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Improving Project Delivery

# Sustainable Design and Construction

## Practice Guide

- The must-have reference on sustainable design and construction documentation
- Provides best practices for project delivery methods as related to sustainable design
- Bonus content available on a password-protected website

# The CSI Sustainable Design and Construction Practice Guide

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# Preface

## Introduction to the Practice Guide Series

Beginning with the publication of the first *Manual of Practice* (MOP) in 1967 continuing through the publication of its successor document, the *Project Resource Manual* (PRM), it has been the intent of CSI that these publications embody accepted standards for the preparation of construction specifications and project manuals, and a detailed source of information on quality documentation for the life cycle of a facility.

Through these publications, CSI has sought to aid owners, designers, specifiers, contract administrators, contractors, construction product representatives, and facility managers in the performance of their jobs.

In 2008, CSI began an effort to update the knowledge formerly contained in the MOP and PRM to present it anew and ensure its continued relevance. As with the earlier collections of this knowledge, the intent is to provide an authoritative resource on the organization, preparation, use, and interpretation of construction documents, encompassing the entire life cycle of a facility from conception through facility management.

To accomplish this update CSI established the Practice Guides Task Team. One of the task team charges was to organize the presentation of this information into modules to support areas of practice where CSI currently offers certificates and certifications, such as Project Delivery addressed by the Construction Documents Technology (CDT) certificate; Specifications, addressed by the Certified Construction Specifier (CCS) certification; Contract Administration, addressed by the Certified Construction Contract Administrator (CCCA) certification; and Product Representation, addressed by the Certified Construction Product Representative (CCPR) certification, as well as other areas of practice for which education and certification may be developed.

To keep current with changes in the industry, the task team also reviewed other CSI documents and standards, and updated references to them that appear in the *Practice Guides*. A similar effort was made to incorporate changes in contract documents produced by The American Institute of Architects (AIA) and the Engineers Joint Construction Documents Committee (EJCDC), and to introduce the new standard contract documents developed by the ConsensusDOCS Coalition.

The task team also recognized the growing impact of "green" or sustainable practices on the subject matter contained in the *Practice Guides*. Each *Practice Guide* now addresses the topic of sustainable practice to some degree and a more detailed examination of the topic is contained in this *Practice Guide.*

Two other topics that have had an impact on the *Practice Guides* are: Building Information Modeling (BIM) and Integrated Project Delivery (IPD). The growing impact of BIM on the practice of specification writing and its potential impact on quality documentation made a discussion of this topic imperative. Likewise, IPD has grown in importance over the past several years and has had an impact on the way practitioners relate to the process of creating and interpreting construction documents.

The *Practice Guide Series* is not intended to be composed of static documents but to be a living set of guides with the capacity to change and be updated as the construction industry changes around them. The input of users of this Series will be critical to the future updating of the Series and the authors and reviewers welcome feedback from users.

## Description of *The CSI Sustainable Design and Construction Practice Guide*

*The CSI Sustainable Design and Construction Practice Guide* is a compilation of information and recommended practices for those who participate in some way in the design and construction of sustainable facilities. As one volume in the series of *Practice Guides* published for the CSI, this *Practice Guide* presents a comprehensive body of knowledge regarding sustainable design principles, and contains important and useful information on how to apply sustainable practices for the design and construction of facilities. This *Practice Guide* does not endorse any specific existing sustainable design rating system or program, and does not attempt to establish or defend any scientific or philosophical arguments that have created a market for sustainable design. This *Practice Guide* offers guidelines and standards on how to apply sustainable design and construction principles in practical terms. Whether new to the practice of sustainable design and construction or familiar with the practice, this *Guide* provides the reader with tools to do their job smarter and better.

Additional CSI publications that complement the *Practice Guides* are available for download to purchasers of the *Practice Guides*. These documents can be obtained at www.wiley.com/go/csipracticeguides:

- MasterFormat® numbers and titles
- UniFormat™
- SectionFormat™/PageFormat™
- Sample CSI Forms
- GreenFormat™ questionnaire
- Practice Guide Glossary

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# Chapter 1
# Sustainable Design and Construction

Sustainable design and construction is not merely an emerging trend in the construction industry, it is now a standard of professional practice. Sustainable design and construction practices have been in use in Europe and other parts of the world for many decades. Such practices have also been in use in the United States of America for many years.

The American Institute of Architects (AIA) Energy Committee was founded in 1973 by a group of architects known for their work in energy, architecture, and research. The Committee collaborated with the government and with many other interested organizations for more than a decade, during which time the Carter Administration founded what became the US Department of Energy, which funded building research focused on energy. Out of this early focus on energy-related issues, the AIA formed the Committee on the Environment (COTE) in 1990. The AIA/COTE was responsible for the development of a number of foundational documents which address what is now known as sustainable design, including the Environmental Resource Guide (AIA Press, 1992), the Design Charrette Workbook (AIA Press, 1996), and the Top Ten Green Projects program introduced on Earth Day in 1997. The Top Ten Green Projects program first introduced a blend of qualitative and quantitative assessment metrics, with an online submission process. Many COTE chairpersons went on to serve as board members of the United States Green Building Council (USGBC), and many others were instrumental in the development of the Leadership in Energy and Environmental Design (LEED®) Program.

With the formation of the USGBC in 1994, the implementation of a defined and measurable standard for sustainable design in the United States was formally introduced to the design and construction industry. The USGBC introduced its first LEED® Pilot Project Program, also referred to as LEED Version 1.0, in August of 1998. This program has undergone extensive development since that time, progressed through a number of versions, and has been expanded to include a series of different rating systems that address a wide variety of building types. The LEED Reference Guide for Green Building Design and Construction is the most current document in use in the United States of America as of the publication of this Practice Guide.

