is another positive feedback loop. As the earth gets warmer, fewer surfaces remain covered with snow, a reflective surface that bounces incoming heat from the sun back into space. When snow melts, the darker surfaces absorb more heat, which raises the temperature and melts more snow. Similarly, in the built environment, the dark surfaces of roofs, roads, and parking lots absorb more heat from the sun. This heat island effect raises temperatures in urban areas several degrees above the temperature of surrounding areas, increasing the demand for cooling and the amount of energy that buildings use. The additional energy use can increase carbon emissions, which contribute to global warming, further raising urban temperatures and energy use, and the cycle continues.

Figure 2.3. Induced Growth Over Time

Unchecked, positive feedback loops can create chaos in a system. For example, if urban temperatures rise too high, local populations may suffer or abandon the area. In nature, positive feedback loops are typically checked by stabilizing negative feedback loops, processes that shut down uncontrolled growth or other destabilizing forces. Stability and resilience in the system return as the feedback loops begin to control the change. To design sustainable systems, we must understand the positive and negative feedback loops already in existence or those we set in motion, to ensure systems remain stable and habitable over time.

Feedback loops—positive or negative—depend on flows of information. When information about the performance of the system is missing or blocked, the system cannot respond. For example, buildings without appropriate sensors and control systems cannot adjust to changing temperatures and maintain a comfortable indoor environment. The information must be both collected and directed. Most buildings have thermostats to provide information and control temperature. However, there are many other parameters, measurable or quantifiable characteristics of a system, that are relevant to sustainability but do not get measured or reported in effective ways. For example, the amount of energy used by tenant-occupied buildings may be collected by an electricity or gas meter and reported to the utility company but not to the occupants, who therefore have no information about their energy consumption and no incentive to reduce it. If real-time information on energy use is delivered to them in a convenient way, they can use energy more efficiently. Some have called this the Prius effect, after the hybrid car that gives drivers information about fuel consumption so that they can drive in a fuel-efficient way.[16] Installing real-time energy meters where operators can act on the information is an example of connecting elements of a system so that they can interact and respond to each other more appropriately in the feedback loop.

16 Brand Neutral, *The Prius Effect: Learning from Toyota* (2007), brandneutral.com/documents/Prius_Effect.pdf.

THE PRIUS EFFECT

Delivering real-time energy information in a convenient way by installing meters where operators can act on the information and make changes to use energy more efficiently.

In addition to elements, their relationships, and the feedback loops among them, systems theory explores the emergent properties of a system—patterns that emerge from the system as a whole and are more than the sum of the parts. For example, the pattern of waves crashing along the beach is an emergent property: the pattern is more than the water molecules that make up the ocean, more than the surface of the shore, more than the gravitational pull of the moon or the influence of the wind. The waves emerge as a result of the interactions and relationships among the elements.

Similarly, the culture of a company emerges from the people who work there, the buildings in which they work, the services or products they provide, the way they receive and process information, the management and power structure, and the financial structure. These elements and flows combine in both predictable and unpredictable ways to form a unique and individual organization. The elements of the system (people, buildings), the flows within the system (of materials, money, and information), the rules that govern those flows (management and structures), and the functions of the system (providing goods or services, generating a profit) determine whether the company is a good place to work and will be sustainable over time.

To influence the behavior of a system, it is important to find the leverage points—places where a small intervention can yield large changes. Providing building occupants with real-time energy information is an example of using a leverage point to alter behavior. Rather than changing the elements of the system—the envelope of the structure, the mechanical system, the building occupants, the electricity grid—the change focuses merely on delivering available data to a point where it can be acted on appropriately. This minor tweak can dramatically raise the efficiency of the system. Donella Meadows's essay "Leverage Points: Places to Intervene in a System" provides an excellent summary of how to find and use leverage points to make meaningful change.[17]

In ***Natural Capitalism***, Hawkens, Lovins, and Lovins explore how capital markets can be used for—rather than against—sustainability, not by eliminating them or adding intensive regulation, but by using leverage points within the system. One leverage point they examine is the goals that govern the system. By valuing not only financial capital but also natural capital and human capital, existing systems and structures can lead to sustainability.

17 D. Meadows, *Leverage Points: Places to Intervene in a System* (1999), sustainer.org/pubs/Leverage_Points.pdf.

PROJECT CASE STUDY

CANNON DESIGN CHICAGO OFFICE RELOCATION

LEED PLATINUM

Cannon Design's Chicago office, certified under LEED for Commercial Interiors, relocated to Michigan Plaza, two adjacent mixed-use office towers in Chicago's central business district. The company's former longtime home spread employees and operations across four different floors, so this move marked a watershed: for the first time Chicago office employees are now able to occupy a single, contiguous 60,000 square foot floor that spans two buildings. Ultimately, this is a workplace designed to benefit the people that work in it. Prior to relocating to this space, the project team conducted an online survey open to all employees to estimate the percentage of time employees dedicated to formal and informal collaboration, learning, personal head-down work time and socialization. The space plan for the project responded to needs identified in this survey. In all, the design incorporates twenty different workplace setting types to encourage all employees to work in the manner that best suits each individual's style and the task at hand. Canon Design also valued an energy-efficient space, and used the site selection process to achieve their goals—the chosen building is certified under ENERGY STAR and achieved Gold under the LEED O+M rating system.

An interactive sustainability reporting dashboard occupies a prominent space in the heart of the office, immediately adjacent to the library and central gathering space. This dashboard tracks real-time energy consumption within the office and also displays other key annual environmental measures for the office, including waste management, water consumption and vehicle miles traveled. To learn more about the Cannon Design Chicago office visit usgbc.org/projects/cannon-design-chicago-office-relocation

Photo by Christopher Barrett

LEVERAGE POINTS

Places to Intervene in a System (in increasing order of effectiveness):

12. Constant, parameters, numbers (such as subsidies, taxes, standards)

11. The sizes of buffers and other stabilizing stocks, relative to their flows

10. The structure of material stocks and flows (such as transport networks, population age structures)

9. The lengths of delays, relative to the rate of system change

8. The strength of negative feedback loops, relative to the impacts they are trying to correct against

7. The gain around driving positive feedback loops

6. The structure of information flows (who does and does not have access to what kinds of information)

5. The rules of the system (such as incentives, punishments, constraints)

4. The power to add, change, evolve, or self-organize system structure

3. The goals of the system

2. The mindset or paradigm out of which the system—its goals, structure, rules, delays, parameters—arises

1. The power to transcend paradigms

For instance, when carpet manufacturer Interface Flooring switched from being a producer of carpet to a provider of the service of floor coverings, it created a shift in the company's mission. Instead of buying carpet, customers could buy the *service* of the carpet, which would be owned by Interface. The company would be responsible for maintaining the carpet over time, replacing worn areas, and disposing of any "waste." This shift served as a leverage point to enable the company system to change radically toward sustainability, reducing waste, and improving performance of the product while maintaining profit. In other words, Interface Flooring moved from an open system to a closed system. The new mental model resulted not just in more efficient processes, but also in a radical restructuring of the company and all its operations.

Buildings are part of a world of nested systems that affect and are affected by one another. Once the project team understands the network of systems that affect a given project, the energy and matter that flow through the systems, and the relationships and interdependencies that exist, the deeper and more effectively integration can occur.

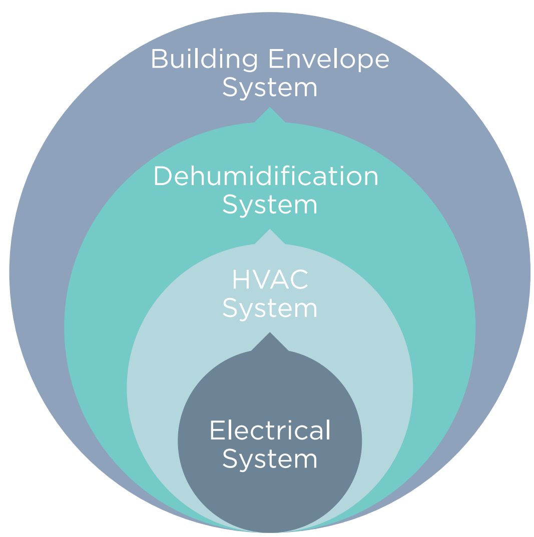


Figure 2.4. Nested Systems

When designing aspects of the built environment, consider the systems in which the project will be located and the systems the project will create. Learn about the relationships between the elements, the flows of resources and information, and the leverage points that can lead to dramatic changes. Before starting any project, the team can explore these systems by asking questions. Whether working in the planning, design, construction, or operations phase, these questions may provide insight into the systems context and ways to move more fully toward sustainability in an integrated way.

QUESTIONS A PROJECT TEAM NEEDS TO EXPLORE AS MEMBERS BEGIN WORKING TOGETHER, INCLUDE:

- Where is the project located, and who are its neighbors—locally, regionally, and beyond? What is the local watershed? The bioregion? What are the characteristics of these systems?
- How do resources, such as energy, water, and materials, flow into the project? Where do they come from, and from how far away? What other purposes or projects do those flows serve?
- What natural processes are at work on the site? How do resources, such as rainwater, wastewater, and solid waste, flow out of the system? Where do they go? Are there places on site where these flows can be captured, stored, or reused?
- What are the goals of the owner? What is the function or purpose of the project? How will the project meet those goals?
- What is the community within the project? Who are the people who come here, and where do they come from? Where do they go? What brings them together, and what might keep them apart? How will the project change their interactions?
- How does the project community interact with other, overlapping communities? What are the interrelationships? Are there sources of conflicts? What is the economic system within the project? How does it fit into larger or overlapping economic systems?
- What are the leverage points within the system? Are there places where small changes can produce big results?

In a linear design process, the solutions to one problem may cause other problems elsewhere in the system. When problems are solved through a systems-based approach, multiple problems can often be solved at the same time. This synergy is possible when we take the time to explore the interconnections and approach a project in a holistic manner. In the context of the built environment, systems thinking allows us to explore and support the rich interactions that make healthy, thriving, and sustainable communities.

LIFE-CYCLE APPROACH

Green building takes a life-cycle approach, looking at the entire life of a project, product, or service, rather than a single snapshot of a system. The dimension of longevity distinguishes green building from conventional building practice, which may fail to think across time, and helps create communities and buildings that are meant to last. For a building, a life-cycle approach begins with the initial predesign decisions that set goals and a program to follow. It continues through location selection, then design, construction, operations and maintenance, refurbishment, and renovation. A building's life-cycle ends in demolition or, preferably, reuse.

In most cases in our industrial system, we treat the manufacture of products, the construction of buildings, and the operations of organizations as open systems. We take materials from outside the system, use them to make something, and then discard what remains. This throughput of resources occurs at every phase of the life-cycle, creating a constant cycle of consumption and waste. In addition to the upstream effects that happen before a material is used, there are downstream impacts associated with its operation and end of life. We need to consider both upstream and downstream effects in our decision-making processes.

Systems thinking relies on identifying and acting on opportunities to close this loop. Because we typically do not consider building elements as linked into a larger set of systems, this waste remains largely invisible. By incorporating the upstream effects into our analysis of alternatives, we can get a broader picture of the environmental costs and benefits of materials. The practice of investigating materials from the point of extraction to their disposal is sometimes described as cradle to grave—a term that suggests a linear process through an open system. To emphasize the cyclical aspect of a closed system, architect William McDonough and colleague Michael Braungart coined the phrase cradle to cradle. In a closed system, there is no waste, and all things find another purpose at the end of their useful lives.

A comprehensive, life-cycle approach improves the ability to address potentially important environmental and human health concerns. For example, a product may consist of material mined in Africa, manufactured in Asia, and shipped to the United States for purchase. By focusing only on the energy efficiency of this product during its use, we might miss the damage caused by its transport from the place of manufacture or by the extraction of its raw material. Or a window may have a high recycled content but not be highly efficient. By looking only at the percentage of recycled content, we might select a product that will compromise the project's energy-saving goals. In a green building project, the team must consider embodied energy—the total amount of energy used to harvest or extract, manufacture, transport, install, and use a product across its life-cycle—alongside performance and adaptability. The careful consideration of all attributes may lead to the selection of products that did not at first appear to be the most sustainable option.

Life-cycle thinking can be applied to environmental considerations, in which case it is called life-cycle assessment (LCA), and to cost considerations, or life-cycle costing (LCC). These are distinct approaches with different methodologies but are often confused. Both can support more sustainable decision making, but they use different types of data and provide different kinds of information.

Life-cycle assessment attempts to identify and quantify environmental effects throughout the life of materials, products, or buildings. It identifies all

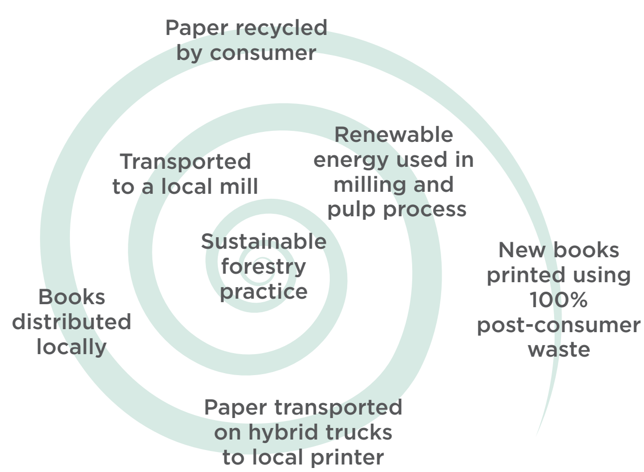


Figure 2.5. Considering a Product's Entire Life-cycle

the processes and associated inputs (energy, water, materials) and outputs (wastes, by-products), from the extraction and processing of raw materials and recycled feedstocks, the transportation of these materials, and the manufacturing and packaging of the product to its use, maintenance, and finally its recycling or disposal. These inputs and outputs are quantified and their effects on the environment and human health are measured. Although LCA does not address all potential effects, it provides a comprehensive picture of the life-cycle. This information can then be used to support decision making. Tools and databases used in conducting LCAs are available from sources in the U.S. government and the private sector.

Life-cycle costing looks at both purchase and operating costs as well as relative savings over the life of the building or product. It calculates payback periods for first costs, providing a context for making decisions about initial investments. For example, more efficient mechanical systems generally cost more than inefficient equipment, but by looking beyond the purchase price and calculating all the energy, maintenance, replacement, and other costs over the life-cycle of the equipment, we can better understand the true cost of the equipment—both to the environment and to the building owner.

LCC can be used in comparing alternatives with different initial and operating costs. For a building this usually includes the following costs:

- Initial purchase, acquisition, or construction
- Fuel
- Operation, maintenance, and repair
- Replacement
- Disposal (or residual value for resale or salvage)
- Finance charges
- Other intangible benefits or costs, such as increased employee productivity

Life-cycle thinking can be applied to all decisions in green building, not just products and buildings. Teams need to look for opportunities to evaluate the environmental impacts of design decisions and improve sustainability at all points in the project's life-cycle. Once decisions have been made at each phase, however, those opportunities can become limited. The key to sustainability is to establish goals and targets early in the process, understand the systems that are in play, and anticipate how those systems are likely to change and evolve.

Land-use and urban planners also draw on the concept of life-cycles because decisions about the location of roads and infrastructure can affect all future decisions about that land for centuries. Consider again the example from Section 1 of Rome's road structure: these roads were built for pedestrians and therefore remain walkable and pedestrian oriented even today. This does not mean that there are no opportunities to make vehicle-oriented development greener, but it does mean that the challenges of reducing transportation impacts, such as carbon footprint, are greater in projects where pedestrian access is not an initial goal.

With future implications of the built environment in mind, we must rethink the processes we use at all phases of the life-cycle. Assembling the right team, establishing goals, and understanding the systems and metrics for success will help ensure that we move closer to a sustainable built environment.

INTEGRATIVE PROCESS

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.

An integrative process 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. By understanding building system interrelationships, project teams will ideally discover unique opportunities for innovative design, increased building performance, and greater environmental benefits. 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. As a result, solving for one problem may create other problems elsewhere in the system. For example:

- Separating residential and commercial uses and failing to connect them with alternative transportation means that people will drive cars to reach their destinations, generating air pollution and traffic
- Filling a landscape with ornamental plants not appropriate for the local climate means that large amounts of water may be required throughout the life of the project
- Creating air-tight buildings for energy efficiency without providing adequate ventilation results in poor indoor air quality for building occupants

When an integrated, systems-based approach is used, the solution to one problem can lead to solutions to many problems. The process of planning a project's water use might lead to the design of systems that capture rainwater and greywater to meet water supply and irrigation needs while reducing runoff and protecting water quality. More broadly, by thinking about the system across the entire life-cycle, integrative strategies can be developed synergistically.

FOR EXAMPLE:

- Locating homes near jobs and shops and designing safe, pedestrian-friendly streets can encourage people to walk, both reducing vehicle emissions and improving their health
- Designing landscapes that use native species can both reduce water consumption and provide habitat for local fauna
- Orienting buildings appropriately on a site and designing them to catch sunlight for heating and illumination and natural breezes for cooling and ventilation can save energy, improve indoor air quality, and even increase workers' productivity
- Composting improves the quality of the soil and reduces greenhouse gas emissions related to trash hauling

Practitioners of an integrative process must develop new skills that might not have been required in their past professional work: critical thinking and questioning, collaboration, teamwork and communication, and a deep understanding of natural processes. An integrative process is a different way of thinking and working, and it creates a team from professionals who have traditionally worked as separate entities.