According to the USGBC, buildings have the following calculated impacts on the environment (*USGBC, Reference Guide for Green Building Design and Construction, 2009 edition: page xi*):

- Buildings consume more than 30 percent of the total energy used in the United States.

- Buildings consume more than 60 percent of the total electricity used in the United States.
- In 2006, the commercial building sector produced more than 1 billion metric tons of carbon dioxide; an increase of more than 30 percent over 1990 levels.
- Toilet flushing alone uses more than 5 billion gallons of potable water each day.
- A typical North American commercial building generates about 1.6 pounds of solid waste per employee each working day; that amounts to approximately 300 tons of waste each year in a building housing 1,500 employees.

Many other statistical accounts can be cited, but it is clear that the design and construction industries produce major impacts on the environment (though these are not the only industries producing such impacts). To be fair, those impacts are both positive and negative. On the positive side, buildings create exciting and useful indoor environments that allow us to live better and more productive lives in a host of ways. On the negative side, our need for buildings requires consumption of nonrenewable resources and produces waste that is not entirely recyclable or reusable, and the ongoing operation and maintenance of buildings can produce pollutants and other byproducts that can harm the environment and building occupants.

As building owners, design professionals, product manufacturers, suppliers, and contractors in the design and construction industry (among many other participants too numerous to name), we have a collective responsibility to be aware of the impacts that our industry has on the environment, and to do what we can to maximize the positive benefits of our activities while minimizing or eliminating resulting negative impacts.

This ***Sustainable Design and Construction Practice Guide*** will provide a compilation of information and recommended practices for those who participate in some way in the design and construction of sustainable buildings and facilities, regardless of location worldwide. As one volume in a series of Practice Guides published by the Construction Specifications Institute (CSI), this Practice Guide will establish a comprehensive body of knowledge regarding sustainable design and construction principles, and will contain important and useful information on how to apply sustainable practices to the design and construction of buildings and facilities.

This Practice Guide does not endorse any specific existing sustainable design or green building rating system or program. This Practice Guide generally addresses nonresidential construction, though larger-scale multiunit residential facilities and similar project types are certainly addressed in the same context as nonresidential facilities.

This Practice Guide does not attempt to establish or defend scientific or philosophical arguments that have created a market for sustainable design. This Practice Guide addresses the issues of sustainable design and construction presuming the need for these practices as a professional standard. This Practice Guide offers guidelines and standards on how to apply sustainable design and construction principles in practical terms, and contains the following:

- Key definitions that are in common use in the sustainable design and construction industry.
- Building Codes, Reference Standards, and other regulatory issues related to the practice of sustainable design and construction.
- Basic information on existing sustainable design standards and rating systems, and a discussion of their applicability to sustainable design and construction practices.

- Description of the roles and responsibilities of each of the common participants in the design and construction process regarding sustainable design and construction.
- A compendium of suggested "best practices" that are not specifically related to a particular green building program or rating system.
- A brief guide to green building material product selection to provide a basic understanding of this process as a basis for the practical application of sustainable product selections.
- Discussion of sustainable design and construction practices in the context of each of the project delivery methods identified in the Project Delivery Practice Guide (Wiley & Sons, 2010).
- Practice standards for design professionals and product representatives regarding the proper documentation of sustainable design and construction information. These practice standards also extend to the end user of sustainable design and construction information, including the contractor, the owner, and the facility manager.

## 1.1 Definitions

The following terms are commonly used in discussions of sustainable design and construction. For the purposes of this Practice Guide, the following definitions are established:

### 1.1.1 Building Energy Conservation

Minimizing thermal energy transfer through the building envelope.

(Sources: www.c2es.org/technology/factsheet/BuildingEnvelope and www.energyland.emsd.gov.hk/en/building/energy_use/envelope.html—definition is a compilation made from both references)

### 1.1.2 Building Energy Efficiency

Reducing electrical power, gas, and other fossil fuel usage through high-performance equipment, appliances, and products, and by implementing design strategies to reduce and control electrical use.
(Author's definition)

### 1.1.3 Embodied Energy

1. Defined by the AIA as "a measure of the total energy consumed by a product during its life or complete life cycle. It includes all the energy used during mining or milling the raw materials, manufacturing the raw materials into a product, transporting the product, and installing the product, as well as finally removing or recycling the product."

   (Source: wiki.aia.org/Wiki%20Pages/Embodied%20Energy.aspx)

2. Energy used directly and indirectly in raw material acquisition, production of materials, and the assemblage of those materials into a building.

   (Source: Jean Carroon, *Sustainable Preservation: Greening Existing Buildings.* Hoboken, NJ: John Wiley & Sons, 2010)

### 1.1.4 Environmental Product Declaration

According to ISO 14025 Environmental Product Declaration (EPD) is quantified environmental data for a product with pre-set categories of parameters based on the ISO 14040 series of standards, but not excluding additional environmental information.

### 1.1.5 Green Building

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction.

(Source: www.epa.gov/greenbuilding/pubs/about.htm; definition by the US Environmental Protection Agency [EPA])

### 1.1.6 Greenwashing

The act of misleading consumers regarding the environmental practices of a company; or the environmental benefits of a product or service, or any form of marketing or public relations that links a corporate, political, religious, or nonprofit organization to a positive association with environmental issues for an unsustainable product, service, or practice.

(Sources: http://sinsofgreenwashing.org/findings/faqs/ and www.sustainabilitydictionary.com/greenwashing/—definition is a compilation made from both references)

### 1.1.7 Heat Island Effect

Occurs when hardscapes, such as dark, nonreflective pavement and buildings, absorb heat, and radiate it to surrounding areas.