The integrative process requires more time and collaboration during the early conceptual and design phases than conventional practices. Time must be spent building the team, setting goals, and doing analysis before any decisions are made or implemented. This upfront investment of time, however, reduces the time it takes to produce construction documents. Because the goals have been thoroughly explored and woven throughout the process, projects can be executed more thoughtfully, take advantage of building system synergies, and better meet the needs of their occupants or communities, and ultimately save money, too. The specific steps involved in the integrative process will be addressed in Section 3.

Nature has much to teach us about applying systems thinking, a life-cycle approach, and integrative processes to our work. By observing natural patterns, such as how heat flows, water moves, or trees grow, we can learn to design systems that use resources effectively. The fields of biomimicry and permaculture provide two different and innovative approaches to solving problems by following nature's patterns and strategies. Both of these fields of practice ask: how would nature solve this? Similarly, green building practitioners can use the core concepts addressed in this section to determine the nature of the systems in which they are working, meet the needs of the community, and set goals and priorities for the project.

Section 3

Sustainable Thinking at Work: New Processes for Building Green

Green building requires a new way of thinking and approaching the design, construction, operation, and renovation of buildings and communities. Basic elements of this approach were presented in Section 2. The concepts of green building are valid for many types of buildings at all stages of development and questions will likely arise as you begin to apply them. How do teams organize as part of an integrative process? How does systems thinking change the way sites are developed? How does life-cycle assessment affect materials selection? In short, how does this new approach work in real life?

This chapter focuses on the processes surrounding green building—*how* these concepts can change the way you do things—and describes successful approaches to green building, with case examples of actual projects. The strategies and technologies of green building—*what* is done—will be discussed in Section 4.

GETTING STARTED

SEVERAL PRINCIPLES FORM THE FOUNDATION FOR SUCCESSFUL PRACTICE:

PROCESS MATTERS. How you approach projects is crucial to what you do and are able to accomplish. In other words, a good process is essential to good outcomes.

GET IN EARLY. The commitment to green building should be made as early as possible so that it can assist in framing effective goals. Trying to add green features to a project late in the process is the most expensive and least effective approach. For community or neighborhood projects, the commitment should be made at the beginning of the land-use planning phase so that it can inform land-use decisions and zoning, design of transportation systems, and layout of infrastructure. For new construction, early means before the site is selected and before the team is selected, if possible. For operations and maintenance projects, commitments need to be established before any action toward change is taken.

FOLLOW THROUGH. The commitment to green needs to continue throughout the life of the project. The green building process does not end when the project team hands the site over to the owner, facility manager, or tenant. Follow-through is needed at all stages to ensure that the strategies and technologies are maintained or adapted as necessary to remain effective. Additionally, ongoing training ensures knowledgeable operation and maintenance of these strategies and technologies, as well as an opportunity to provide feedback on the challenges faced and lessons learned.

LOOK BEYOND FIRST COSTS TO LONG-TERM SAVINGS. This new process doesn't typically cost more, but it does shift costs earlier. Increased efficiency and savings come later. Up-front goal setting, analysis, and evaluation of alternatives will assist in making decisions that result in savings over the long term through synergies and integration. Synergies are actions that complement each other, creating a whole greater than the sum of its parts. The savings are often reflected in life-cycle costing. Green strategies and technologies often have very short payback periods, but when organizations budget planning and design costs separately from capital projects and operations, savings in one category may not provide a persuasive argument for increased spending in another. It might be necessary to bring the stakeholders from these departments together to establish mechanisms for interdepartmental and collaborative decision making and funding.

INCLUDE AND COLLABORATE. Green building demands that a multidisciplinary team of professionals join with members of the community involved or affected by the project to look at the big picture, not just the individual elements that concern each of them most immediately.

ESTABLISHING AN ITERATIVE PROCESS

All the activities described in this section take place in an iterative process that contains numerous feedback loops. An iterative process is circular and repetitive. It provides opportunities for setting goals and checking each idea against those goals.

An iterative process has a cyclical nature:

- Establish clear goals and overarching commitments
- Brainstorm and develop creative solutions
- Research and refine ideas
- Explore synergies between specific strategies
- Establish metrics for measuring success
- Set new goals based on the work that has been done

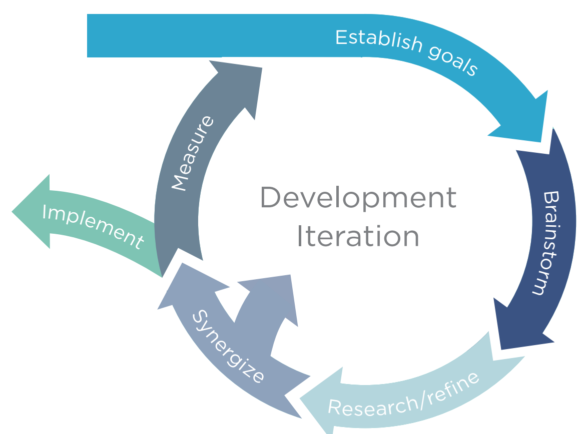


Figure 3.1. Iterative Process

This is a way for project teams to apply systems thinking and integrative process. It differs from traditional processes in that it is not linear, as when one team member completes a task and passes the work off to the next person. Instead, the team works together, in small groups and as a whole, to develop the project design and plan collaboratively. Ideas are continually being developed by the entire team, researched and refined by smaller groups, and then brought back to the team to consider critical next steps and make final decisions.

In early project meetings, it is important to establish a common commitment to the planning and implementation process. Some team members might not be familiar with an iterative process. Even when the team is experienced, it is worth reviewing the steps to ensure that all team members understand it in the same way—perhaps by asking how they might approach a problem. Sometimes the iterative process involves looking deeply at why or how a specific idea would work; at other times the team will compare one strategy with others to explore synergies and trade-offs.

Defining critical milestones, assigning champions, and clarifying goals up front will enable projects of all sizes and types to incorporate sustainability more effectively. Over the course of a project, especially a long and complex one, goals and targets evolve. Through the iterative process, a team can be ready to address changes and make deliberate decisions by using information from smaller group meetings.

An experienced facilitator can encourage people to voice their thoughts. A facilitator assists the team in expressing new ideas and ensuring that varying perspectives are valued. Additionally, this person brings the group back to explore how proposals will either further or hinder achievement of the project goals.

Careful documentation helps capture the lessons learned on the project so that they can be applied in the future—either within the timeline of that project or on subsequent green building projects.

Many different types of meetings may be useful in an iterative process. Although approaches will vary based on the specific project and team, the process often includes charrettes, team meetings, small task groups, and stakeholder meetings.

Charrettes are an important tool in an iterative process. Named after the carts that carried French architecture students' models to their final review (often as the students frantically completed their work en route with the help of friends), charrettes are intense workshops designed to produce specific deliverables. A charrette brings together the project team with stakeholders and outside experts as needed for creative thinking and collaboration. Generally held at the beginning of the project, charrettes assist in establishing goals. These sessions can also be held throughout the project at major milestones for focused, integrated problem solving. They energize the group and promote trust through productive dialogue. Additionally, they ensure alignment around goals, objectives, and actions. Although we typically think of "design charrettes," charrettes can be used for all types of building projects.

STAKEHOLDERS

The term stakeholder encompasses more than just decision makers and includes those who must live with the decisions and those who must carry them out. This cross-section of perspectives depends on the type of project. Participants in a design-build project might include the building owner, developer, client, design team members, facility managers, community representatives, local regulatory agencies, local environmental groups, ecologists, and tenants or other building users. Building operations projects might also include cleaning contractors, waste management contractors, landscape contractors, local real estate and leasing specialists, and salvage and resale companies.

Charrettes derive their value from the collaboration of people from different disciplines and perspectives. When setting up charrettes, then, include all relevant stakeholders and experts. Those outside the project team, particularly stakeholders in the community, might need encouragement to attend and a commitment that their voices will be heard. One-on-one conversations prior to the event are often useful in gaining initial trust and confidence. An educational component can ensure that participants with varying levels of knowledge all have an adequate understanding of the topics under consideration.

The combination of brainstorming, different perspectives, and a focus on results distinguish the charrette from other types of meetings. Because charrettes are highly structured, they require a strong facilitator, who may come from outside the core project team. The ideal candidate is an excellent listener who can distill the big picture from multiple viewpoints. It is critical that this person guide the conversation in a productive and unbiased direction.

Since charrettes are generally designed to result in a concrete product, an agenda and clear goals are needed. Discussion questions and activities must be designed to meet those goals. However, the charrette also needs to be flexible enough to allow for the emergence of extraordinary ideas. In advance, the project owner or developer may draft a statement that establishes the goals of the charrette and its relevance to the project. The statement inspires the team to reach the goals and also assures participants that their work is important and will influence the final project. Clear goals and specific deliverables and outcomes help all participants understand the purpose of the charrette and set the foundation for an effective agenda. Each agenda needs to be tailored to the specific project, but in general, a charrette takes the following form:

- Background briefing, to ensure that all participants have the basic information on the project and topics to be discussed
- Brainstorming, small-group work, reports, further brainstorming, and subsequent reports structured around discussion questions and specific tasks
- Synthesis of work, development of recommendations, and identification of deliverables
- Initial response from the owner or developer to the recommendations, affirming the commitment to sustainable approaches and ideas
- In follow up, a written report documenting the charrette and identified action items should be sent to all participants

TEAM MEETINGS can allow the group to work together creatively on new synergies. For example, the development of an integrated water conservation system might require collaboration between the landscape architect, the civil engineer, the structural engineer, and the mechanical, electrical, and plumbing (MEP) designer. Meetings are more effective if facilitated by a neutral party who encourages all team members to speak up.

SMALL TASK GROUPS provide opportunities to explore particular topics, conduct research, and refine the ideas for presentation at a later team meeting. They are generally composed of existing team members but may require outside experts. They do not need to be multidisciplinary unless appropriate for the task. Task group members should view their work as exploratory and consider all ideas, even those that appear to be poor choices or infeasible. Investigation of high-risk ideas can lead to the most innovative aspects of a project. Many of the specific strategies discussed in Section 4 of this guide require task groups to flesh out ideas and determine appropriate application.

STAKEHOLDER MEETINGS are held with neighbors, community members, and others with a vested interest in the project. They enhance a project team's interaction with and understanding of community issues, concerns, and ideas. Local residents frequently bring a deep understanding of the place—the local context, culture, and history, as well as the strengths and needs of the community.

In most communities, it is essential to win the trust of local residents and organizations, which may involve one-on-one and small-group meetings. It is easy for a project team to underestimate the value of this step and instead call an evening meeting with the community to present the proposed project. Effective stakeholder meetings involve both careful listening and openness to determine the most feasible and effective solutions for the community.

As with any break with tradition, barriers and obstacles can arise when a team uses an iterative process. In the article "Integrated Design Meets the Real World," authors Wendt and Malin highlight the benefits of the integrative design process but also discuss some of the obstacles:

- Meetings can be expensive to run and hard to schedule
- Communication between meetings often breaks down
- People may be resistant to green goals
- Participants can balk at the iterative, integrative process
- Traditionalists may resist the up-front loading of modeling, testing of assumptions, and analysis
- People may be reluctant to embrace new technologies[18]

Importantly, experts interviewed for the article noted that they got better at the process over time, especially when they were able to work with the same project team members on more than one project.

TEAM SELECTION

One defining element of the green building process is the project team, a broad, inclusive, collaborative group that works together to design and complete the project. This team differs from the group of stakeholders who participate in the charrettes. The members of this group are highly invested and involved across all stages of the project. They are deeply involved in the problem-solving and decision-making processes at every step.

Individual projects require different blends of expertise. For example, the appropriate team for developing a sustainable operations program would likely involve the facility owner, facility management team, vendors, occupants' representatives, and a sustainability expert. Additionally, the expertise of individual project team members will be more critical at different points in the project. For example, an ecologist might be most relevant during the initial stages of the project, to help the team understand and work with the site, but could bring forward valuable ideas and find synergies throughout the process.

The team process favors a design-build or integrative project delivery (IPD) contracting process rather than traditional design-bid-build, in which the contractors are brought in after many elements of the project have been determined. Design-build and IPD enable team members to participate from the early project stages, including goal setting and initial brainstorming.

18 A. Wendt and N. Malin, Integrated Design Meets the Real World, *Environmental Building News* 19(5) (2010), buildinggreen.com/articles/IssueTOC.cfm?Volume=19&Issue=5.

PROJECT CASE STUDY

VILLA ALEGRE

LEED PLATINUM

Santa Fe Civic Housing Authority has completed the first affordable LEED for Homes units in the Santa Fe area: 111 units in Villa Alegre Phase 1 and 2. Phase 1 of the project consists of 60 units plus a community center; phase 2 consists of 50 senior housing units, one caretakers' unit, and a community center. The project team succeeded in making 97 of the 111 units affordable, despite the difficult economic conditions at that time. Redevelopment financing ultimately featured two Low Income Housing Tax Credit allocations (family, 9%; senior, 4%) that received 2009 tax allocations and two American Recover and Reinvestment Act (ARRA) grants, through the Tax Credit Assistance Program (TCAP) and the Capital Fund Recovery Competition (CFRC).

As an infill project in a historic district, Villa Alegre needed a context-sensitive design that could achieve neighborhood acceptance. Active engagement with the community proved to be invaluable when the project team headed into rigorous Santa Fe City approval meetings with neighborhood support rather than opposition. Engaging the community via design charrettes also focused the team's efforts on energy and water efficiency—important in a fragile high desert environment with less than 12 inches of rain per year. This focus would achieve goals on multiple levels and make the most appropriate use of the grant money. The project team's collaborative approach to solving problems contributed to its successful achievement of LEED Platinum certification. You can learn more about Villa Alegre at usgbc.org/projects/villa-alegre-phase-1-2-0.

Photo by Patrick Coulie

Team members should understand green building and have experience participating in a team. The experience and commitment to sustainability needs to extend to subcontractors and trades as well. Requests for proposals and interviews should include questions about experience in green building and sustainability. Ideally, evaluation of bids is based on the *best low* bid rather than the *lowest* bid. Even when this is not possible, as on many public projects, prerequisites identified in the RFP can help ensure that teams are qualified. Specific qualifications to look for might be past participation in integrative design processes, experience on green or LEED-certified projects, and LEED professional credentialing, from LEED Green Associate to LEED Accredited Professional. If inexperienced people are on the team, some training and orientation to the process will be necessary.

For a design-build project, the team usually includes the following people:

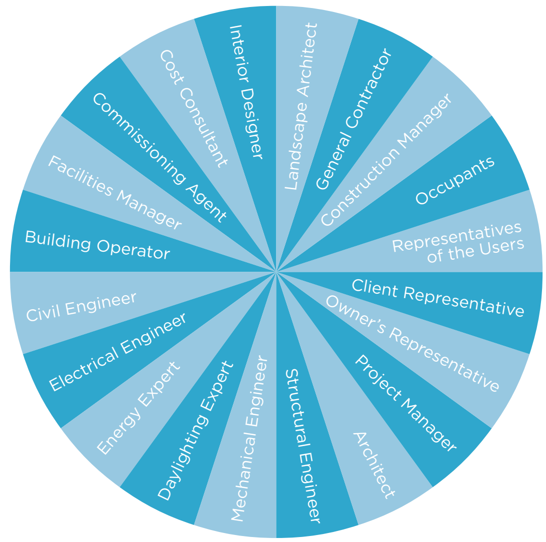


FIGURE 3.2. Members of an Integrated Team

GOAL SETTING

This guide repeatedly emphasizes the importance of project goals; every green building project needs to be grounded in strong goals and set a clear pathway to ensure they are achieved. Clear goals articulate what the project will be designed to accomplish, by:

- Making sure that the vision is clear
- Providing a frame of reference for the whole project
- Defining the sustainability targets and keeping the project on track to meet them

Setting lofty-sounding general goals can be tempting; however, such goals may not provide enough information to guide a project. For example, saying that a project should be "healthful" may be appealing, but what does that really mean in the project context? How will you know if you are on the right track? This type of high-level goal needs to be accompanied by ***metrics***, things that can be measured, and ***targets***, levels of achievement that should be reached. Each goal may have multiple metrics and targets. For example, if by "healthful" the team means that the project should protect indoor air quality, one metric for that might be the amount of volatile organic compounds (VOCs) in building materials. A target associated with that metric might be that all paints have zero VOCs. There are many attributes to indoor air quality, so in addition to addressing the potential sources of pollutants (such as materials that emit VOCs), the team must develop metrics and targets for proper ventilation.

Project goals and their associated metrics and targets can be both quantitative and qualitative. For example, if a goal is that a neighborhood project be walkable, a team might consider as a quantitative measure the percentage of homes that are within a quarter-mile of destinations such as parks, restaurants, and stores. They also might consider qualitative factors, such as whether the project has functional sidewalks. This metric is qualitative because the presence of sidewalks doesn't necessarily contribute to walkability. The usage of those sidewalks, however, can demonstrate the walkability of the neighborhood. Another example: the goal of a waste management program in an existing building might be to make recycling convenient. The quantitative metric might be the number and location of recycling receptacles and the ratio of receptacles to employees on site. A qualitative factor might be the usage of recycling receptacles: are those adjacent to workspaces and offices used more than those at central locations, such as break rooms, or vice versa? Such assessments can help the team achieve its goal through changing the placement or number of receptacles.

In addition to being measurable and accompanied by appropriate metrics and targets, effective ***goals must be achievable.*** Goals that are completely out of reach because of cost or available technology do not provide guidance and can lead to frustration. On the other hand, goals that articulate aspirations will provide a challenge that inspires the team to new heights. For example, "to stop global climate change" is an unachievable, ineffective goal. Similarly, if the project is in an existing building with limited roof area and a limited budget, "to achieve net-zero energy" is unrealistic because the building cannot accommodate on-site energy generation or be redesigned with no mechanical system. In both cases, a better project goal might be "to avoid contributing to greenhouse gas emissions." The team could achieve this goal by reducing the project's energy use and offsetting emissions by purchasing renewable energy credits.

Goals should reflect the ***spatial scales and time horizons*** that the project can affect, assuming a realistic rate of change. Stopping global climate change is beyond the space and time constraints of a single project. Even "to reduce greenhouse gas emissions by 30%" may be impossible for a project to implement all at once. Therefore, many climate-related targets are written, "to reduce greenhouse gas emissions by 30% by 2030." This type of time horizon is particularly appropriate for very large or complex projects, such as cities, organizations with multiple locations, and large campuses, where there are many different sources of greenhouse gases and time is needed to develop and implement sufficient reduction measures and policies.

Systems thinking and integrative principles encourage setting goals that go beyond deciding to seek specific LEED credits or a specific certification level. Although some teams use green building checklists, such as the LEED checklist, as the basis for setting project goals, projects are likely to be most successful if goals reflect why the project is being undertaken and how success will be demonstrated and measured. Once these goals are articulated, checklists can serve as the basis for making decisions throughout the process.

Since it is crucial to reach an agreement on the project goals, a charrette, perhaps followed by a series of team meetings, is recommended. The number of meetings will depend on how complex the project is and how quickly alignment can be reached by the stakeholders. Before these meetings, the project owner should think about underlying goals for the project, why it is needed or wanted, and what it should achieve, and discuss these points with the facilitator. Next, the project team and major stakeholders should engage in an initial goal-setting discussion, building upon the owner's initial ideas. This session should include representatives of the community and other experts to provide information on local environmental, social, and economic issues.

Once the goals have been established, they need to be listed and described in a written report. Identifying a project team member as the “goal keeper” ensures that all subsequent work can be related to the goals. Different goals may require different champions, depending on the complexity of the project. For example, the role of the commissioning agent is to ensure that goals are articulated by the owner, understood by the design team, incorporated into the design, and then achieved during construction. Thus the commissioning agent is well positioned to follow the progress of the project in relation to established goals. Not every project has a commissioning agent, but that role can be played by other members of the team.

OBSERVATION OF THE SYSTEM

Getting to know the site is part of the needs assessment and evaluation process. This will help during the team’s big-picture discussions of how to turn the goals into a concrete action plan. Design-build projects that can choose a site will benefit from setting goals before selecting a location for the project, thereby ensuring that the location contributes to the overall project plan rather than presenting challenges that the team must overcome.

The most obvious way to learn about a place is to spend time there, preferably at different times of day and in different seasons. By observing the place, people, wildlife, plants, and weather, team members can understand the patterns that make the place unique. Before they can do that effectively, from a sustainability perspective, they need to understand what ***is.*** This applies to existing buildings as well. The building ownership and management structure, use and users, and relationship to the community need to be taken into account. For instance, if the building has 32 tenants, installation of submeters in all data centers will have different implications than if it were a single-tenant facility. By studying the site, the team, with help from the facilitator, can ensure the project’s connection to the neighborhood.

Meaningful data gathering and interpretation often require the expertise of technical specialists, such as hydrologists, ecologists, engineers, economists, and anthropologists. There are many tools that can support this effort, such as systematic data collection and analysis and mapping. For existing buildings, information may be obtained through occupant surveys, building walkthroughs, and audits.

Geographical information systems (GIS) can help illustrate how different elements intersect and overlap. Map layers might show soils, infrastructure, shade, wind patterns, species distribution, land uses, demographics, roads and transit routes, traffic patterns, walkways and barriers, material flows, and solid waste pathways. Maps can also display growth projections, targeted development areas, and other indicators of how the site is likely to change over time.

PROJECT CASE STUDY

STEVENSON HIGH SCHOOL

LEED GOLD

The project team established three goals at the beginning of this Existing Buildings: Operations and Maintenance project. The first was to benchmark the school's performance against other surrounding schools. The second was to use LEED as a tool to identify opportunities for improvement to the facilities and operations. Lastly, the project team wanted to use the school as a teaching tool for the students. As part of the initial benchmarking efforts the project team pursued ENERGY STAR, earning a rating of 79 through building upgrades undertaken prior to the LEED process. By additionally pursuing LEED certification, the school's ENERGY STAR rating improved to 87. Lighting was one of the key areas for improvement within the one-million-square-foot facility. Inventorying the many varied lighting fixtures proved challenging, but the process helped to organize inventory as well as identify unused lamps and those ready for an upgrade. To meet the goal of using the school as a teaching tool, school leadership established a Green Committee in 2007 and integrated the LEED process into the curriculum. The Advanced Placement Environmental Science students conducted a sweep of the school to measure water flow from all faucets and showers. The teachers and Green Committee members created a survey to gather feedback regarding occupant comfort. Ultimately, the involvement of students and stakeholders helped the building achieve LEED Gold. For more information about Adlai E. Stevenson high school please visit usgbc.org/projects/adlai-e-stevenson-high-school

Photo provided by James Steinkamp Photography

OBSERVING A SYSTEM

To observe and understand the site, team members must ask many questions:

- What are the general climatic patterns of the site? What are the microclimates, and how and why do they occur? How does water fall on and run off the site? How does the sun affect these conditions?
- What are the soils like on the site? Are they rich loam or hard clay? Has the site ever been used for agriculture? Can it be used to grow food now?
- What plants and animals exist on the site? How did they get there? Are they healthy or stressed?
- How does energy get to the site? Is the site remote or connected to a utility grid?
- Are there roads? What type? Where do they go? Do they have sidewalks? How do the current occupants use this infrastructure?
- What kind of buildings are on the site? How tall are they? How do they connect to the street? Are they new or old? Occupied or vacant? What are they used for?

It is important also to understand the patterns at work at different spatial scales. Mapping should always extend beyond the project borders to show how it fits into a local as well as regional scale. For example, the level of detail at a small scale might reveal much about the local street grid, but zooming out reveals connections to the regional transporation system.

Once all the relevant information about the project has been collected and assessed, it is time to return to the project goals. Given what the team has learned about the project systems, its needs and resources, do the goals of the project make sense? Are they achievable? Are there other ways to meet those goals by finding other leverage points in the systems? For a renovation project, the team might prepare a gap analysis that compares existing conditions with goals and identifies the gaps. Depending on what has been learned through observation, it may be necessary to go back and refine or revise the goals.

EXPLORATION AND SELECTION OF TECHNOLOGIES AND STRATEGIES

Sustainable design requires thinking methodically through the types of strategies for each aspect of the system and evaluating alternatives against project goals through an iterative process. Although this process may be more involved and more expensive than a conventional design process, it is more likely to help the team arrive at solutions that will serve the project owner, the occupants, and the community over time. In general, the evaluation and selection phase of a sustainable design process involves listing all types of strategies and technologies that might make sense. This broad list is then reviewed and options narrowed based on certain criteria, such as whether a strategy is feasible on the site, whether a technology is available, and whether an approach is appropriate for the project. Once the list has been narrowed, more focused analysis may be required.

For some projects, it may seem easy to list the alternatives and then decide on the best one. For example, when designing a new waste management program in a town that has only two waste haulers, the choice may seem simple. But even this situation requires a thorough investigation. The team would first collect all the relevant information about the two waste haulers. They might find that one costs less but that the other has a higher recycling diversion rate, the percentage of waste materials diverted from traditional disposal methods and recycled, composted, or reused. One hauler may accept only sorted recyclables, but the team has determined that a commingled program is more appropriate for the project occupants. Choosing between these two based on this information would require revisiting the team goals. But what if the team values both recycling and cost savings? Or what if another goal is to reduce the greenhouse gas emissions associated with solid waste? The team would then have to consider additional information, such as the distance of each waste management facility from the project site, the types and sizes of trucks used for hauling, and their associated emissions factors. There might be other solid waste strategies that the team should consider, such as composting green waste and other organic matter on site or at another location. Each type of disposal for each type of material would have a different greenhouse gas emissions factor, which must be added to the transportation-related emissions.

That example illustrates four important points.

- When systems thinking is applied to sustainable design, it is often necessary to consider information beyond cost. A wide range of tools can help teams evaluate components of a system, including modeling, life-cycle analysis, and life-cycle cost analysis, as well as inventorying. These tools and technologies will be discussed in Section 4.
- Even if the system is evaluated using a complex computer model, the best solution may depend on the team's goals, metrics, and targets, as well as their resources. The alternatives must be analyzed and evaluated against the goals.
- Although alternatives are often viewed as an either-or choice, there may be more than two options. In the waste hauler example, the question is about more than which hauler to select. When deciding between two alternatives, the project team must ask whether there is a third option (or a fourth or a fifth ...). The question can spark the creativity needed to find new solutions that lead to sustainability.
- Sometimes other variables, besides goals, targets, and costs, may make certain solutions inappropriate for the site. Sustainable design means finding not only the measures that perform best in a model but also the solutions that will perform best over the life of the project.

EVALUATING STRATEGIES

For existing building projects, the evaluation process should take the following steps:

- Set goals
- Benchmark performance
- Identify improvement opportunities
- Prioritize and align improvement opportunities with the project goals
- Implement the program
- Measure performance and undergo third-party verification
- Set revised or new goals

When a focus on performance requires the use of new technologies, sufficient time needs to be allotted for testing and inspections. The process of exploring and selecting technologies and strategies may be repeated as more information becomes available about the system. For example, in building energy analysis, modeling should be conducted very early in the project to inform initial decisions. As the project takes shape, the model is run again to evaluate general approaches to mechanical system design. The model might be refined when design development documents are 50% complete, and again at 75% and 90% of completion, to analyze the increasingly specific lighting systems, controls, and other components and strategies. In addition, modeling, design, and construction documents should be reviewed regularly by appropriate members of the project team, such as the commissioning agent. These commissioning reviews help ensure that the design meets the project goals defined at the beginning of the project.

As a project progresses, budget constraints often become apparent, and steps are needed to reduce costs. Value engineering, a formal review based on the project's intended function and conducted to identify alternatives that reduce costs and improve performance, is a critical part of the sustainable design process. Conceptually, this review fits in well with sustainable design, which is always focused on finding higher-performing, more efficient solutions. In practice, however, value engineering is often synonymous with cost cutting and is typically focused on first costs only; systems that have higher first costs but lower operating costs and higher efficiency may be abandoned. Any value engineering exercise must therefore keep the big picture in mind and include all stakeholders so that the decisions support the project goals.

IMPLEMENTATION

Once the planning and design phases are complete, it is time to think through each step of implementation and anticipate where problems might arise and compromise the project's commitment to sustainability. This up-front planning can help keep a project on schedule and on budget while protecting the project goals.

In both design-build and operations and maintenance projects, the first activities of the implementation phase focus on fine-tuning the decisions made during design and strategy selection, to make sure all selected strategies are practical given the constraints of construction.

FROM PLANNING TO PRACTICE

Management plans for design-build construction projects are critically important; they must be developed, implemented, and documented.

A **construction activity pollution prevention plan** addresses measures to prevent erosion, sedimentation, and discharges of potential pollutants to water bodies and wetlands.

An **indoor environmental quality management plan** spells out strategies to protect the quality of indoor air for workers and occupants; it includes isolating work areas to prevent contamination of occupied spaces, timing construction activities to minimize exposure to off-gassing, protecting the HVAC system from dust, selecting materials with minimal levels of toxicity, and thoroughly ventilating the building before occupancy.

A **waste management plan** addresses the sorting, collection, and disposal of waste generated during construction or renovation. It must address management of landfill waste as well as recyclable materials.

For operations and maintenance projects, the implementation phase may be less an event than an on-going process. Continual tweaks optimize operations, and major systems are overhauled for efficiency and ability to deliver energy and cost savings. Making sure everyone has the necessary training and information and clearly understands his or her role is the key to successful sustainable operations and maintenance programs.

With design-build projects, the construction process causes environmental damage, but the effects can be managed and reduced by using sound practices and alternative technologies.

THE FOLLOWING STRATEGIES CAN HELP PROJECTS MEET SUSTAINABILITY GOALS DURING CONSTRUCTION:

- Reducing the amount of fossil fuels used in construction equipment by minimizing grading and earth moving, as well as using biodiesel or other alternative fuels.
- Preventing air and water pollution by addressing dust and implementing a construction activity pollution prevention plan.
- Ensuring indoor air quality by following an indoor environmental quality management plan for protecting ductwork and pervious materials, preventing dust, and protecting any occupied spaces from pollutants.
- Minimizing landfill waste by reducing construction debris and following a waste management plan that addresses waste separation and hauling, also saving costs.

As in all phases of a green building process, any changes made during implementation should be carefully documented. Although documentation may take time, it is necessary so that achievement of sustainability goals can be verified. Whether for compliance with regulatory requirements, LEED certification, or other third-party verification, clear and organized documentation throughout implementation will help ensure success. Documentation during the implementation phase might include change orders, chain-of-custody letters to verify that materials came from a sustainable source, waste hauling tickets, updated or revised construction management plans, commissioning or retrocommissioning reports, or other LEED documents. Careful recording and sharing of lessons learned can help improve future projects and advance the field of green building.

ON-GOING PERFORMANCE

The construction and operations of green building and neighborhood projects are never really complete. Daily life in any building or community requires on-going delivery or production of resources, as well as routine maintenance and upkeep. Even the most low-tech, passive systems need to be maintained to foster a healthful environment for people and prevent environmental harm to the planet. Heating, cooling, ventilation, and other systems must be properly cared for to ensure that they work effectively using minimum amounts of energy and water. Maintenance activities must be adapted throughout the life of the project so that the benefits are captured over time.

The key to understanding whether a project is performing sustainably is information—the right information at the right time. Data should document a project's on-going pursuit of sustainability goals. Project teams may be tempted to gather the data that are easy to collect and can be used as proof that the building is sustainable; the right data, in contrast, serve as honest, genuine feedback.

Orientation and training of the occupants and personnel must be repeated as new tenants move in, staff is hired, and lessons are learned. Education of building occupants encourages their full participation in sustainability opportunities. It helps stakeholders understand their role in optimizing performance and become vested in the green building goals. Education can take various forms, such as occupant luncheons, educational events, or interpretive signage. Tenant lease agreements, occupant handbooks, and staff training manuals will help newcomers benefit from a green project and contribute to its success. All members of the community should have easy access to information on how they can support sustainability and should be encouraged to participate and suggest improvements.

Just as with regular tune-ups and scheduled maintenance on an automobile, regular inspections and maintenance ensure that all building systems are performing well and continue to meet sustainability goals throughout the life of the project. Maintenance of mechanical, electrical, and plumbing systems is essential and needs to be included in regular operations budgets. Additional types of inspections to reveal problems or opportunities for improvement could include the following:

- Retrocommissioning
- Energy and water audits
- Solid waste audits
- Occupant surveys, including thermal comfort and transportation analysis
- Green purchasing and green housekeeping program assessments

These strategies will be discussed in Section 4.

On-going measurement and verification are essential to identifying opportunities for improvement. Sophisticated building automation systems are available to continuously collect and trend data; the process can also be conducted manually. The crucial next step is data analysis: a knowledgeable team member should regularly review the data, look for trends, spikes, or unusual values that may identify areas needing attention or repairs. Such observations can also reveal avenues to new energy and cost savings. Post-occupancy surveys complement performance-based data collection by indicating whether the project meets occupants' needs, is comfortable, and supports productivity.

The right information needs to flow to the right place. Whether that means measurement tools designed for daily use by maintenance staff, clear and accessible resource materials for occupants and residents, or collection and interpretation of building automation system outputs, the flow of information can be used as a feedback loop within the built environment to promote continuous improvements and support the commitment to sustainability.

Whether you are working on a small interior retrofit project or designing a whole new city, integrated sustainable design and operations processes support sustainability goals and innovation that lead to improvement.

PROJECT CASE STUDY

RECERTIFICATION: ADOBE SF 601 TOWNSEND

LEED PLATINUM

Adobe's San Francisco office is an adaptive reuse project that retrofitted a building completed in 1905 to operate at a high level of performance. In 2008 the project team earned a LEED platinum certification for Existing Buildings: Operations & Maintenance. The team recently recertified the project at the platinum level under LEED v2009. Cutting energy use in a plant with 900 workers, 1,800 personal computers, and continuously-operating data servers was a challenge. To meet energy goals, the project team used a web-based monitoring system, developed partly with Adobe software. The software permits energy and water use to be tracked—and adjusted—in detail, and also reports total CO_2 emissions. To date, 41 energy conservation measures and related strategies have been implemented, resulting in an ENERGY STAR score of 100, the maximum possible score. Electricity usage has been effectively reduced 63% over a seven-year period.

Water use at 601 Townsend has been reduced by 62%. Faucet and shower head aerators reduce maximum water flow to just two quarts per minute. Restrooms feature a mix of high-efficiency flush toilets, dual flush toilets, and waterless urinals.

The diversion of solid waste from landfill through composting and recycling has risen from 23% to 98%. Every desk now has a second, smaller "side-saddle" wastebasket so that compostable and recyclable items stay separated. Adobe's standards mandate that all products from copy paper to carpet must contain high recycled content. Even take-out food service products (paper plates, napkins, cups, etc.) are compostable. For more information about Adobe's 601 Townsend offices visit usgbc.org/projects/re-certification-adobe-sf-601-townsend.