(Source: LEED for New Construction 2009 Reference Guide Glossary)

### 1.1.8 High-Performance Building

High-performance buildings maximize operational energy savings; improve comfort, health, and safety of occupants and visitors; and limit detrimental effects on the environment.

(Source: www.nyc.gov/html/ddc/downloads/pdf/guidelines.pdf; definition from New York City Guidelines)

### 1.1.9 Historic Investment Tax Credit

The Historic Investment Tax Credit (HITC) is a program run on the federal and state levels to provide tax credits to building owners, homeowners, and developers as a financial

incentive to rehabilitate historic buildings and stimulate private investment. Credits received may be used to offset income tax liability or as equity in the rehabilitation project by investors. The federal program is administered by the National Park Service on behalf of the Secretary of the Interior and the Internal Revenue Service on behalf of the Secretary of the Treasury in partnership with state historic preservation offices.

(Source: Commonwealth Architects)

### 1.1.10 Life Cycle Assessment

Life Cycle Assessment (LCA) is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service by:

- Compiling an inventory of relevant energy and material inputs and environmental releases;
- Evaluating the potential environmental impacts associated with identified inputs and releases;
- Interpreting the results to help make a more informed decision.

(Source: www.epa.gov/nrmrl/lcacces)

### 1.1.11 Net Zero or Zero Energy Building

Net Zero or Zero Energy Building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies.

(Source: www.nrel.gov/sustainable_nrel/pdfs/39833.pdf)

### 1.1.12 Product Category Rule

Product Category Rules (PCRs) define the criteria for identification of a specific product category and establish the parameters for preparing an Environmental Product Declaration (EPD) compliant with ISO-14025.

### 1.1.13 Recycling

Collecting recyclable materials that would otherwise be considered waste; sorting and processing recyclables into raw materials such as fibers, manufacturing raw materials into new products, and purchasing recycled products.

(Source: www.epa.gov/osw/conserve/rrr/recycle.htm)

### 1.1.14 Renewable Resources

A resource that can be used continuously without being completely depleted (because it regenerates itself within a useful amount of time).

(Source: www.geysers.com/glossary.htm)

### 1.1.15 Renewable Energy

An energy source replenished by natural processes at a rate comparable or faster than its rate of consumption. Examples include solar radiation, tides, winds, and hydroelectricity.

(Source: http://agsci.oregonstate.edu/orb/biotechnology-terms)

### 1.1.16 Reuse

The recovery of materials and products for the same or a similar end use.

(Source: www.consumersunion.org/other/zero-waste/reuse.html)

### 1.1.17 Sustainability

Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

(Source: www.un-documents.net/ocf-02.htm; definition created in 1987 at the World Commission on Environment and Development [the Bruntdland Commission])

### 1.1.18 Sustainable Design

1. The careful meshing of human purposes with the larger patterns and flow of the natural world.

   (Source: www.aia.org/practicing/groups/kc; paraphrase of educator and author David Orr)

2. A process that supports and improves the health of the systems that sustain life.

   (Source: www.aia.org/practicing/groups/kc; paraphrase of architect Bill Reed)

### 1.1.19 Sustainable Construction

Sustainable construction aims at reducing the environmental impact of a building over its entire lifetime, while optimizing its economic viability and the comfort and safety of its occupants.

(Source: www.isover.com/Our-commitment-to-sustainability/Toward-sustainable-buildings/What-is-sustainable-construction)

### 1.1.20 Sustainable Management

The ability to direct the course of a company, community, organization, or country in ways that restore and enhance all forms of capital (human, natural, manufactured, and financial) to generate stakeholder value and contribute to the well-being of current and future generations.

(Source: www.sustainabilitydictionary.com)

# 1.2 Building Codes

Building codes exist to provide enforceable, adoptable, regulatory language to promote public safety in the design and construction of buildings. As the building design and construction industry has evolved to include more emphasis on sustainable design and construction practices, model building codes have begun to evolve to incorporate sustainable design and construction requirements as well.

Building codes themselves are not enforceable unless adopted by a governing authority (city, county, state). Model Building Codes are written in "code language," and governing authorities enact them into law, often with amendments written to address specific, local requirements or applications.

## 1.2.1 International Codes and the International Code Council

### 1.2.1.1 International Building Code

The International Building Code (IBC) is the parent model code to the family of International Codes (I-Codes) published by the International Code Council (ICC). The I-Codes are continually developed, maintained, and updated, through Code Development Cycles, which include a public forum process allowing professionals from around the world to contribute to the evolution of the codes. Updated versions of the I-Codes are typically published on three-year cycles.

The intent of this code is defined in Section 101.3 of the International Building Code:

> "The purpose of this code is to establish the minimum requirements to safeguard the public health, safety, and general welfare through structural strength, means of egress, facilities, stability, sanitation, adequate light and ventilation, energy conservations, and safety to life and property from fire and other hazards attributed to the built environment and to provide safety to fire fighters and emergency responders during emergency operations."
>
> (Source: IBC 2009, Section 101.3)

While this intent statement is focused on safeguarding public health, key sustainable indicators such as energy conservation, adequate light, and adequate ventilation are noted.

**The IBC is generally organized as follows:**

- Administrative sections, which allow governing authorities to establish processes if they are not already in place.
- Sections to define the building Use, Occupancy Type, and Types of Construction with the associated requirements and limitations.
- Sections to define Fire-Resistance-Ratings, Fire Protections, and Means of Egress requirements imposed on the design and construction of buildings.
- Accessibility for disabled persons.