Photo courtesy of Adobe

SUCCESS DEPENDS ON THESE ESSENTIALS:

- Start early
- Find the right team and process
- Understand the systems across space and time
- Develop clear and measurable goals
- Follow an iterative process to ensure achievement of goals
- Commit to continuous improvement

The next section will review specific concepts and strategies for different aspects of green design, planning, and operations. Each of these concepts and strategies should be viewed within the context of systems thinking, using integrated processes. This framework encourages green building practitioners to view projects as an interconnected system and thus find the best solutions for the built environment.

Section 4

Green Building Core Concepts and Application Strategies

The first three sections of this guide set a foundation for green building practice by addressing integrated processes versus conventional practice. This section builds on that groundwork, presenting fundamental concepts alongside strategies for putting green building into action.

Although there are many ways to organize green building projects, this section uses some of the major categories associated with the LEED rating systems for organization:

- LOCATION AND TRANSPORTATION
- SUSTAINABLE SITES
- WATER EFFICIENCY
- ENERGY AND ATMOSPHERE
- MATERIALS AND RESOURCES
- INDOOR ENVIRONMENTAL QUALITY
- INNOVATION

Despite this organizational framework, many synergistic opportunities can be found both within and between categories. For example, the location of a project can have a significant effect on occupants' transportation choices, the project's energy needs, and potential opportunities for using renewable energy.

LOCATION AND TRANSPORTATION

The location of a building is as important as how it is built. Through its location, a building can meet the needs of the local community, support active street life, and promote healthy lifestyles. Building location also plays an important role in reducing greenhouse gas emissions.

If people can take public transportation, ride bicycles, or walk to the building, the project helps reduce the carbon emissions associated with commuting. A project that is connected to the community by pedestrian paths and bicycle lanes encourages people to walk or bike instead of drive, not only helping to reduce air pollution, but also promoting physical activity.

In ideal cases, sustainable design projects start in one of two ways—either the team starts with a site and considers the best functions and uses for that particular location, or the team starts with a function and determines the best location for that land use. In either case, by understanding the goals of the project as well as the opportunities and constraints of a particular location, the team will be able to arrive at an optimal set of solutions.

When selecting a location, the team must consider many attributes of the overall system:

- Has the site been previously developed?
- Is it connected to local infrastructure and public transportation?
- What is the nature of the street life in the area, and how can the project contribute to the community?
- Where do people in the area live and work, and how do they travel?

LEED RATING SYSTEMS ADDRESS PROJECT LOCATION AND DESIGN THROUGH THE FOLLOWING TOPICS:

- Location
- Transportation
- Neighborhood pattern and design

LOCATION

A good project site channels development into places where it will improve, rather than degrade, the triple bottom line. The best locations are those that promote smart growth, an approach that protects open space and farmland by emphasizing development with housing, jobs, and services near each other.

Infill development makes use of sites in previously developed areas, often filling spaces between existing structures. This practice helps limit the amount of land covered by buildings, pavement, or infrastructure while also making more efficient use of the space within existing communities.

Brownfield sites, in particular, can actually improve environmental performance. The U.S. Environmental Protection Agency (EPA) defines brownfields as land where development may be complicated by the presence or potential presence of hazardous substances, pollutants, or contaminants.[19] Development or redevelopment of brownfields may require the cleanup of contaminated soil or groundwater. Brownfields provide real opportunities for green building projects to go beyond just reducing their effects on the environment.

Other sites are less appropriate for development. For example, development of sites that have been in agricultural use, called greenfields, and sites that are far from existing development and infrastructure will increase the total regional development footprint, reduce the amount of land available for open space or agriculture, and fragment wildlife habitat. Locating a project on such sites may encourage development to continue outside built-up areas. Development is also discouraged on wetland areas, floodplains, steep slopes, and endangered species habitat.

STRATEGIES TO ADDRESS LOCATION:

- **CHOOSE REDEVELOPMENT AND INFILL DEVELOPMENT**. Build on previously developed land and brownfield sites.
- **LOCATE NEAR EXISTING INFRASTRUCTURE.** Avoid triggering suburban sprawl and unnecessary materials use by consolidating development along existing roads, power lines, and water supplies.
- **PROTECT HABITAT.** Give preference to locations that do not include sensitive site elements and land types.
- **INCREASE DENSITY.** Create a smaller footprint and maximize the FAR (floor area ratio) or square footage per acre.
- **INCREASE DIVERSITY OF USES.** Provide the services that are most needed within communities and support a balance of jobs and housing.
- **ENCOURAGE MULTIPLE MODES OF TRANSPORTATION.** Enable occupants to walk, bicycle, and use public transit.

TRANSPORTATION

According to the U.S. Energy Information Administration, transportation accounted for 33% of total U.S. greenhouse gas emissions in 2008. [20] Globally, transportation is responsible for 13.5% of total carbon dioxide emissions.[21] Generally, this is a result of three fundamental factors: land use, vehicle technology, and transportation fuels.

19 U.S. Environmental Protection Agency, Brownfields Definition (2009), epa.gov/brownfields/overview/glossary.htm.

20 U.S. Energy Information Administration, Emissions of Greenhouse Gases Report (December 8, 2009), eia.doe.gov/oiaf/1605/ggrpt/.

21 K. Baumert, T. Herzog, and J. Pershing, Navigating the Numbers: Greenhouse Gas Data and International Climate Policy (Washington, D.C.: World Resources Institute, 2005).

Attention to each of those factors can reduce the consequences of transportation. Land use decisions can help reduce the length and frequency of vehicle trips and encourage shifts to more sustainable modes of transportation. Vehicle technology determines the quantity and types of energy and support systems needed to convey people and goods to and from the site. Fuel determines the environmental effect of vehicle operation. Current efforts to improve vehicle fuel efficiency and reduce the carbon intensity of motor fuels may be insufficient to meet greenhouse gas reduction goals unless accompanied by significant changes in land use and human behavior. Regardless of substantial investments in technology and alternative energy, poor planning can still cause a net increase in greenhouse gas emissions as commuters weigh options for how they travel to and from work, school, home, and errands.

Promoting alternative transportation as a convenient and viable option through site selection, design, and incentives benefits both the building occupants and the developer. The LEED rating systems give project teams flexibility when considering site-specific needs and opportunities for alternative transportation. Project teams can reduce transportation effects by ensuring access to alternative modes of transportation, encouraging walking and bicycling, and providing fueling facilities for alternative-fuel vehicles. Project teams are also rewarded for reducing the number and length of automobile trips by locating in high-density areas or infill sites already served by mass transit. Sites without access to public transportation start at a disadvantage and may require additional attention to transportation, particularly local land use design and alternative fuels. It is still possible for such a project to substantially reduce its transportation effects if the team focuses on local connectivity and the energy efficiency of the vehicles used to serve its needs. For example, an office complex without transit access might provide incentives for carpooling, or facilities for alternative-fuel vehicles like plug-in hybrids.

STRATEGIES TO ADDRESS TRANSPORTATION IN DESIGN AND PLANNING:

- **LOCATE NEAR PUBLIC TRANSIT.** Select a project site within easy walking distance of an existing transportation network.
- **LIMIT PARKING.** The lack of parking spaces on the project site will spark interest in alternative transportation options.
- **ENCOURAGE BICYCLING.** Install secure bike racks and showers for commuters.

STRATEGIES TO ADDRESS TRANSPORTATION IN OPERATIONS AND MAINTENANCE:

- **ENCOURAGE CARPOOLING.** Designate preferred spaces for carpool vehicles in the parking area.
- **PROMOTE ALTERNATIVE-FUEL VEHICLES.** Provide a convenient refueling station on the site.
- **OFFER INCENTIVES.** Develop an alternative commuting incentive program for building occupants.
- **SUPPORT ALTERNATIVE TRANSPORTATION.** Promote alternatives to single-occupant car commuting at the building and/or city level.

NEIGHBORHOOD PATTERN AND DESIGN

Community layout and planning influence occupants' and residents' behavior while setting a standard for future development. For example, where culs-de-sac connect to increasingly wide connector roads, services are clustered into strip malls, and jobs are centered in office parks, the emphasis is on the private realm and the automobile. On the other hand, in communities with well-connected street grids, diverse land uses, and buildings facing wide sidewalks, the emphasis is on pedestrians and the public realm. Neighborhood pattern and design strategies are those that help make a project easy to navigate, accessible, and appealing to pedestrians. The focus is on the diversity of land uses, the design of streets, and the functions of the community. Residents meet their needs within their neighborhoods, including going to work or school, finding places to meet or play, and getting healthful food.

STRATEGIES FOR SUSTAINABLE NEIGHBORHOOD PATTERN AND DESIGN:

- **DESIGN WALKABLE STREETS.** Focus on building frontage, ground-level façade, building height-to-street-width ratio, and sidewalks. Limit street speeds.
- **INCLUDE STREET TREES,** shade, benches, and other amenities for pedestrians.
- **USE COMPACT DEVELOPMENT STRATEGIES.** Consolidate development by increasing the number of units of residential space and square feet of commercial space per acre.
- **PROMOTE CONNECTIVITY.** Limit culs-de-sac, prohibit gated communities, and use a street grid pattern.
- **PROVIDE DIVERSE LAND USES.** Include a wide mix of services, such as shops, restaurants, schools, religious centers, grocery stores, parks, civic buildings, and recreational facilities.
- **CREATE A DIVERSE COMMUNITY.** Provide housing types for a wide range of incomes and abilities. Incorporate, rather than segregate, affordable and senior housing.
- **SUPPORT ACCESS TO SUSTAINABLE FOOD.** Include community gardens, farmers markets, urban farms, and community-supported agriculture programs.
- **ENSURE THAT ALL RESIDENTS HAVE EASY ACCESS TO GROCERY STORES** and other food choices beyond fast food.

SUSTAINABLE SITES

A site's relationship to the local bioregion, watershed, and community will help determine how a project can contribute to a sustainable environment. A sustainable project serves more than the immediate needs of the building. Good site design can provide ecosystem services and create a sense of place. Site design also plays an important role in helping projects adapt to the effects of climate change.

Thoughtful site design begins with a thorough assessment of the site. By getting to know a site's best features and its challenges, the team can appropriately integrate the building and grounds into the local ecosystem. Good site design benefits the project by creating synergies between building and site, and it also benefits the larger community through strategies such as rainwater management and habitat conservation.

When assessing and designing a site, the team must consider many things:

- Is there adequate open space surrounding the project, or could the project provide open space to the building and community?
- What is the local climate of the project?
- Has the site been previously developed?
- What species in the area might use the site as habitat and be affected?

LEED RATING SYSTEMS ADDRESS PROJECT SITE DESIGN AND MAINTENANCE THROUGH MANY TOPICS, INCLUDING THE FOLLOWING:

- Site design and management
- Rainwater management
- Heat island effect

SITE DESIGN AND MANAGEMENT

Projects often set broad goals for sustainable design and management of a site, such as reducing the environmental impacts of landscaping, minimizing maintenance costs, and contributing to the restoration and regeneration of an area. Achieving these goals requires careful plant selection, integration of innovative irrigation systems, and a new approach to outdoor lighting design.

Strategies for designing and maintaining a sustainable site can include selecting native and adapted species that thrive without irrigation, pesticides, or fertilizers. Certain plants can enhance soil nutrients, supporting regenerative project goals; others naturally deter pests. Plants can also be selected to minimize evapotranspiration, the return of water to the atmosphere through evaporation from plants' leaves; this characteristic is important in arid climates. Strategic selection of plants creates wildlife habitat and supports integrated pest management (IPM), a sustainable approach that controls pest infestation and damage in an economical way while minimizing hazards to people, property, and the environment.

Strategically locating functional and decorative hardscape on a project site may reduce the amount of impervious area, surfaces that have been compacted or covered by materials that do not allow water to infiltrate. Impervious areas found in the built environment include concrete, brick, stone, asphalt, and sealed surfaces. Strategies for reducing hardscape include using pervious paving systems for parking lots, walkways, and decorative areas, such as patios. Pervious paving areas allow rainwater infiltration and also reduce heat island effects.

The benefits of sustainable site design and management reach far beyond a project's boundary. Site lighting can provide adequate nighttime illumination while preserving the integrity of the night sky. By reducing glare and contrast between light and dark areas, which can diminish night vision, smart lighting design can actually improve site safety while maintaining views of the stars and decreasing stress to nocturnal animals. To achieve such goals, teams avoid up-lighting and over-lighting, direct full cutoff fixtures downward to illuminate paths and exits, and shield fixtures to prevent light trespass, the spilling of light beyond the project boundary.

STRATEGIES FOR DEVELOPING A SUSTAINABLE SITE DESIGN:

- **MINIMIZE HARDSCAPE.** Substitute pervious surfaces for traditional paving.
- **USE NATIVE LANDSCAPING.** Select plants that are native to the area both to reduce water use and to provide habitat for local birds and other species. Incorporate mulch into the landscape to build the soil and naturally suppress weeds.
- **PREVENT LIGHT POLLUTION.** Avoid up-lighting, glare, and trespass by using shielded fixtures and strategic lighting design.
- **PRESERVE OPEN SPACE AND SENSITIVE AREAS.** Consolidate the development footprint and protect and restore natural vegetation, wetland areas, and bodies of water.
- **PROTECT AND RESTORE HABITAT.** Designate areas as protected habitat and open space for the life of the project. Develop a conservation management program to make sure that the natural environment is protected. Consider putting protected areas into a land trust.

STRATEGIES FOR SUSTAINABLE SITE OPERATIONS AND MAINTENANCE:

- **DEVELOP A SUSTAINABLE SITE MANAGEMENT PLAN.** The plan should address the application of chemicals and the cleaning of hardscape and building exterior, and it should include an integrated pest management program.
- **IMPLEMENT CONSERVATION PROGRAMS.** Work with ecologists and nonprofit organizations to implement conservation programs that protect species and habitat.
- **MAINTAIN SITE LIGHTING TO PREVENT LIGHT POLLUTION.** Ensure that fixtures are replaced according to the original design. If higher light levels are needed, include timers that shut them off automatically after hours.

RAINWATER MANAGEMENT

The rainwater systems of most American urban areas treat precipitation as a problem to be removed from the area as quickly as possible to prevent flooding. The result of this strategy, combined with the ever-expanding boundary of the urban edge and the increase in paved roads and hardscape, is damaging to the watershed's functioning. The alternative, applying systems-based, integrative processes to rainwater management, encourages teams to mirror natural systems by slowing the flow of water and retaining water on site. Project teams can increase infiltration of rainfall into the ground, capture and reuse it, and use natural processes to treat the remaining water that runs off the property.

Impervious surfaces, such as asphalt and concrete, prevent percolation and infiltration and encourage water runoff, causing soil erosion and in some places sedimentation of local waterways. This runoff can also carry harmful chemicals into the water system, degrading surface water quality and harming aquatic life and recreation opportunities in receiving waters. This nonpoint source pollution, from diffuse land uses rather than a single facility, is one of the biggest threats to surface water quality and aquatic ecosystems.

LEED recognizes and encourages planning, design, and operational practices that control rainwater and protect the quality of surface and ground water. Many of these solutions fall within the scope of low-impact development (LID) and Green Infrastructure (GI), approaches to land management that mimic natural systems and manage rainwater as close to the source as possible.[22] Common strategies include minimizing impervious surfaces, protecting soils, and enhancing native vegetation. The Department of Environmental Resources in Prince George's County, Maryland, for example, uses LID control measures that integrate five components: site planning, hydrologic analysis, integrative management practices, erosion and sediment control, and public outreach. This approach protects surface water by managing rainwater on site and creating buffers between development and water resources.

22 U.S. Environmental Protection Agency, *Low Impact Development* (2011), epa.gov/owow/NPS/lid/.

Rainwater management can also include the collection and reuse of water for nonpotable purposes, such as landscape irrigation, toilet and urinal flushing, and custodial uses. This helps reduce rainwater runoff while avoiding the unnecessary consumption of potable water. It is important to understand a region's environmental conditions when selecting a rainwater management strategy. For example, in the eastern United States, on-site water collection is often encouraged as a way to slow rainwater runoff and reduce nonpoint source pollution. Conversely, in some western states, long-standing water laws prohibit on-site water collection because the water is obligated to downstream users.

STRATEGIES FOR RAINWATER MANAGEMENT THROUGH DESIGN:

- **MINIMIZE IMPERVIOUS AREAS.** Increase the area of permeable surfaces, such as vegetated roofs, porous pavement, and landscaped areas.
- **CONTROL RAINWATER.** Install dry ponds, rain gardens, bioswales, and similar landscape features designed to hold water and slow the rate of runoff.
- **INCORPORATE RAINWATER MANAGEMENT INTO SITE DESIGN.** Use features that serve multiple functions, such as planters that collect rainwater, streets that include bioswales to capture and hold rainwater, and mulch that both builds soil and holds moisture.

STRATEGIES FOR RAINWATER MANAGEMENT IN OPERATIONS AND MAINTENANCE:

- **REDIRECT RAINWATER.** Direct runoff into rain gardens, bioswales, and other landscape features that retain water.
- **HARVEST RAINWATER.** In many jurisdictions, collected water can be used as process water, to flush toilets, or to provide irrigation.

HEAT ISLAND EFFECT

Cities are typically warmer than nearby rural areas. The flat, dark surfaces of roadways, parking lots, and tarred rooftops absorb and retain the sun's heat during the day and are slow to radiate it at night. The result, known as the heat island effect, is an increase in air temperature in a developed area compared with an undeveloped area. The increased heat absorption in urban areas has several consequences:

- The additional use of air-conditioning increases energy demand and costs. The rise in energy costs is dramatic because the highest demand for air-conditioning occurs during peak hours for energy consumption.
- Wildlife species not adapted to the higher temperature (and related effects including changes in resource availability) decline.

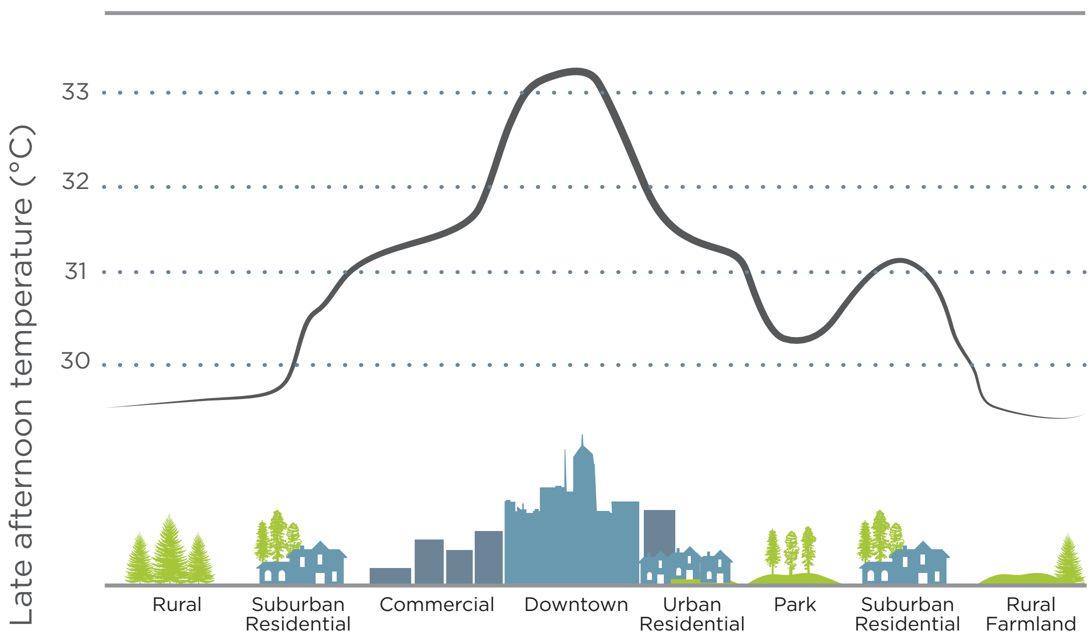


Figure 4.1. Diagram of Heat Island Effect

To mitigate those harmful effects, project teams can install surfaces that have high solar reflectance (SR) or solar reflectivity index (SRI). SRI combines reflectivity with emissivity, or the ability of a material to emit energy through radiation. The use of reflective materials and those with high SRI values reduces heat gain, thus increasing comfort and reducing demand for air-conditioning. Materials that help reduce the heat island effect include open grid paving, white roofs, and vegetated "green" roofs.

STRATEGIES FOR REDUCING THE HEAT ISLAND EFFECT:

- **INSTALL REFLECTIVE ROOF SURFACES.** Light-colored roofs absorb less heat.
- **REDUCE THE AREA OF PAVED SURFACES EXPOSED TO SUNLIGHT.** Limit the amount of hardscape, design narrow roads, use light-colored paving, shade hardscape with greenery, and locate parking underground.
- **PLANT AN URBAN FOREST OR A GREEN ROOF.** Use street trees, shrubs, and landscaping to reduce heat island effects through evapotranspiration and provide shade.

WATER EFFICIENCY

The U.S. Geological Survey estimates that the United States uses more than 400 billion gallons of water per day. The operation of buildings, including landscaping, accounts for approximately 47 billion gallons per day—12% of total water use.[23] As residential, commercial, industrial, and other development expands, so does the use of the limited potable water supply, water that is suitable for drinking. Most buildings rely on municipal sources of potable water to meet their needs, from flushing toilets to washing dishes to irrigating landscapes. High demand strains supplies and under extreme conditions necessitates water rationing. Furthermore, large amounts of wastewater can overwhelm treatment facilities, and the untreated overflow can contaminate rivers, lakes, and the water table with bacteria, nitrogen, toxic metals, and other pollutants. To avoid this damage to the ecosystem, additional municipal supply and treatment facilities must be built at public cost. Water pumping and treatment, both to and away from the project, also require energy, whose production generates additional greenhouse gas emissions.

Green building encourages innovative water-saving strategies that help projects use water wisely. Project teams can follow an integrative process to begin assessing existing water resources, opportunities for reducing water demand, and alternative water supplies. For example, much of the water that leaves the site as waste water or rainwater runoff can actually be used for nonpotable functions.

GUIDING QUESTIONS FOR A TEAM TO CONSIDER MAY INCLUDE THE FOLLOWING:

- How much rain falls on the site per year?
- How will water be used on site, and how can the amount be reduced?
- What are the sources of graywater, such as from sinks and showers, that could be collected and reused for nonpotable uses, such as irrigation?

23 S.S. Hutson, N.L. Barber, J.F. Kenny, K.S. Linsey, D.S. Lumia, and M.A. Maupin, *Estimated Use of Water in the United States in 2000* (2004), pubs.usgs.gov/circ/2004/circ1268/pdf/circular1268.pdf.

Some project teams use their sites' annual precipitation to determine how much water they should use. Clearly, the water balance approach is more achievable for projects that receive more rain and require less irrigation. However, projects around the country are experimenting with this goal. It requires reducing demand by designing sites to minimize or eliminate the need for irrigation and installing plumbing fixtures that either conserve water (such as low-flow lavatories and dual-flush toilets) or eliminate demand entirely (such as waterless urinals and composting toilets). Additionally, captured rainwater and treated graywater can be used instead of potable water for toilet flushing, irrigation, and cooling towers.

The value of any particular measure for overall water conservation efforts depends on the end uses in the project. For example, office buildings typically lack extensive laundry and kitchen facilities; water is used for HVAC systems, restrooms, and landscaping. In contrast, kitchen sinks and dishwashers dominate the end use for restaurants. A water end-use profile can help project teams identify the largest users of water and evaluate the cost-effectiveness of specific conservation strategies.

An "efficiency first" approach to water conservation can be very effective. First look at ways to use water efficiently and reduce potable water use. Then, consider the use of nonpotable water and alternative sources of water. LEED rewards projects that both reduce demand and reuse water for indoor and outdoor water uses.

INDOOR WATER USE

Indoor use encompasses water for urinals, toilets, showers, kitchen or break room sinks, and other applications typical of occupied buildings. Indoor water use can be reduced by installing water-efficient fittings and fixtures, using nonpotable water for flush functions, and installing submeters to track and log water use trends, check fixture performance, and identify problems. Buildings also use significant amounts of water to support industrial processes and systems, such as cooling towers, boilers, and chillers. These systems provide both heat and cool air and water for building operations. Process water also includes the water used for certain business operations (e.g., washing machines, dishwashers). Commercial building projects can reduce water use by selecting efficient cooling towers, chillers, boilers, and other equipment, and by substituting harvested rainwater and nonpotable water for certain applications.

Understanding how water is being used allows teams to identify where they should focus conservation efforts. Submeters report how much water is being used by systems and fixtures and alerts managers to leaks or other inefficiencies. Metering the water lost to evaporation during cooling tower operation can provide particularly important information. Facilities may be able to receive credit from the utility company for sewer charges if they reduce the amount of water entering the sewer system.

STRATEGIES FOR REDUCING INDOOR WATER USE:

- **INSTALL EFFICIENT PLUMBING FIXTURES.** Install new high-efficiency fixtures, including high-efficiency lavatories, kitchen sinks and showers, dual-flush toilets, waterless urinals, and composting toilets. High-efficiency fixtures use less water than specified by the Energy Policy Act (EPAct) of 1992. Select EPA WaterSense and ENERGY STAR products. In existing buildings, if porcelain replacement proves cost-prohibitive, install new flush valves or flow restrictors (e.g., aerators) to achieve water savings.
- **USE NONPOTABLE WATER.** If permitted by the jurisdiction, use captured rainwater, graywater, or municipally-provided reclaimed water for flush fixtures. Design and install plumbing systems that can use captured rainwater or graywater in flush fixtures. Graywater use is not an option in all municipalities, so it is important check regulations before planning to use this strategy.
- **INSTALL SUBMETERS.** Meter indoor water systems and monitor the data to track consumption trends, determine fixture performance, and pinpoint leaks.

OUTDOOR WATER USE

Landscape irrigation, a significant component of many commercial buildings' water use, presents an important opportunity to conserve water. Reductions in irrigation can be achieved by specifying water-wise landscaping and water-efficient irrigation technology, using nonpotable water, and installing submeters to track and log irrigation trends.

Native and adapted species support water efficiency goals because these plants typically don't need to be irrigated. Xeriscaping is the use of drought-tolerant native or adapted plants along with rocks, bark mulch, and other landscape elements. High-performance irrigation systems, such as drip systems and bubbler distribution systems, channel water directly to root systems; weather-based irrigation controllers respond to weather conditions. Potable water use for irrigation can be further reduced by using nonpotable water for outdoor applications. Finally, as with indoor water use, submetering helps teams understand how much water is being used for irrigation.

STRATEGIES FOR REDUCING OUTDOOR WATER USE:

- **CHOOSE LOCALLY ADAPTED PLANTS.** Landscape with native and adapted plants that require less water. These plantings have the added benefit of providing habitat for native wildlife.
- **USE XERISCAPING.** These drought-tolerant plantings have extremely low water needs. Especially in arid regions, employ xeriscape principles when designing the site landscape.
- **SELECT EFFICIENT IRRIGATION TECHNOLOGIES.** Drip and bubbler systems and weather-based controllers can save water.
- **USE NONPOTABLE WATER.** Captured rainwater, graywater, or municipal reclaimed water is suitable for irrigation.
- **INSTALL SUBMETERS.** Meter the irrigation system to track water consumption and identify leaks.

ENERGY AND ATMOSPHERE

Energy has emerged as a critical economic issue and top priority for policymakers. Unsustainable energy supply and demand have serious implications for everything from household budgets to international relations. Buildings are on the front line of this issue because of their high consumption of energy. Studies have repeatedly shown that efficient buildings and appropriate land use offer opportunities to save money while reducing greenhouse gas emissions. One such study, conducted by the New Buildings Institute, investigated 121 LEED-certified commercial office buildings in the United States and found that they used 24% less energy than the national average. Almost half of the buildings in the study achieved an ENERGY STAR Portfolio Manager score of 75 or above, with an overall average score of 68.[24]

Set up by EPA as a part of the ENERGY STAR program, ENERGY STAR Portfolio Manager is an interactive, online management tool that supports tracking and assessment of energy and water consumption. In Portfolio Manager, a score of 50 represents average building performance. The New Buildings Institute study also collected data suggesting that a significant percentage of buildings underperformed their benchmarks. This finding reinforces the importance of commissioning systems and monitoring performance so that green buildings can maintain their efficiencies and achieve their full potential over time.

The proper design and operations of buildings and neighborhoods can dramatically boost energy efficiency and benefits from cleaner, renewable energy supplies.

FOLLOWING AN INTEGRATIVE PROCESS HELPS IDENTIFY SYNERGISTIC STRATEGIES FOR THE FOLLOWING AREAS:

- Energy demand
- Energy efficiency
- Renewable energy
- Ongoing performance

24 C. Turner and M. Frankel, *Energy Performance of LEED for New Construction Buildings* (March 4, 2008), newbuildings.org/sites/default/files/Energy_Performance_of_LEED-NC_Buildings-Final_3-4-08b.pdf.

ENERGY DEMAND

Saving energy begins with conservation—reducing energy demand. Green buildings and neighborhoods can reduce demand for energy by capturing natural, incident energy, such as sunlight, wind, and geothermal potential, to reduce loads. For example:

- Community planning can support building configurations that minimize solar gain in summer and maximize it in winter
- Adjacent buildings can be designed to shade and insulate each other
- Building designs that incorporate passive strategies, like daylight, thermal mass, and natural ventilation, reduce the demand for artificial lighting, heating, and cooling
- Technologies and processes can be used to help occupants understand their patterns of energy consumption and reduce both individual and aggregate energy demand

In addition to reducing demand, green building encourages sustainable methods for meeting energy needs. This may be most applicable when addressing a project's use of refrigerants, substances used in cooling of systems. Refrigerants were widely employed throughout the 20th century for transferring thermal energy in air-conditioning and refrigeration systems. Although these substances have remarkable functional properties, they also have damaging side effects on the environment. In the 1980s, research emerged demonstrating that certain refrigerants for building systems were depleting stratospheric ozone, a gas that protects human health and the environment by absorbing harmful UV radiation, and contributing to climate change. The Montreal Protocol subsequently banned the production of chlorofluorocarbon (CFC) refrigerants and is phasing out hydrochlorofluorocarbon (HCFC) refrigerants. CFCs and HCFCs are organic chemical compounds known to have ozone-depleting potential.

To achieve LEED certification, new buildings may not use CFC-based refrigerants, and existing buildings must complete a total CFC phase-out prior to project completion. LEED awards points for projects that entirely avoid the use of refrigerants or select refrigerants that balance concerns about ozone depletion and climate change. LEED recognizes that although there are no perfect refrigerants, it is possible to carefully consider performance characteristics and environmental effects and select a refrigerant with an acceptable trade-off.

Taken together, demand reduction strategies provide the foundation for further energy efficiency efforts and the effective use of renewable energy.

STRATEGIES FOR REDUCING ENERGY DEMAND IN DESIGN AND PLANNING:

- **ESTABLISH DESIGN AND ENERGY GOALS.** Set targets and establish performance indicators at the outset of a project and periodically verify their achievement.
- **SIZE THE BUILDING APPROPRIATELY.** A facility that is larger than necessary to serve its function creates costly and wasteful energy demand.
- **USE FREE ENERGY.** Orient the facility to benefit from natural ventilation, solar energy, and daylight.
- **INSULATE.** Design the building envelope to insulate efficiently against heating and cooling losses.

STRATEGIES FOR REDUCING ENERGY DEMAND IN OPERATIONS AND MAINTENANCE:

- **USE FREE ENERGY.** Use the facility's orientation and appropriate shades, windows, and vents to take advantage of natural ventilation, solar energy, and daylight.
- **MONITOR CONSUMPTION.** Use energy monitoring and feedback systems to encourage occupants to reduce energy demand.

DEMAND RESPONSE

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.

LEED IN PRACTICE

REDUCE DEMAND BY REDUCING BUILDING SIZE

Energy demand typically increases in direct relation to building size: the more square feet in a building, the more energy it consumes. Although there are exceptions, the relationship between square footage and consumption is very strong.

The LEED for Homes rating system includes a point adjustment to compensate for the effect of square footage on resource consumption. This prerequisite is for projects using the Energy and Atmosphere prescriptive path.

LEED for Homes is currently the only LEED rating system with this type of adjustment.

ENERGY EFFICIENCY

Once demand reduction strategies have been addressed and incorporated, the project team can begin to employ strategies to promote energy efficiency—using less energy to accomplish the same amount of work. Getting the most work per unit of energy is often described as a measure of energy intensity. Common metrics for buildings and neighborhoods include energy use per square foot and use per capita. Figure 4.2 outlines a typical office building's energy use. Each category provides an opportunity for increasing efficiency and savings.

Through the integrative process, green building project teams can identify opportunities for employing synergistic strategies. For example, by improving the building envelope, the space between exterior and interior environments of a building which typically includes windows, walls, and roof, teams may be able to reduce the size of HVAC systems or even eliminate them altogether. This kind of integrative design can reduce both initial capital costs and long-term operating costs.