- Interior environment and energy efficiency. To a large extent, sections related to these requirements reference other codes within the family of I-Codes.
- Wall and Roof Assembly requirements.
- Sections on Structural Design including required loads, testing and inspection requirements, foundations, and specific requirements based on chosen structural materials.
- Additional sections regarding requirements for materials used in constructing the built environment.
- Sections on Systems such as electrical and plumbing.
- Elevators and Conveying Systems.
- Special Construction, Construction Safety, and requirements for existing structures.
- Specific Appendices, which governing authorities may wish to adopt on a per-section basis.

#### 1.2.1.2 International Energy Conservation Code

The International Energy Conservation Code (IECC) represents the most direct link to sustainable design requirements within the family of I-Codes. The ICC organized the IECC to closely align with ASHRAE Standard 90.1 while providing enforceable model code language necessary for jurisdictional adoption. In fact, the IECC specifically references ASHRAE 90.1 as an alternative compliance path for commercial buildings.

The intent of this code is defined in Section 101 of the IECC:

> "This code shall regulate the design and construction of buildings for the effective use of energy. This code is intended to provide flexibility to permit the use of innovative approaches and techniques to achieve the effective use of energy. This code is not intended to abridge safety, health, or environmental requirements contained in other applicable codes or ordinances."
>
> (Source: IECC 2009, Section 101.3)

**The IECC is generally organized as follows:**

- Includes administrative sections, which allow governing authorities to establish processes if they are not already in place.
- Definitions.
- Section to define Climate Zone classifications, which are used as the first step in establishing building design and construction requirements related to energy use and specific to the local environment.
- Sections that establish minimum requirements for insulation and fenestration materials.
- Sections that include the requirements for Residential and Commercial building energy efficiency, respectively. These chapters and sections are organized to address the specifics of each major building component that affects energy consumption.
  - Building envelope insulation requirements.
  - Fenestration performance requirements and limits on fenestration areas.
  - Required Heating, Ventilating and Air Conditioning (HVAC) equipment types, minimum efficiencies, and equipment controls.

- Required efficiencies of Service Water Heating equipment.
- Requirements for electrical lighting controls and limits on the density of installed electrical lighting.

#### 1.2.1.3 International Mechanical Code

The International Mechanical Code (IMC) provides for the enforceable oversight of mechanical systems within buildings. Generally, in the context of this code "mechanical" systems are those used for Heating, Ventilating, and Air Conditioning (HVAC).

The intent of this code is defined as follows:

> "The purpose of this code is to provide minimum standards to safeguard life or limb, health, property, and public welfare by regulating and controlling the design, construction, installation, quality of materials, location, operations and maintenance or use of mechanical systems."
>
> (Source: IMC 2009, Section 101.3)

**The IMC is generally organized as follows:**

- Sections on administration, definitions, and general requirements.
- Requirements for Ventilation of interior spaces including minimum ventilation rates, minimum amounts of outdoor air, restrictions on where outdoor air intake systems can be located, and system controls. The requirements of the IMC may or may not align with ASHRAE 62 (detailed in later sections) depending on which version of the code is enforced at any given time.
- Requirements for the installation of exhaust systems including dedicated requirements for a wide range of specific types of exhaust systems. These sections also regulate how exhaust air is removed from a building and where terminations may be located.
- Requirements for the design and installation of air duct systems.
- Regulations regarding the installation of combustion air systems for fuel-burning appliances other than gas-fired appliances. Gas-fired appliances are specifically addressed in the International Fuel Gas Code (IFGC).
- Requirements for installation of chimneys and vents, restrictions and requirements for specific appliances, fireplaces, and solid fuel-burning equipment, and installation and repair of boilers, water heaters, and other pressure vessels.
- Installation and repair of refrigeration systems including specific requirements for each type of refrigerant used in building construction.
- Material and installation requirements for piping systems.

## 1.2.2 Emerging Trends in Building Codes

### 1.2.2.1 International Green Construction Code

Recent national development in the code community has resulted in the introduction of the International Green Construction Code™ (IgCC), which was unveiled in 2010. When adopted by states or individual cities and communities, this code will lead to an increase in high-performance or green buildings. It is notable that the IgCC offers a jurisdictional compliance option to use the ANSI/ASHRAE/USGBC/IES Standard 189.1–2009, Standard for the Design of High-Performance Green Buildings. IgCC and

this standard both cover sustainable criteria that include materials and resource use, energy efficiency, indoor environmental quality, water use efficiency, and the building's impact on its community and site.

As of the date of publication of this Practice Guide, the IgCC has been adopted by the states of Rhode Island, Maryland, Florida, North Carolina, Oregon, and the city jurisdictions of Richland, WA; Kayenta Township, AZ; Boynton Beach, FL; Keene, NH; Fort Collins, CO; and Phoenix and Scottsdale, AZ.

#### 1.2.2.2 Municipal Requirements

Many states and local jurisdictions adopt their own version of sustainable design and construction requirements, especially as they relate to energy use. A well-known example is the energy use regulations in Part 6 of Title 24 in the California Code of Regulations. Other states have seriously discussed adopting model requirements from California's Title 24 regulations. Product manufacturers have also seriously considered issues related to compliance with this regulation in the event that it becomes more prevalent nationwide.

The design professional and the entire design team are tasked with thoroughly researching local jurisdiction requirements for all locally adopted requirements related to sustainable design and construction.

#### 1.2.2.3 ASHRAE Standard 189.1, Standard for the Design of High-Performance Green Buildings

ASHRAE Standard 189.1 is written to be adopted as an enforceable code for the siting, design, construction, and operation of high-performance buildings. In addition to providing necessary code language, ASHRAE Standard 189.1 is intended to help simplify compliance processes which are often deemed overly complex or requiring detailed calculations unregulated by the design and construction industry. ASHRAE Standard 189.1 targets commercial buildings four stories and higher. Specifically excluded from ASHRAE Standard 189.1 are single-family homes, multifamily structures of three stories or fewer above grade, and manufactured homes (mobile and modular homes).