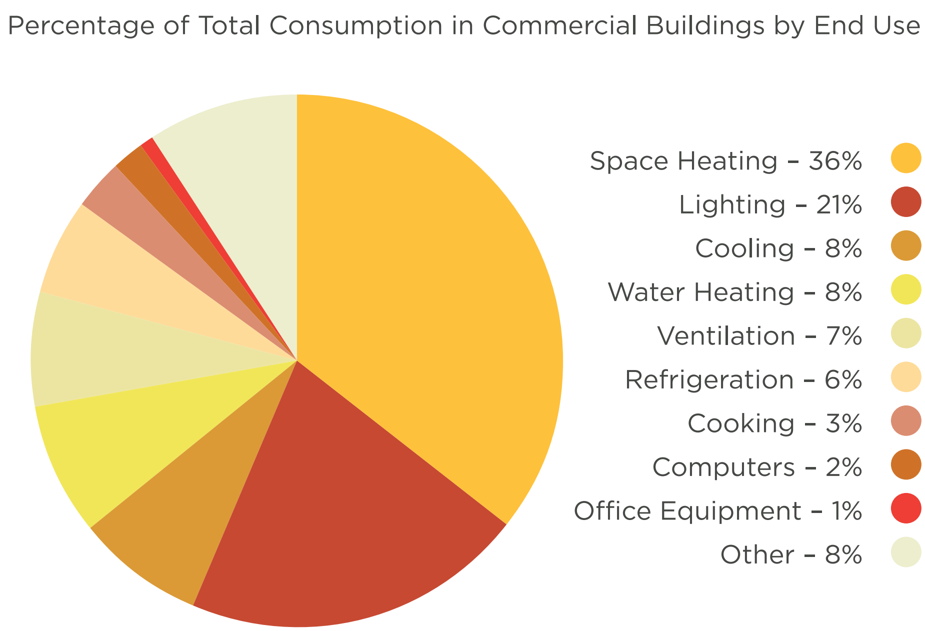


Figure 4.2. Distribution of Building Energy Use

STRATEGIES FOR ACHIEVING ENERGY EFFICIENCY:

- **ADDRESS THE ENVELOPE.** Use the regionally-appropriate amount of insulation in the walls and roof and install high-performance glazing to minimize unwanted heat gain or loss. Make sure that the building is properly weatherized.
- **INSTALL HIGH-PERFORMANCE MECHANICAL SYSTEMS AND APPLIANCES.** Apply life-cycle assessment to the trade-offs between capital and operating costs, and evaluate investments in energy efficiency technologies. Appliances that meet or exceed ENERGY STAR requirements will reduce plug load demands.
- **USE HIGH-EFFICIENCY INFRASTRUCTURE.** Efficient street lighting and LED traffic signals will reduce energy demands from neighborhood infrastructure.
- **CAPTURE EFFICIENCIES OF SCALE.** Design district heating and cooling systems, in which multiple buildings are part of a single loop.
- **USE ENERGY SIMULATION.** Computer modeling can identify and prioritize energy efficiency opportunities.
- **MONITOR AND VERIFY PERFORMANCE.** Ensure that the building systems are functioning as designed and support the owner's project requirements through control systems, a building automation system, and commissioning and retrocommissioning.

RENEWABLE ENERGY

Reduced demand and increased efficiency often make it cost-effective to meet most or all of a building's energy needs from renewable sources. So-called green power is typically understood to include solar, wind, wave, biomass, and geothermal power, plus certain forms of hydropower. Use of these energy sources avoids the myriad of environmental impacts associated with the production and consumption of nonrenewable fuels, such as coal, nuclear power, oil, and natural gas.

LEED distinguishes between renewable energy production and the purchase of off-site green power or carbon offsets. Renewable energy production typically involves a system that generates clean electricity, such as solar photovoltaic panels that convert the sun's energy into electricity. Off-site renewable energy is typically purchased at a premium price per kilowatt-hour from a utility or a provider of renewable energy certificates (RECs). RECs represent a tradable, nontangible commodity associated with the qualities of renewable electricity generation. RECs, and their associated attributes and benefits, can be sold separately from the underlying physical electricity associated with a renewable-based generation source. A project team that cannot purchase green power through the local utility can offset the building's energy use by purchasing green power from renewable energy projects around the country. Sometimes project teams can enter into REC agreements that provide for specific energy sources, such as wind or biomass, from a particular generation facility. Carbon offsets represent a unit of carbon dioxide equivalent that is reduced, avoided, or sequestered to compensate for emissions occurring elsewhere.

STRATEGIES FOR MEETING ENERGY DEMAND WITH RENEWABLE ENERGY:

- **GENERATE RENEWABLE ENERGY.** Install photovoltaic cells, solar hot water heaters, or building-mounted wind turbines.
- **PURCHASE OFF-SITE RENEWABLE ENERGY OR CARBON OFFSETS.** Buy green power, renewable energy certificates, or carbon offsets to reduce the environmental impact of energy consumed on-site and promote renewable energy generation and the reduction in carbon dioxide emissions.

ONGOING ENERGY PERFORMANCE

Attention to energy use does not end with the design and construction of an energy-efficient building. It is critical to ensure that a project functions as designed and that it sustains and improves this performance over time. Performance goals set during planning and design can be undermined by design flaws, construction defects, equipment malfunctions, and deferred maintenance. Monitoring and verification provide the basis for tracking energy performance, with the goal of identifying and resolving any problems that may arise. Monitoring often involves comparing building performance measurements with predictions from a calibrated energy simulation or industry benchmarking tool. EPA's ENERGY STAR Portfolio Manager is one of the most widely used benchmarking systems. Users enter data on electricity and natural gas consumption, along with other supporting information, into a web-based tool. The system then evaluates the performance of the building against that of others with similar characteristics. This is an exceptionally useful, free tool for gauging the relative performance of buildings.

Commissioning is a systematic investigation by skilled professionals who compare building performance with performance goals, design specifications, and most importantly, the owner's requirements. This process begins early in design, with the specification of requirements. The requirements are considered throughout the building design and construction process and become the baseline for evaluation. Ongoing commissioning for building operations ensures that a building continues to meet its fundamental operational requirements. Retrocommissioning is the same process applied to existing buildings; it is intended to keep a building on track for meeting or exceeding the original operational goals.

The cost of commissioning is often repaid with recovered energy performance. A Lawrence Berkeley National Laboratory study found that commissioning for existing buildings had a median cost of $0.27 per square foot and yielded whole-building energy savings of 15%, with an average simple payback period of 0.7 years. For new construction, median cost was determined to be $1 per square foot with a median payback time of 4.8 years based on energy savings alone.[25] Overall, this study concluded that commissioning is one of the most cost-effective means of improving energy efficiency in commercial buildings.

LEED recognizes and encourages operational energy performance through its requirements for building commissioning and credits for metering.

25 E. Mills et al., *The Cost Effectiveness of Commercial Buildings Commissioning: A Meta-Analysis of Existing Buildings and New Construction in the United States* (November 23, 2004), dot.ca.gov/hq/energy/Cx-Costs-Benefits.pdf.

STRATEGIES FOR INCORPORATING ONGOING PERFORMANCE MEASUREMENT INTO A PROJECT:

- **ADHERE TO THE OWNER'S PROJECT REQUIREMENTS.** Prepare detailed owner's project requirements at the beginning of the design process and conduct commissioning throughout the life-cycle of the project to ensure that the building functions as designed.
- **PROVIDE STAFF TRAINING.** Knowledge and training empower facilities managers to maintain and improve the performance of buildings.
- **CONDUCT PREVENTIVE MAINTENANCE.** Develop a robust preventive maintenance program to keep the building in optimal condition.
- **CREATE INCENTIVES FOR OCCUPANTS AND TENANTS.** Involve building occupants in energy efficiency strategies. Promote the use of energy-efficient computers and equipment, bill tenants from submeter readings to encourage energy conservation, educate occupants about shutting down computers and turning out lights before they leave, and give them regular feedback on energy performance.

MATERIALS AND RESOURCES

Materials are the foundation of the buildings in which we live and work. The ubiquitous nature of materials and resources makes it easy to overlook the embodied environmental impact and costs associated with extraction, production, transportation, consumption, and disposal. The Materials and Resources (MR) credit category focuses on minimizing the embodied impacts associated with the entire life-cycle of building materials. Each requirement identifies a specific action that fits into the larger context of a life-cycle approach to embodied impact reduction.

Setting goals for using sustainable materials and resources is an important step of the green building process. "Reduce, reuse, recycle" may seem like the extent this work; and clearly, reducing consumption is critical, and reusing and recycling waste are important strategies. But green building requires rethinking the selection of materials as well. Ideally, the materials and resources used for buildings not only do less harm than typical materials but go further and regenerate the natural and social environments from which they originate. To evaluate the best options and weigh the trade-offs associated with materials selection, teams must think beyond a project's physical and temporal boundaries. Life-cycle thinking can help a team make informed, defensible decisions.

Plentiful opportunities exist to reduce the harms associated with materials. Using less, finding materials with environmentally preferable attributes, using locally -harvested materials, and eliminating waste provide a great starting place. A systems-based, life-cycle perspective and an integrative decision making process will help projects achieve their goals addressing materials and resource use.

LEED ADDRESSES THE FOLLOWING ISSUES RELATED TO MATERIALS AND RESOURCES:

- Conservation of materials
- Environmentally, socially, and locally preferable materials
- Waste management and reduction

CONSERVATION OF MATERIALS

Meaningful material conservation begins with eliminating the need for materials and new materials during the planning and design phases. The highest form of material conservation is reuse. Reusing existing buildings or using salvaged materials not only eliminates the need for new materials to be created but also retains the cultural value and the contextual relevancy of those materials. Another way to reduce demand for new materials is to design denser, mixed-use neighborhoods. Compared with sprawling communities, denser, more compact mixed-use neighborhoods require fewer miles of road and less physical infrastructure to support the same number of people. Similarly, smaller, more efficiently built buildings and homes require fewer board-feet of lumber or linear feet of pipe, as well as fewer resources to maintain. Experienced contractors often have great ideas for implementing such material-saving strategies. Bringing them in at the early phases of an integrated process, instead of waiting until the design is complete, can add real value to the design team and the project as a whole.

Materials procurement doesn't end at the end of construction. For example, companies' ongoing procurement strategies can provide real opportunities to reduce material usage.

STRATEGIES FOR CONSERVING MATERIALS THROUGHOUT A PROJECT'S LIFE-CYCLE:

- **REUSE EXISTING BUILDINGS AND SALVAGED MATERIALS.** Selecting resources that have already been harvested and manufactured results in tremendous materials savings.
- **PLAN FOR SMALLER, MORE COMPACT COMMUNITIES.** Reduce the need for new roads and other infrastructure by preventing sprawling land-use patterns.
- **DESIGN SMALLER, MORE FLEXIBLE HOMES AND BUILDINGS.** Use space-efficient strategies, reduce unused space such as hallways, and provide flexible spaces that can serve multiple functions.
- **USE EFFICIENT FRAMING TECHNIQUES.** Advanced framing, in which studs are spaced 24 instead of 16 inches on center, and structural insulated panels, which combine framing and insulation into one rigid component, use less material than conventional framing without compromising performance.
- **PROMOTE SOURCE REDUCTION IN OPERATIONS.** Designate office supply reuse centers. Encourage paper conservation through double-sided and electronic printing.

ENVIRONMENTALLY PREFERABLE MATERIALS

After opportunities to conserve materials have been exhausted, selection of new material begins. Green building professionals have created demand for increasingly sustainable products, and suppliers, designers, and manufacturers are responding. This creates a cycle of consumer demand and industry delivery of environmentally preferable products, spurring market transformation of building products. Environmentally preferable attributes to consider include:

- Support the local economy
- Sustainably grown and harvested
- Have intended end-of-life scenarios that avoid landfill
- Contain recycled content from industrial or consumer sources
- Made of bio-based material
- Free of toxins
- Long lasting, durable, and reusable
- Made in factories that support human health and workers' rights

For consumers the biggest challenge is identifying what products are truly green. As public interest in sustainability has grown, so has the practice of greenwashing, or presenting misinformation to the consumer to portray a product or policy as being more environmentally friendly than it actually is. Misinformation is common among products because it is difficult to compare two products with different sustainable attributes. For example, consider cabinets made of wheat husks sourced from all over the country and bound together in resin versus solid wood cabinets made from local timber. There are upstream, downstream, and cost considerations to each option. Product transparency tools like life-cycle assessment (LCA), Environmental Product Declarations (EPDs), and material ingredient disclosures provide a more comprehensive picture of materials and products, enabling project teams to make informed decisions. Careful product selection can produce greater overall benefits, while encouraging manufacturers to improve their products through innovation.

STRATEGIES TO PROMOTE SUSTAINABLE PURCHASING DURING DESIGN AND OPERATIONS:

- **IDENTIFY LOCAL SOURCES OF ENVIRONMENTALLY PREFERABLE PRODUCTS.** Using local materials not only reduces the environmental harms associated with transportation, it also supports the local economy.
- **DEVELOP A SUSTAINABLE MATERIALS POLICY.** Outline the goals, thresholds, and procedures for procurement of ongoing consumables and durable goods. Incorporate systems thinking. Evaluate materials based on their upstream and downstream consequences. Monitor compliance to ensure that the policy is effective.
- **SPECIFY GREEN MATERIALS AND EQUIPMENT.** Give preference to rapidly renewable materials, regional materials, salvaged materials, and those with recycled content. Choose vendors who promote source reduction through reusable or minimal packaging of products. Look for third-party certifications, such as the Forest Stewardship Council, Green Seal, and ENERGY STAR.
- **SPECIFY GREEN CUSTODIAL PRODUCTS.** Choose sustainable cleaning products and materials that meet Green Seal, Environmental Choice, or EPA standards to protect indoor environmental quality and reduce environmental damage.

WASTE MANAGEMENT

Building construction generates large amounts of solid waste, and waste is generated across the building life-cycle as new products arrive and used materials are discarded. This waste may be transported to landfills, incinerated, recycled, or composted. Solid waste disposal contributes directly to greenhouse gas emissions through transportation and the production of methane—a potent greenhouse gas—in landfills. Incineration of waste produces carbon dioxide as a byproduct. EPA estimated the greenhouse gas emissions from building waste streams and found that the United States currently recycles approximately 32% of its solid waste—the carbon dioxide equivalent of removing almost 40 million cars from the road. Improving recycling rates to just 35% could result in savings equivalent to more than 5 million metric tons of carbon dioxide.[26]

26 U.S. Environmental Protection Agency, *Measuring Greenhouse Gas Emissions from Waste* (2010), epa.gov/climatechange/wycd/waste/measureghg.html.

Figure 4.3. Construction Activities can Produce Significant Waste

The intent of LEED credits in this category is to reduce the waste that is hauled to and disposed of in landfills or incineration facilities. In its solid waste management hierarchy, EPA ranks source reduction, reuse, recycling, and waste-to-energy as the four preferred strategies for reducing waste in landfills. Source reduction encourages the use of innovative construction strategies, such as prefabrication and designing to dimensional construction materials, thereby minimizing material cutoffs and inefficiencies. During construction or renovation, materials should be recycled or reused whenever possible. During the building's daily operations, recycling, reuse, and reduction programs can curb the amount of material destined for local landfills. When materials no longer have a use in the building, project teams may consider waste-to-energy, an increasingly common strategy to reduce land allocation to landfills. When strict air quality control measures are enforced, waste-to-energy can be a viable alternative to extracting fossil fuels to produce energy.

STRATEGIES TO REDUCE WASTE DURING CONSTRUCTION:

- **DESIGN BUILDINGS THAT PRODUCE LESS WASTE.** Use strategies such as designing for dimensional construction materials, prefabrication, or material efficient framing.
- **DEVELOP A CONSTRUCTION WASTE MANAGEMENT POLICY.** Outline procedures and goals for construction waste diversion. This policy should specify a target diversion rate for the general contractor.
- **ESTABLISH A TRACKING SYSTEM.** Ensure that the general contractor provides waste hauler reports and captures the full scope of the waste produced. Designate a construction and demolition waste recycling area. Diligent monitoring will ensure that the policy is effective.

STRATEGIES TO REDUCE WASTE DURING OPERATIONS AND MAINTENANCE:

- **DEVELOP A SOLID WASTE MANAGEMENT POLICY.** Outline procedures and goals for solid waste diversion. This policy should specify a target diversion rate for the facility.
- **CONDUCT A WASTE STREAM AUDIT.** Establish baseline performance for the facility and identify opportunities for increased recycling, education, and waste diversion.
- **MAINTAIN A RECYCLING PROGRAM.** Provide occupants with easily accessible collectors for recyclables. Label all collectors and list allowable materials. Through signage or meetings, educate occupants about the importance of recycling and reducing waste.
- **MONITOR, TRACK, AND REPORT.** Use hauler reports or other reliable data to monitor and track the effectiveness of the policy. Track performance goals and provide feedback to the occupants.
- **COMPOST.** Institute an on-site composting program to turn landscaping debris into mulch. Work with the waste hauler to allow for collection and composting of food and other organic materials.
- **PROVIDE RECYCLING FOR DURABLE GOODS.** Institute an annual durable goods drive where e-waste and furniture are collected on site and disposed of properly through donation, reuse, or recycling. Allow occupants to bring e-waste and furniture from home.

LEED IN PRACTICE

LEED for Building Operations & Maintenance encourages building managers to embrace new attitudes toward waste and close the life-cycle loop by reusing and recycling on-site materials. Understanding the content of a waste stream is the first step to improving the waste diversion rate at a facility.

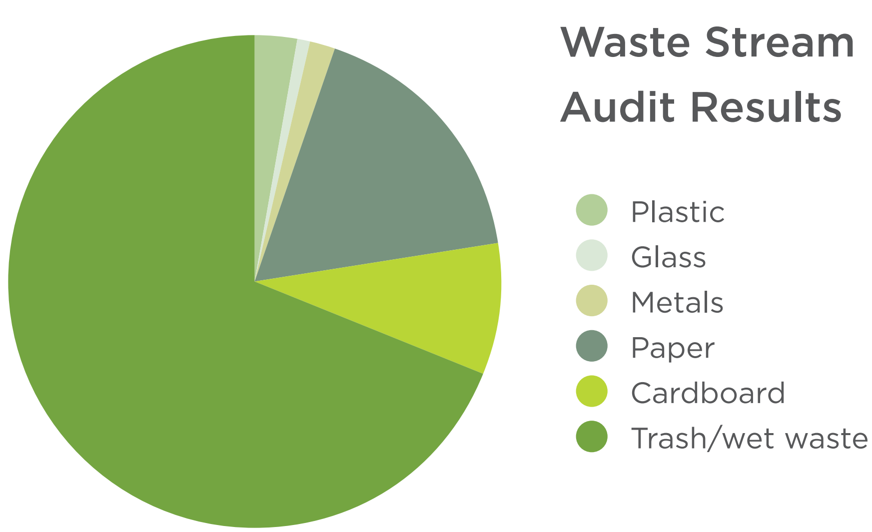


Figure 4.4. Waste Stream Audit Results

To comply with LEED requirements, a project team conducts a waste stream audit for the entire consumables waste stream. The audit results are used to establish a baseline that identifies the amount and percentage of each material in the waste stream. Results from the waste audit can reveal opportunities for increasing recycling and waste diversion and be used to adjust the recycling procedures at the facility.