ASHRAE Standard 189.1 addresses multiple aspects of building design. This standard covers requirements for site sustainability, efficient water use, energy efficiency, indoor environmental quality (IEQ), and the impact on the atmosphere, materials, and resources. Similar to the organization of ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings, ASHRAE Standard 189.1 includes both mandatory provisions that are required for compliance and prescriptive and performance criteria that aid in compliance but are not required. ASHRAE Standard 189.1 is intended to be used in conjunction with ASHRAE Standards 90.1 and 62.1 and adopts these standards via reference.

The US Army has adopted ASHRAE Standard 189.1 as part of its sustainable design and development initiative. It is anticipated other agencies, organizations, and jurisdictions will follow suit in the coming years.

The following subject areas, as well as plans for construction and high-performance operation, are addressed in separate chapters within ASHRAE Standard 189.1:

- Scope Descriptions
- Compliance Paths
- Mandatory Provisions: Criteria and components that must be included

- Prescriptive Option: Criteria that involves little or no calculations
- Performance Option: Compliance based on equivalence to the Prescriptive Option or improved above prescriptive minimums

## 1.3 Reference Standards

There are many design standards associated with sustainable building practices, which are written to be adopted or referenced in building codes and construction specifications. It is important to understand the basic concepts of these referenced standards and how they apply to whole building systems, individual trades, and impacts on energy consumption and persons who occupy facilities. The reference standards discussed in this section were developed by the American National Standards Institute (ANSI), the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), and ASTM International (ASTM). As the result of society's evolving emphasis on sustainable design and construction, many of these standards, or portions thereof, have been incorporated into model building codes, green building rating systems, and jurisdictional policies.

### 1.3.1 ASHRAE Standard 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

ASHRAE Standard 52.2 is a testing standard written to standardize the testing of filtration media. Design professionals can use this standard for specifying filtration media and devices. Owners and end users can use this standard to compare air filtration products. While not specifically a "sustainable design" standard, ASHRAE 52.2 is referenced by other guidelines and rating systems where indoor air quality and protection of equipment is of concern.

### 1.3.2 ASHRAE Standard 55, Thermal Environmental Conditions for Human Occupancy

ASHRAE Standard 55 defines conditions for an acceptable thermal environment. While not specifically a "sustainable design" standard, ASHRAE Standard 55 establishes the minimum thermal comfort performance criteria used in the design, commissioning, and testing of buildings. Therefore, this standard is often referenced by other guidelines and rating systems as a benchmark for comparison.

Occupant health is very important (as defined by ASHRAE Standard 62.1), but comfort of building occupants is equally important. ASHRAE Standard 55 defines acceptable temperature and humidity ranges, limits to thermal radiation differentials, and maximum delivered air speeds. The Standard attempts to quantify variables that satisfy a specified fraction of the occupants. The calculations are complex and include estimations for occupancy activities, clothing, and other variables that affect comfort.

### 1.3.3 ASHRAE Standard 62.1, Ventilation for Acceptable Indoor Air Quality

ASHRAE Standard 62.1 is a reference standard for indoor air quality in commercial buildings. The Standard covers minimum filtration and air cleaning requirements, methods for controlling exfiltration and infiltration, and methods for controlling air quality within buildings and associated equipment. For instance, the Standard details requirements for drain pans and cleaning access at air handlers to help ensure proper drainage of condensate and to allow for cleaning of coils. Additionally, the Standard addresses ventilation controls, ventilation rate requirements including calculation procedures, and requirements for separating intake and exhaust terminations.

This Standard defines minimum ventilation requirements on per-person and per-unit-area basis. The Standard dictates a detailed calculation procedure that results in the minimum, controlled volumetric flow (cubic feet per minute or liters per square meter) of outdoor air that must be delivered to each space within the building. The reader is encouraged to refer to the Standard for specifics as the details of the calculation procedures and installation requirements are quite thorough and beyond the scope of this book.

### 1.3.4 ASHRAE Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings

ASHRAE Standard 90.1 is currently the most widely referenced building energy standard in the United States. This standard has evolved significantly over the past 35 years and serves as the basis for many other codes and energy standards.

**Compliance with ASHRAE Standard 90.1 is:**

- Specifically required by the USGBC LEED® Green Building Rating System.
- Accepted as an alternate compliance path within the International Energy Conservation Code (IECC).
- The basis for many jurisdictional authorities that generate their own energy code requirements, as well as the IgCC.

The purpose of ASHRAE Standard 90.1 is to establish the minimum energy efficiency requirements of buildings, other than low-rise residential buildings, for:

- Design, construction, and operation and maintenance.
- Utilization of on-site, renewable energy resources.

**ASHRAE Standard 90.1 provides minimum requirements for:**

- Energy-efficient design and construction of the building envelope.
- Efficiency of building service water heating systems.
- Limiting building electrical power and lighting densities.

- Efficiency of the Building HVAC systems.
- Existing buildings receiving new construction (additions and renovations) and new systems installed in existing buildings.

ASHRAE Standard 90.1 includes mandatory requirements which must be met in each category for compliance. Additionally, this Standard includes prescriptive and performance criteria that can be used to increase performance and to "trade off" weaker-performing building elements with stronger-performing building elements. Unlike the mandatory provisions, meeting these prescriptive and performance criteria is not required for compliance.

Many building projects are required to perform an energy model to demonstrate that ASHRAE Standard 90.1 has been met or exceeded.

Based on local climate, ASHRAE Standard 90.1 establishes minimum requirements for building envelope insulation values, including both wall and roof systems. Insulation components are typically defined by a minimum associated R-value and assemblies are typically defined by a maximum associated U-value. The Standard also defines maximum solar heat gain coefficients (SHGC) and U-values for fenestration (glazing). Additionally, it includes maximum allowable fenestration area, expressed as "window to wall ratio" (WWR).

ASHRAE Standard 90.1 establishes substantial minimum efficiency requirements for the heating, ventilating, and air conditioning (HVAC) system. It requires the design engineer to compare the project-specific planned systems with prescribed "baseline" HVAC systems. This Standard assigns each building baseline HVAC systems based on building size and use. When the designer is proposing a system for a new building, the goal is for the chosen system to perform more efficiently then the designated "baseline" system.

The Standard includes requirements for efficient service water heating, which includes water heating for uses other than space heating. Mandatory provisions include minimum equipment efficiencies, installation requirements that promote efficient operation, minimum controls requirements, and specific requirements for heated pools.

In the chapter dedicated to electrical power, the Standard dictates efficient design and installation including minimum transformer efficiencies, limitations on voltage drop through the electrical distribution system, and control of certain branch receptacles.

Based on building, space, and functional type, ASHRAE Standard 90.1 identifies maximum installed electric lighting densities, expressed in watts per square foot (w/sf). Additionally, the Standard includes detailed requirements for lighting control systems throughout various building and space types.

Many state and local energy codes will continue to reference the most current edition of ASHRAE Standard 90.1 as the baseline for compliance.

ASHRAE Standard 90.1 is on a continuous update and maintenance cycle. Addenda are regularly developed and published by the ASHRAE Standards Committee. For instance, ASHRAE Standard 90.1–2010 is simply ASHRAE Standard 90.1–2007 plus all addenda that have been approved by both the IES and ASHRAE Boards of Directors.

Figure 1.1 indicates the history of the development of ASHRAE Standard 90.1 in terms of requirements for energy savings over previous editions.

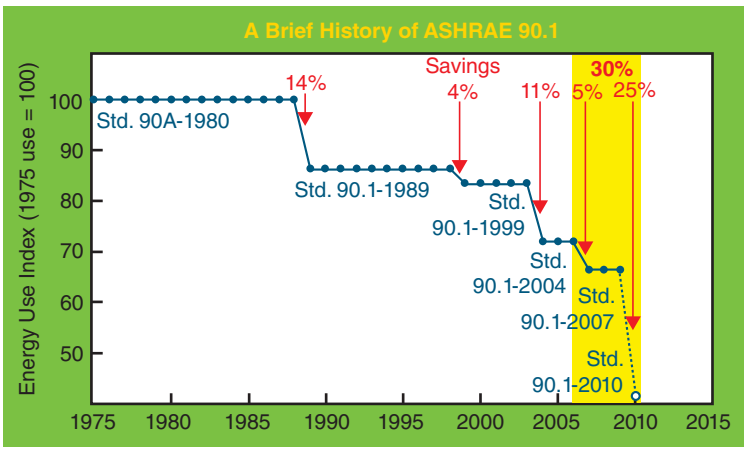


**Figure 1.1** Brief history of ASHRAE 90.1

Source: http://usgbcblog.blogspot.com/2011/02/from-cutting-edge-to-common-practice.html

## 1.3.5 ASTM E60 Committee on Sustainability

ASTM International Committee E60 on Sustainability was formed in 2008. The Committee publishes its scope of activity as follows:

> "The acquisition, promotion, and dissemination of knowledge, stimulation of research and the development of standards related to sustainability and sustainable development. The committee shall include environmental, social, economic, and other issues relating to sustainability. The committee shall support and serve as a resource for other ASTM committees in their activities that include sustainability issues. This support may include dissemination of specific requests for standards throughout ASTM's existing committee base, as well as the maintenance of appropriate liaison relationships (internal and external) related to this subject area.
>
> The committee will not duplicate the efforts of existing ASTM technical committees. The work of this committee will be coordinated with other ASTM committees and other organizations having mutual interest."
>
> (Source: ASTM International, www.astm.org/COMMIT/SCOPES/E60.htm)

The results of the ASTM Committee E60 work are found throughout ASTM Standards that impact sustainability. ASTM E2129 Standard Practice for Data Collection for Sustainability Assessment of Building Products is an example of such influence. ASTM E2129 covers instructions for how to collect data for assessing the sustainability of building products. It is important to note that this standard only addresses data collection methods and procedures, but does not address interpretation of the data.

Other significant and relevant ASTM standards managed or created by the ASTM E60 Committee on Sustainability include the following:

- E1971, Standard Guide for Stewardship for the Cleaning of Commercial and Institutional Buildings
- E1991, Standard Guide for Environmental Life Cycle Assessment (LCA) of Building Materials/Products

  See also WK35154 proposed withdrawal
- E2114, Standard Terminology for Sustainability Relative to the Performance of Buildings

  See also WK30009 proposed revision

- E2129, Standard Practice for Data Collection for Sustainability Assessment of Building Products
  See also WK28303 proposed revision
- E2392/E2392M, Standard Guide for Design of Earthen Wall Building Systems
- E2396, Standard Test Method for Saturated Water Permeability of Granular Drainage Media [Falling-Head Method] for Vegetative (Green) Roof Systems
  See also WK28327 proposed revision
- E2397, Standard Practice for Determination of Dead Loads and Live Loads Associated with Vegetative (Green) Roof Systems
  See also WK28329 proposed revision
  See also WK29759 proposed revision
- E2398, Standard Test Method for Water Capture and Media Retention of Geocomposite Drain Layers for Vegetative (Green) Roof Systems
  See also WK28328 proposed revision
- E2399, Standard Test Method for Maximum Media Density for Dead Load Analysis of Vegetative (Green) Roof Systems
- E2400, Standard Guide for Selection, Installation, and Maintenance of Plants for Green Roof Systems
- E2432, Standard Guide for General Principles of Sustainability Relative to Buildings
  See also WK26068 proposed revision
- E2635, Standard Practice for Water Conservation in Buildings Through In-Situ Water Reclamation
- E2717, Standard Practice for Estimating the Environmental Load of Residential Wastewater
- E2727, Standard Practice for Assessment of Rainwater Quality
- E2728, Standard Guide for Water Stewardship in the Design, Construction, and Operation of Buildings