Assume that a project team has conducted a waste stream audit and tracked 300 pounds of waste, consisting of the following:

	Pounds	Percentage
Trash and wet waste	200	68
Paper	60	20
Cardboard	25	8
Plastic	6	2
Metal	5	1
Glass	4	1

Because 28% of the waste stream is recyclable paper and cardboard paper, the project team should provide recommendations to improve the recycling rate and source reduction of these items. The team should also share the audit results with the building's occupants to encourage their participation in on-site recycling programs.

INDOOR ENVIRONMENTAL QUALITY

Indoor Environmental Quality (EQ) encompasses the conditions inside a building—air quality, lighting, thermal conditions, acoustics, and their effects on occupants. Strategies for addressing EQ issues include those that protect human health, improve quality of life, and reduce stress and potential injuries. Better indoor environmental quality can enhance the lives of building occupants, increase the resale value of the building, and reduce liability for building owners. Additionally, since the personnel costs of salaries and benefits typically surpass the operating costs of an office building, strategies that improve employees' health and productivity over the long run can have a large return on investment. EQ goals often focus on providing stimulating and comfortable environments for occupants and minimizing the risk of building-related health problems.

To make their buildings places where people feel good and perform well, project teams must balance selection of strategies that promote efficiency and conservation with those that address the needs of the occupants and promote well-being. Ideally, the chosen strategies do both: the solutions that conserve energy, water and materials also contribute to a great indoor experience.

LEED ADDRESSES THE FOLLOWING ISSUES RELATED TO INDOOR ENVIRONMENTAL QUALITY:

- Indoor air quality
- Lighting
- Acoustics
- Occupant experience

INDOOR AIR QUALITY

The quality of air outdoors has received considerable attention in recent decades, and strategies to reduce smog and other air pollutants are vitally important. However, the air we breathe indoors—where millions of Americans spend most of the day—can be even more polluted. Many common sources generate indoor air contaminants:

- People smoking tobacco inside the building or near building entrances or air intakes
- Building materials such as paints, adhesives, flooring, composite wood, insulation, wall materials, and furniture that may emit volatile organic compounds (VOCs), substances that vaporize at room temperature and can cause health problems

- Combustion processes in HVAC equipment, fireplaces and stoves, and vehicles in garages or near entrances
- Mold resulting from moisture in building materials
- Cleaning products
- Radon or methane off-gassing from the soil underneath the building
- Pollutants from specific processes used in laboratories, hospitals, and factories
- Pollutants tracked in on occupants' shoes
- Occupants (bioeffluents) and their activities

The best way to prevent indoor pollutants is to eliminate or control them at the sources. The next line of defense is proper ventilation to remove any pollutants that do enter. Both approaches need to be considered at all phases of the building life-cycle.

STRATEGIES FOR DESIGNING FOR GOOD INDOOR AIR QUALITY:

- **PROHIBIT SMOKING.** Institute a no-smoking policy for the building and around building entrances, operable windows, and air intakes.
- **DESIGN FOR PROPER VENTILATION.** Consider the number of occupants in each space and the activities they will be engaged in. Make sure that the ventilation system, whether natural or mechanical, is sized appropriately and can provide enough fresh air.
- **PROTECT AIR THAT COMES INTO THE BUILDING.** Locate air intakes away from likely exhaust sources, such as idling vehicles or smoking areas. Use air filtration to remove outdoor air contaminants. The filters should have high minimum efficiency reporting value (MERV) ratings. The higher the MERV rating the greater the particulates captured by the filter.
- **TEST FOR RADON OR OTHER ON-SITE CONTAMINANTS.** If present, include a ventilation system to address possible emissions.
- **DESIGN FOR ENTRYWAY SYSTEMS.** Use grilles, grates, or mats at building entrances to reduce the dust, dirt, and contaminants carried into the facility by people's shoes.
- **SPECIFY LOW-EMITTING MATERIALS.** Use materials with low VOC emissions.

STRATEGIES FOR IMPROVING INDOOR AIR QUALITY DURING CONSTRUCTION:

- **KEEP BUILDING CLEAN DURING CONSTRUCTION.** Follow good housekeeping and dust control during construction.
- **PROTECT MATERIALS AND EQUIPMENT.** Protect materials from moisture exposure, protect and cap ducts and mechanical systems.
- **CONDUCT A FLUSH-OUT.** Before occupancy, flush out off-gassed compounds and other contaminants left behind at the end of construction.

Indoor air quality must be maintained throughout the life of a building to protect occupants on an ongoing basis.

STRATEGIES FOR IMPROVING INDOOR AIR QUALITY DURING OPERATIONS AND MAINTENANCE:

- **ENSURE ADEQUATE VENTILATION.** Operate ventilation systems to supply ample outside air to the occupants. Follow the most recent industry standards, such as ASHRAE Standard 62, Ventilation for Acceptable Indoor Air Quality.
- **MONITOR OUTDOOR AIRFLOW.** Use an outdoor airflow measurement device that can measure and control the minimum outdoor airflow rate.
- **MONITOR CARBON DIOXIDE.** Use monitors and integrate them with a ventilation system that regulates the supply of air based on occupants' demand. With demand-controlled ventilation, air flow is automatically increased if concentrations exceed a setpoint.
- **CALIBRATE SENSORS.** Perform routine preventive maintenance, such as calibrating sensors and monitors, to ensure that accurate data are used to modulate systems.
- **PROHIBIT SMOKING.** Enforce a no-smoking policy in the building and around building entrances, operable windows, and air intakes. Communicate the policy to building occupants through building signage and tenant meetings.
- **DEVELOP AND IMPLEMENT A GREEN CLEANING POLICY.** To minimize the introduction of contaminants, outline procedures and goals for the custodial program at the facility. This policy should specify standards for selecting cleaning products and technologies, such as Green Seal standards, California Code of Regulations, and certification of cleaning equipment from the Carpet and Rug Institute.
- **CONDUCT CUSTODIAL EFFECTIVENESS ASSESSMENT.** Identify opportunities for improving building cleanliness and reducing occupants' exposure to potentially harmful biological and particulate contaminants.
- **USE ENTRYWAY SYSTEMS.** Have grilles, grates, or mats at building entrances to reduce the dust, dirt, and contaminants brought into the facility by people's shoes. Develop cleaning procedures to properly maintain the entryway systems.
- **USE INTEGRATED PEST MANAGEMENT.** A coordinated program of nonchemical strategies, such as monitoring and baiting, will reduce the need for pesticides and other potentially toxic contaminants.

LIGHTING, ACOUSTICS, AND OCCUPANT EXPERIENCE

To be healthy, happy, and productive in the building, occupants need to feel comfortable and in control of their environment. This includes thermal comfort, lighting and views, acoustics, and ergonomics. Feeling too hot or too cold, having insufficient lighting or being unable to look out a window, dealing with too much noise or having an uncomfortable work station can all cause stress and reduce quality of life. Because people's needs vary and even the same individual may have different needs and preferences at different times, the ability to control the indoor environment is a critical component of occupants' comfort and satisfaction.

Figure 4.5. Daylit Classroom. photo credit: Josh Partee 2009

Thermal comfort includes more than just temperature; it also includes humidity and air movement. An area may be the right temperature, but if the air is stagnant or if air ducts blow directly on work stations, people will feel uncomfortable. An operable window may make office workers more comfortable than a sealed environment maintained at ideal temperatures simply because it gives them some control over their environment.

Lighting levels and views to the outdoors are other important aspects of the indoor experience. Providing enough lighting for particular tasks is critical to protect occupants' eyesight over time. Studies by the Heschong Mahone Group have demonstrated that providing daylighting in classrooms can improve student scores by 7% to 18%.[27] They also found improvements in office workers' productivity. In addition to admitting daylight, windows that let people focus their eyes across a longer distance and see the outdoors may play a role in occupants' comfort. Of course, too much light can interfere with some tasks, and direct sunlight or glare can create discomfort as well. Good lighting design considers the tasks to be done in a space, the orientation of the building, the layout of the room, the type of glass and configuration of the windows, even the type of furnishings and colors of surfaces.

Appropriately sized and located windows can dramatically increase the amount of daylight introduced into a space; clerestory windows, light shelves, and reflective paint and materials bounce and diffuse the natural light. In office buildings, locating private offices toward the building core and siting cubicles at the perimeter brings daylight into a large area. Low cubicle partitions allow daylight to travel to the core spaces while permitting views of the outdoors. Adjustable window shades give occupants control over excessive brightness and glare.

27 Heshong Mahone Group, *Windows and Offices: A Study of Office Worker Performance and the Indoor Environment* (CEC PIER, 2003), h-m-g.com/projects/daylighting/summaries%20on%20daylighting.htm.

Daylight can also decrease the need for artificial lighting. Daylight controls help in dimming or turning off electrical lights entirely when daylight is sufficient. These controls should be zoned so that the spaces near the windows have dimmed artificial lighting, and the spaces farther away from the perimeter, with less natural light, have higher levels of artificial light.

When designing buildings, consider energy conservation and indoor environmental quality together. It is easy to view these considerations as contradictory. However, a systems-based, integrated approach can identify solutions that contribute to both goals. For example, daylighting and natural ventilation can not only save energy but also improve occupants' experience. Furthermore, once the building design team members understand who the occupants are, what they will be doing, and how they will be doing it, they can create environments tailored to those needs while providing sufficient control and flexibility.

EQ systems must be evaluated and adjusted once the building is occupied. Installing sensors to monitor conditions and conducting occupant surveys are important parts of green building operations.

STRATEGIES FOR IMPROVING OCCUPANTS' COMFORT AND CONTROL:

- **USE DAYLIGHTING.** Design the building to provide ample access to natural light and views for the occupants. Optimize access to views by using low partitions and vision panels.
- **INSTALL OPERABLE WINDOWS.** If possible, provide windows that can be opened to the outside. To save energy, sensors may be included to inform the HVAC system to shut down if a window is open.
- **GIVE OCCUPANTS TEMPERATURE AND VENTILATION CONTROL.** In mechanically ventilated buildings, provide thermostats that allow occupants to control the temperature in their immediate environment. Provide adjustable air diffusers that allow occupants to adjust the air flow as well.
- **GIVE OCCUPANTS LIGHTING CONTROL.** Provide adjustable lighting controls so that occupants can match lighting levels to their tasks. These may be designed in combination with daylight and occupancy sensors to conserve energy.
- **CONDUCT OCCUPANT SURVEYS.** Use valid survey protocols to assess occupants' satisfaction with the indoor environment. Evaluate results to identify areas of dissatisfaction and prepare a corrective action plan to make the necessary operational changes.
- **PROVIDE ERGONOMIC FURNITURE.** Include furniture that is adjustable to prevent repetitive stress injuries.
- **INCLUDE APPROPRIATE ACOUSTIC DESIGN.** Use soft surfaces and other strategies to ensure that sound levels remain comfortable for the activity level of the space.

LEED IN PRACTICE

LEED for Building Operations and Maintenance encourages facilities managers to assess occupants' comfort levels while at work. Through a confidential survey, occupants can rate the heating and air-conditioning, acoustics, air quality, lighting levels, cleanliness, and other aspects of their work spaces. Facilities managers evaluate the responses to determine any areas of dissatisfaction, then develop a corrective action plan to address problems and improve occupants' comfort.

INNOVATION

Through Innovation, LEED encourages additional environmental benefits beyond those already achieved through other rating system categories. Innovative strategies expand the breadth of green building practice by incorporating cutting-edge techniques, processes and products into the development of a project. Ideally, innovation is a byproduct of the green building process discussed in this guide. The integrative and iterative processes required to achieve the environmental benefits addressed by LEED encourage new methods and standards, while advancing the practice of green building.

Projects incorporating these strategies and achieving exemplary levels of performance are rewarded with innovation credits. These may include the use of pilot credits, which are designed to test new and revised LEED credit language, and new or innovative green building technologies and concepts.

Strategies and practices rewarded as innovative today may become credits in future rating systems. In fact, as LEED continues to evolve and today's innovation become tomorrow's standard, strategies that may have earned Innovation credit in the past may not necessarily earn recognition today.

EXAMPLES OF INNOVATIVE STRATEGIES INCLUDE:

- Developing a comprehensive green building educational program for members of the community, occupants, residents or other stakeholders.
- Creating, implementing, and maintaining a program for occupants or other stakeholders to divert a significant amount of waste generated from outside sources to appropriate recycling locations.

PROJECT CASE STUDY

THE ALDO LEOPOLD LEGACY CENTER

LEED PLATINUM

The Aldo Leopold Legacy Center near Baraboo, Wisconsin was the first building recognized by USGBC as carbon neutral—an exceptional achievement that helped the project earn points in the Innovation category. The project team prepared a greenhouse gas emissions budget based on the requirements of the World Resources Institute Greenhouse Gas Protocol. Conservatively accounting for carbon generation and sequestration in metric tons of CO_2 equivalent (a measure of greenhouse gas emissions that combines multiple heat-trapping gases, such carbon dioxide, methane, and nitrous oxide), the activities of the center will result in the net *reduction* of CO_2 emissions each year.

Projected annual greenhouse gas emissions from Aldo Leopold Legacy Center		
	CO_2 equivalent per year (metric tons)	
Total emissions		13.42
Offset from renewable energy	–6.24	
Onsite forest sequestration	–8.75	
Total emissions reduction		–14.99
Net balance of emissions		–1.57

More information about the Aldo Leopold Legacy Center is available at aldoleopold.org/legacycenter/carbonneutral.html.

Section 5

About USGBC and LEED

The U.S. Green Building Council (USGBC) and its community are changing the way buildings and communities are designed, built and operated.

USGBC believes in better buildings: places that complement our environment and enhance our communities; places that give people better, brighter, healthier spaces to live, work and play.

> **USGBC's Vision**
>
> ***Buildings and communities will regenerate and sustain the health and vitality of all life within a generation.***

ABOUT USGBC

USGBC is transforming the building landscape in a number of ways.

ADVOCACY

USGBC provides policymakers and community leaders with the tools, strategies, and resources they need to take leadership positions, foster innovation, and inspire action. From national advocacy programs promoting green schools to policy engagement with decision-makers in the White House and the U.S. Congress, as well as state houses and city halls across the country, USGBC is accelerating the uptake of policies and initiatives that enable and encourage market transformation toward a sustainable built environment.

COMMUNITY

The USGBC community comprises member organizations that participate in forums, exchanges, and regular communication. Additionally, there are regional USGBC chapters and affiliates across the nation. This network of industry leaders provides green building resources, education, and opportunities for green building professionals to stay connected in their communities.

EDUCATION

USGBC provides high-quality educational programs and materials on green design, construction, and operations for professionals from all sectors of the building industry. The focus is on developing practical knowledge, exploring new business opportunities, and learning how to create more healthful, productive, and efficient places to live and work. USGBC's diverse delivery formats, including webinars and publications, make learning about green building accessible to all.

GREENBUILD INTERNATIONAL CONFERENCE AND EXPO

Greenbuild is the world's largest conference and exposition dedicated to green building. Launched in 2002, it has become an important annual event for the green building industry. Each year, tens of thousands of professionals convene to take part in educational sessions, tour green buildings, and view exhibits of green products and technologies.

LEED® GREEN BUILDING PROGRAM

USGBC's Leadership in Energy and Environmental Design (LEED) program is a third-party green building certification program and an international symbol of excellence in the design, construction, and operation of high-performance green buildings and neighborhoods. It encourages and accelerates adoption of sustainable building and community development practices through the creation and implementation of a green building benchmark that is voluntary, consensus based, and market driven.

ABOUT LEED

LEED RATING SYSTEMS

Comprehensive and flexible, LEED is applicable to buildings at any stage in their life-cycles. New construction, the ongoing operations and maintenance of an existing building, and a significant tenant retrofit to a commercial building are all addressed by LEED rating systems. The rating systems and their companion reference guides help teams make the right green building decisions for their projects through an integrated process, ensuring that building systems work together effectively. Through a consensus-based process, the rating systems are continually evaluated and regularly updated to respond to new technologies and policies and to changes in the built environment. In this way, as yesterday's innovation becomes today's standard of practice, USGBC and LEED continue to push forward market transformation.

The following project types and scopes are addressed by LEED rating systems:

LEED FOR Building Design and Construction	LEED BD+C: New Construction LEED BD+C: Core and Shell LEED BD+C: Schools LEED BD+C: Retail LEED BD+C: Healthcare LEED BD+C: Data Centers LEED BD+C: Hospitality LEED BD+C: Warehouses and Distribution Centers LEED BD+C: Homes LEED BD+C: Multifamily Midrise
LEED FOR Interior Design and Construction	LEED ID+C: Commercial Interiors LEED ID+C: Retail LEED ID+C: Hospitality
LEED FOR Building Operations and Maintenance	LEED O+M: Existing Buildings LEED O+M: Data Centers LEED O+M: Warehouses and Distribution Centers LEED O+M: Hospitality LEED O+M: Schools LEED O+M: Retail
LEED FOR Neighborhood Development	LEED ND: Plan LEED ND: Built Project

Figure 5.1. LEED Rating Systems

RATING SYSTEM STRUCTURE

The LEED rating systems consist of prerequisites and credits. Prerequisites are required elements or green building strategies that must be included in any LEED-certified project. Credits are optional elements—strategies that projects can elect to pursue to gain points toward LEED certification.