A database referencing over 500 ASTM standards and 300 other standards and programs from organizations involved in sustainability is available at www.astm.org/COMMIT/sustain.html. This database is being enhanced to allow online and public submission of related standards for inclusion. This database is being maintained by the ASTM E60 Committee on Sustainability. Members and visitors to the website can use the information below to help stimulate discussions regarding the need for future sustainability standards.

## 1.4 Green Building Rating Systems

Environmental certification systems first appeared in 1990 when the *Building Research Environmental Assessment Method* (BREEAM) was issued in the United Kingdom. The year 1996 saw the creation of *Haute Qualité Environnementale* (HQE) in France. The introduction by the *US Green Building Council* (USGBC) in 1998 of the *Leadership in Energy & Environmental Design* (LEED) program was the first US-based green building rating system. Japan followed in 2001 with its *Comprehensive Assessment System for Built Environment Efficiency* (CASBEE). Most other international green building rating systems that have

been developed are based on the four pioneering systems BREEAM, HQE, LEED, and CASBEE. Each rating system is unique to a culture and climate, although a few attempt to be applicable to every location and circumstance.

This section focuses on current commercial green building rating systems and programs around the world that call for third-party verification of environmental claims, with a concentration on whole building and community-based high-performance environmental assessment tools. Building material or product assessment tools and labels are not fully addressed. Since there are over 300 different tools and labels to choose from internationally, covering them in detail is beyond the scope of this Practice Guide. However, a list of commonly used product or system green label certification tools applicable to North America include:

- Cool Roof Rating Council (www.coolroofs.org)
- CRI (Carpet & Rug Institute), Green Label/Green Label Plus (www.carpet-rug.org)
- EcoLogo™ (www.ecologo.org/en)
- Energy Star (www.energystar.gov)
- EPA Water Sense® (www.epa.gov/WaterSense)
- FSC (Forest Stewardship Council) (www.fsc.org)
- GREENGUARD (www.greenguard.org/en/index.aspx)
- Green Seal (www.greenseal.org)
- MBDC "Cradle to Cradle" Certification (www.mbdc.com)
- MPI Green (Master Painters Institute) (www.specifygreen.com)
- NSF (National Sanitation Foundation) (www.nsf.com)
- PEFC (Programme for the Endorsement of Forest Certification) (www.pefc.org)
  - ATFS (American Tree Farm System®) (www.treefarmsystem.org/certification)
  - CSA (Canadian Standards Association) (www.csa.ca/cm/ca/en/standards)
  - SFI (Sustainable Forestry Institute) (www.sfiprogram.org)
- SCS (Scientific Certification System) (www.scscertified.com)
  - calCOMPliant™
  - EPP (Certified Environmentally Preferable Product)
  - FloorScore®
  - Indoor Advantage™
  - level™
  - Sustainable Choice™
- SMaRT© (http://mts.sustainableproducts.com/SMaRT_product_standard.html)

This section is further broken down into two subsections, Domestic (USA and Canada) Systems and International Systems. Systems are listed in order of date implemented beginning with the earliest. Discussion of these systems is limited to nonresidential buildings and facilities, and only represents a partial listing.

## 1.4.1 Domestic (USA and Canada) Systems

### 1.4.1.1 Leadership in Energy and Environmental Design (LEED®)

**United States / Canada (Other versions also used in Mexico, Brazil, and India)**

Chartered in 1994, the *United States Green Building Council* (USGBC) first introduced *Leadership in Energy and Environmental Design* (LEED®) Version 1.0 in August

of 1998. Versions of LEED have been established in other countries including LEED Canada, LEED Mexico, LEED Brazil, and LEED India. Primarily implemented in North America, Brazil, and India, the LEED Green Building Rating System (*USGBC; Reference Guide for Green Building Design and Construction, 2009 edition; page xi)* is also independently being applied to individual projects in many other countries around the world.

LEED® is a green building and community rating system that provides third-party verification of high-performance green building and community design, and of specific performance attributes based on the metrics of energy savings, water efficiency, $CO_2$ emissions reduction, improved indoor environmental quality, and stewardship of resources and their impacts.

LEED® provides building owners, facility managers, design professionals, and contractors a basis for designing and implementing green building design, construction, and operations and maintenance solutions. It can be applied to all commercial and residential building types, and to communities. LEED® is relevant throughout the building life cycle including new construction, major renovation, tenant improvements, operations and maintenance, and neighborhood development.

LEED® recognizes high-performance green building in the following key areas of human and environmental health:

- Project location and access to transportation
- Sustainable site development
- Water use and efficiency
- Energy use and efficiency
- Materials and resource selection
- Indoor environmental quality

As of the publication of this Practice Guide, LEED® has implemented the following rating systems:

- LEED-NC or LEED for New Construction and Major Renovations, which is for commercial and institutional projects.
- LEED-EB:OM or LEED for Existing Buildings: Operations & Maintenance, which measures operations, improvements, and maintenance of existing facilities.
- LEED-CI or LEED for Commercial Interiors, which is for tenant fit-out improvements.
- LEED-CS or LEED for Core & Shell, which is for new core and shell construction.
- LEED for Schools, which is specifically for K–12 schools.
- LEED for Retail, which is aimed at retail design and construction projects.
- LEED for Healthcare, which focuses on high-performance healthcare facilities.
- LEED for Homes, which is centered on high-performance single and multi-family housing projects.
- LEED for Neighborhood Development, which incorporates smart growth principles, urbanism and green building into a program for neighborhood design.