Achieving LEED certification requires satisfying all prerequisites and earning a minimum number of credits. Each LEED rating system corresponds to a LEED reference guide that explains credit criteria, describes the benefits of complying with the credit, and suggests approaches to achieving credit compliance.

Although the organization of prerequisites and credits varies slightly depending on the building type and associated rating system, LEED is generally organized by the following broad concepts:

- **LOCATION AND TRANSPORTATION.** LEED emphasizes location and transportation issues by rewarding development that preserves environmentally sensitive places and takes advantage of existing infrastructure, community resources, and transit. It encourages access to open space for walking, physical activity, and time spent outdoors. Credits also encourage smart transportation choices and access to a diversity of uses.
- **SUSTAINABLE SITES.** Choosing a building's site and managing that site during construction are important considerations for a project's sustainability. LEED credits addressing sustainable sites discourage development of previously undeveloped land and damage to ecosystems and waterways; they encourage regionally appropriate landscaping, control of rainwater runoff, and reduced erosion, light pollution, heat island effect, and construction-related pollution.
- **WATER EFFICIENCY.** Buildings are major users of our potable water supply. The goal of credits addressing water efficiency is to encourage smarter use of water, inside and out. Water reduction is typically achieved through more efficient appliances, fixtures, and fittings inside and water-wise landscaping outside.
- **ENERGY AND ATMOSPHERE.** LEED encourages a wide variety of strategies to address energy consumption, including commissioning; energy use monitoring; efficient design and construction; efficient appliances, systems, and lighting; demand response, and the use of renewable and clean sources of energy, generated on-site or off-site.
- **MATERIALS AND RESOURCES.** During both construction and operations, buildings generate large amounts of waste and use tremendous volumes of materials and resources. These credits encourage the selection of sustainably grown, harvested, produced, and transported products and materials. They promote the use of life-cycle assessment to holistically evaluate materials and the disclosure and optimization of material chemical ingredients.
- **INDOOR ENVIRONMENTAL QUALITY.** The average American spends about 90% of the day indoors, where pollutant concentrations may be two to 100 times higher than outdoor levels. Thus indoor air quality can be significantly worse than outside. LEED credits promote strategies that can improve indoor air, provide access to natural daylight and views, and improve acoustics.
- **INNOVATION.** LEED promotes innovation by offering points for improving a building's performance well beyond what is required by the credits or for incorporating green building ideas that are not specifically addressed elsewhere in the rating system. This credit category also rewards the inclusion of a LEED Accredited Professional on the project team.
- **REGIONAL PRIORITY.** USGBC's regional councils, chapters, and affiliates have identified the environmental concerns that are most important for every region of the country, and LEED credits that address those local priorities have been selected for each region. A project team that earns a regional priority credit earns one bonus point in addition to any points awarded for that credit.

LEED for Neighborhood Development is organized around three main categories, focusing on where, what, and how to build green at a community scale.

- **SMART LOCATION AND LINKAGE.** This section of the rating system provides guidance on where the project is built, encouraging the selection of sites with existing services and transit.

- **NEIGHBORHOOD PATTERN AND DESIGN.** Neighborhoods should be compact, complete, connected, and convivial. The intent of credits in this category is to create environments that are walkable, vibrant with mixed-use establishments, and connected to the larger community.
- **GREEN INFRASTRUCTURE AND BUILDINGS.** This category focuses on measures that can reduce the environmental harms associated with the construction and operation of buildings and infrastructure within neighborhoods, with a goal of not just reducing the environmental consequences, but also enhancing the natural environment.

Additionally, LEED emphasizes the critical role of the integrative process and ongoing performance monitoring across all phases and project types.

LEED rating systems have 100 base points plus six Innovation points and four Regional Priority points, for a total of 110 points. The level of certification is determined according to the following scale:

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

RATING SYSTEM DEVELOPMENT AND EVOLUTION

Since its launch in 2000, LEED has been evolving to address new markets and building types, advances in practice and technology, and greater understanding of the environmental and human health impacts of the built environment. These ongoing improvements to LEED are based on principles of transparency, openness, and inclusiveness involving volunteer committees and working groups, as well as USGBC staff, and are approved by a membership-wide vote.

LEED is continually improved through the correction and clarification of credit language. These updates are published as quarterly addenda and include LEED interpretations.

Additionally, the LEED Pilot Credit Library plays an important role in the evolution of LEED. Pilot credits are tested across all rating system types and credit categories and include credits proposed for the next version of LEED. Project teams may attempt any of these pilot credits under the Innovation categories and earn points by providing USGBC with feedback on the credits' efficacy and achievability. USGBC collects and integrates this feedback to refine the pilot credits, and worthwhile credits are then added to the balloted LEED rating system.

CREDIT WEIGHTINGS

The LEED rating system has always been implicitly weighted by virtue of the different point values assigned to each credit and category. These weightings continue to evolve with the rating system as market conditions, user requirements, scientific understanding and public policy change. The weightings ensure that LEED assigns higher point values to the credits with the strongest relationship to the impact categories of greatest concern (See Figure 5.2, which shows the relative importance given to each environmental impact category. Credits are analyzed against these categories and awarded points accordingly). Thus a given credit's point value reflects its potential both to mitigate the environmental harms of a building and to promote beneficial effects.

For more information about credit weightings, see LEED v4 Impact Category and Point Allocation Process Overview: usgbc.org/resources/leed-v4-impact-category-and-point-allocation-process-overview

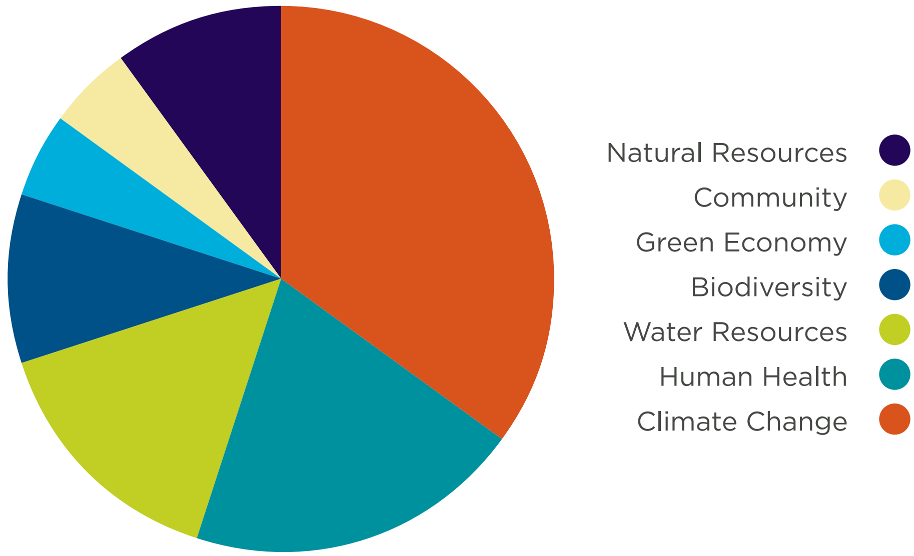


Figure 5.2. Relative Importance of LEED v4 Impact Categories

GREEN BUILDING CODES, STANDARDS, AND RATING SYSTEMS

A growing number of state and local governments are analyzing and revising their building codes to better align with their sustainability goals and green building programs. Even where codes are determined at the state level, many local governments are finding that regulatory minimums for the private sector may need upgrades and more comprehensive enforcement strategies to improve public health, safety, and environmental quality.

A landmark national effort to codify green building practices into adoptable, adaptable and enforceable green building codes has produced regulatory documents that are now available as an overlay to more traditional building codes. The International Green Construction Code (IGCC), including ASHRAE Standard 189.1 as an alternate path to compliance, is a widely supported and first-of-its-kind regulatory framework that recognizes an entire set of risks not otherwise addressed in the codes.

Both distinct and complementary to green building rating systems such as LEED, green building codes are redefining the fundamental protections that are the basis of smart public policy. And, as the floor is raised through the codes, so too is the ceiling raised through beyond-code rating systems like LEED that continue to pave the way, continually raising the bar for leadership.

PROJECT CERTIFICATION

LEED certification provides independent, third-party verification that a building project meets the highest green building and performance measures. Early in the development of a project, the integrated project team needs to determine the project's goals, the level of certification to pursue, and the credits that will help them achieve it. The certification steps generally proceed as follows and are detailed on usgbc.org/leed/certification.

PROJECT REGISTRATION

The LEED process begins with registration. The project team submits a registration form and a fee to GBCI. It is helpful if the project administrator—the team member who registers the project—has previous green building and LEED project experience; ideally, he or she is a LEED Accredited Professional. Once registered, the team receives information, tools, and communications that will help guide the certification process. All project activity, including registration and credit compliance documentation, is completed in LEED Online, a data collection portal through which the team uploads information about the project. This site provides credit templates to be completed and signed by a specified member of the team.

APPLICATION PREPARATION

Each LEED credit and prerequisite has documentation requirements that must be completed as part of the application process. The project team selects the credits it has chosen to pursue and when the necessary documentation, including required information and calculations, has been assembled, the project team uploads the materials to LEED Online.

SUBMISSION

When the team is ready for its application to be reviewed, the project administrator submits the appropriate fee and documentation. For LEED BD+C and ID+C projects, the team can wait to submit documentation until the building project is complete, or the team can seek review of its design-related prerequisites and credits before completion, and then apply for construction-related credits after the project is finished.

APPLICATION REVIEW

Whether the design and construction credits are submitted together or separately, each credit undergoes one preliminary review. The certification reviewer may request additional information or clarification. The team then submits final documentation. After the final review, a team may appeal any adverse decisions on individual credits for an additional fee.

CERTIFICATION

Certification is the final step in the LEED review process. Once the final application review is complete, the project team can either accept or appeal the final decision. LEED-certified projects receive formal certificates of recognition, a plaque, and tips for marketing the achievement. Projects may be included in USGBC's online LEED Project Directory of registered and certified projects.

PROJECT CREDIT INTERPRETATION RULINGS AND LEED INTERPRETATIONS

The LEED rating systems are intended to be flexible, voluntary tools to improve the performance of buildings and promote market transformation. At times a project team may want clarification, further guidance, or additional ways to comply with the rating system's requirements. Project teams therefore have several options in engaging with USGBC and GBCI during the certification submittal process.

Project credit interpretation rulings (Project CIRs), administered by GBCI, allow teams to obtain technical guidance on how LEED requirements pertain to their projects. Project CIRs do not guarantee credit award;

the project applicant must still demonstrate and document achievement during the LEED certification application process. The ruling remains confidential and generally applies only to the one project. LEED Interpretations, however, are precedent setting; project teams are required to adhere to all LEED Interpretations posted before their registration date. These are posted publicly in the online Addenda database.

LEED PROFESSIONAL CREDENTIALS

LEED professionals demonstrate current knowledge of green building technologies, best practices, and the rapidly evolving LEED rating systems. The credentials differentiate professionals in a growing and competitive industry, allow for varied levels of specialization, and give employers, policy makers, and other stakeholders an indication of individuals' level of competence. Exams are updated periodically to ensure they stay current with the latest green building knowledge and practice. Accreditation is available at three levels:

- **LEED GREEN ASSOCIATE** validates basic understanding of green building and the professional field, as gained through experience in sustainability and green building or related educational experience
- **LEED ACCREDITED PROFESSIONAL** demonstrates a deep familiarity with the LEED rating systems developed through active participation in and contribution to a LEED-registered project
- **LEED FELLOW** distinguishes professional leadership, contribution to the standards of practice and body of knowledge, and continual improvement in the field

CERTIFICATES

LEED Professional Certificates™ certify the skills and knowledge of LEED implementation required to provide verification services on LEED projects. Credentialing as a LEED for Homes Green Rater is also available.

To keep their credentials current, professionals must meet continuing education requirements that help them grow their knowledge base, stay current with best practices, and demonstrate that their expertise is meaningful in a rapidly transforming marketplace. Establishing continuing education requirements for LEED Accredited Professionals ensures that the credential continues to distinguish those building professionals who have a thorough understanding of green building principles and practices plus the skills to steward the LEED certification process.

Conclusion

Equipped with fundamental knowledge about green building and LEED core concepts, let's return to the building described at the beginning of this guide by USGBC CEO Rick Fedrizzi. Imagine that large oak table in the LEED Platinum commercial office space and take a seat.

As part of your company's finance team, perhaps you are working closely with the property manager to finalize details on a green lease agreement for this space. Or soon after the lease is signed and your company has moved in, you are part of the operations staff sitting around the same table, discussing the steps needed to implement your company's new green cleaning guidelines.

Now, imagine that the oak table is in your LEED Platinum home. You are enjoying a meal with your kids, home from college for summer vacation. As you pass dishes around the table, filled with fresh food from the supermarket down the block, your daughter applauds you for taking her advice and pursuing LEED certification for your home.

Next, imagine that you are that son or daughter. You are back on campus, sitting at your own oak table, in your school's LEED Platinum student activities center. You share your experiences volunteering at the most recent Greenbuild Conference with your peers and professors. Inspired by your stories, the team decides to plan an on-campus sustainability conference in the months ahead.

Finally, imagine that you are sitting at that oak table, back in the LEED Platinum commercial office space, flooded by natural springtime light. You work closely with your colleagues, following up on plans laid out in a recent project charrette. Looking up, you take pride in what you can contribute as a LEED Green Associate or LEED Accredited Professional.

Every day, we pass into and out of these buildings, often without giving them much notice. There is tremendous opportunity in our homes, our offices, our schools, our hospitals, our places of worship, and our neighborhoods. As we work together to transform the built environment, we can find solutions to climate change, water and resource shortages, unemployment and economic distress. We can tackle tough issues like traffic congestion and respiratory illnesses. With the knowledge you now carry, you are not only equipped to take part in the conversations about these challenges—you are prepared to be a leader, find solutions, and transform the built environment.

Appendices

Appendix A: Resources

LEED GREEN ASSOCIATE CANDIDATE HANDBOOK
usgbc.org/resources/leed-green-associate-candidate-handbook

USGBC EDUCATION RESOURCES
usgbc.org/education

USGBC PUBLICATIONS
usgbc.org/store

GREEN BUILDING CODES OVERVIEW
usgbc.org/ShowFile.aspx?DocumentID=7403

USGBC ADVOCACY CAMPAIGNS
usgbc.org/advocacy/campaigns

LEED RATING SYSTEMS
usgbc.org/leed/rating-systems

LEED CREDIT LIBRARY
usgbc.org/credits

USGBC GLOSSARY
usgbc.org/glossary

COST OF GREEN REVISITED, BY DAVIS LANGDON (2007)
gbci.org/Libraries/Credential_Exam_References/Cost-of-Green-Revisited.sflb.ashx

SUSTAINABLE BUILDING TECHNICAL MANUAL: PART II, BY ANTHONY BERNHEIM AND WILLIAM REED (1996)
gbci.org/Libraries/Credential_Exam_References/Sustainable-Building-Technical-Manual-Part-II.sflb.ashx

THE TREATMENT BY LEED® OF THE ENVIRONMENTAL IMPACT OF HVAC REFRIGERANTS (LEED TECHNICAL AND SCIENTIFIC ADVISORY COMMITTEE, 2004)
gbci.org/Libraries/Credential_Exam_References/The-Treatment-by-LEED-of-the-Environmental-Impact-of-HVAC-Refrigerants.sflb.ashx

LEED v4 IMPACT CATEGORY AND POINT ALLOCATION PROCESS OVERVIEW
usgbc.org/resources/leed-v4-impact-category-and-point-allocation-process-overview

Appendix B: Case Study Information

NORTHWEST GARDENS
Year Completed: 2012
Location: Fort Lauderdale, Florida
LEED Certification Level: Gold
Rating System: LEED for Neighborhood Development (v2009)
Organization Website: hacfl.com
USGBC Case Study Website: usgbc.org/projects/northwest-gardens

CANNON DESIGN CHICAGO OFFICE
Year Completed: 2012
Location: Chicago, Illinois
LEED Certification Level: Platinum
Rating System: LEED for Commercial Interiors (v2009)
Organization Website: cannondesign.com
USGBC Case Study Website: usgbc.org/projects/cannon-design-chicago-office-relocation

VILLA ALEGRE
Year Completed: 2011
Location: Santa Fe, New Mexico
LEED Certification Level: Platinum
Rating System: LEED for Homes (v2008)
Organization Website: santafenm.gov/housing_and_community_development
USGBC Case Study Website: usgbc.org/projects/villa-alegre-phase-1-2-0

ADLAI E. STEVENSON HIGH SCHOOL
Year Completed: 2011
Location: Lincolnshire, Illinois
LEED Certification Level: Gold
Rating System: LEED for Existing Buildings: Operations and Maintenance (v2009)
Organization Website: d125.org
USGBC Case Study Website: usgbc.org/projects/adlai-e-stevenson-high-school

601 TOWNSEND ADOBE OFFICES – RECERTIFICATION
Year Completed: 2012
Location: San Francisco, California
LEED Certification Level: Platinum
Rating System: LEED for Existing Buildings: Operations and Maintenance (v2009)
Organization Website: adobe.com
USGBC Case Study Website: usgbc.org/projects/re-certification-adobe-sf-601-townsend

800.795.1747 usgbc.org