There are four possible levels of certification using the following credit scale*:

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

*LEED for Homes uses a different credit scale as follows:

- Certified: 45–59 points
- Silver: 60–74 points
- Gold: 75–89 points
- Platinum: 90 points and above

Location: The US Green Building Council is located at 2101 L Street NW, Suite 500 in Washington, DC.

Website: www.usgbc.org

### 1.4.1.2 Green Leaf™

**Canada / United States**

Audubon International and the program founder, Greenleaf Environmental Communications, Inc., jointly launched the Audubon Green Leaf™ Eco-Rating Program in 1998 in Canada to meet the lodging industry's need of providing quality guest services while minimizing environmental impact. Audubon International in New York State implemented a pilot Green Leaf™ Program in 2009.

The Audubon Green Leaf™ Eco-Rating Program is based on the premise that what is good for the environment is also good for business. Audubon defines this concept as "eco-efficiency."

Earning a rating of from 1-to-5 Green Leafs confirms and quantifies the business's commitment to water quality, water conservation, waste minimization, resource conservation, and energy efficiency.

Audubon Green Leaf™ is tailored to all types of hospitality centers including hotels, motels, resorts, conference centers, inns, B&Bs, and tourist destinations. Green Leaf™ combines environmental awareness and education with best hospitality management practices. Information and tools are provided to help reduce operating costs in key areas, including saving energy, conserving water, reducing waste, and proper use and handling of hazardous substances.

Green Leaf's™ four core environmental criteria evaluated are:

- Energy Efficiency
- Environmental Management
- Pollution Prevention
- Resource Conservation

Location: Audubon International is located at 46 Rarick Road in Selkirk, New York.

GreenLeaf Environmental Communications, Inc. is headquartered at 171 Nepean Street, Suite 400, Ottawa, Ontario, Canada.

Website: http://greenleaf.audubooninternational.org/

### 1.4.1.3 Collaborative for High-Performance Schools

**United States**

The *Collaborative for High Performance Schools* (CHPS) was founded in 1999 by major utilities in the State of California, and is made up of various government agencies, utilities, and nonprofits, to specifically promote energy efficiency in K–12 schools.

Publication of the CHPS Criteria in 2002 expanded the program to cover many other environmental factors in addition to energy efficiency for school design, construction, and operation.

K–12 schools can use the CHPS program information and tools to create high-performance buildings that provide the basis for a quality education, as determined by research that encompasses spaces that are healthy, well-lit, thermally comfortable, acoustically sound, safe, and constructed to be energy, water, and material resource efficient.

CHPS tools include a six-volume best practices technical manual, training, and conferences, a high-performance building rating and recognition program, and other tools for creating healthy, high-performance schools. The six-volume technical manual covers planning, design, high-performance benchmarks, maintenance and operations, commissioning, and relocatable classrooms. One of the other tools is the CHPS High-Performance Products Database, which is searchable for a variety of sustainable, healthy building products and manufacturers.

The CHPS Program recognizes school projects that achieve the prescribed criteria with a plaque, a listing on the CHPS website, official CHPS participation in school opening ceremonies, and the potential use of the project as a case study.

Location: CHPS offices are located on the second floor of 142 Minna Street in San Francisco, California.

Website: www.chps.net

#### 1.4.1.4 Green Building Challenge, GBTool

**Canada / Italy / Spain / Portugal / the Czech Republic / Israel / South Korea / Republic of China (Taiwan)**

GBTool is the software implementation of the *Green Building Challenge* (GBC) assessment method. GBC began development under Natural Resources Canada in 1996 but in 2002 was handed over to the *International Initiative for a Sustainable Built Environment* (iiSBE). GBTool flexibility allows it to be modified to fit local conditions of each country, and further to be verified against historical case study buildings.

GBTool is the result of an international collaborative effort to develop a flexible environmental assessment tool that fully addresses aspects of building performance while allowing modification by participating countries to adjust the tool for site variations.

GBTool has three primary goals:

- Advance the state-of-the-art in building environmental performance assessment methodologies.
- Monitor sustainability issues to determine their "green" building relevance in general, and the content and structuring of building environmental assessment methods in particular.
- Sponsor conferences promoting an exchange between the building environmental research community and building practitioners while showcasing the performance assessments of environmentally progressive buildings.

GBTool has two primary objectives:

- Develop an internationally accepted generic framework that can be used to compare existing building environmental assessment methods used by others to produce regionally based industry systems.

- Expand the scope of the GBC Assessment Framework from green building to include environmental sustainability issues, while facilitating international comparisons of the environmental performance of buildings.

Other objectives include:

- Test new methods of assessing building performance.
- Showcase "best-practice" examples of green buildings around the world.
- Document the successful elements of individual green buildings.
- Offer direction to participating countries in the development of regionally sensitive assessment models.
- Promote an international exchange of information, ideas, and green building technologies.

GBTool is applicable to attached housing, residential apartments, hospitality (hotel), libraries, offices, K–12 schools, restaurants and cafeterias, retail, supermarket, shopping centers, theater-cinema, indoor parking, and public areas of other main occupancies.

Location: iiSBE is headquartered at 40 The Driveway, Suite 100, Ottawa, Ontario, Canada, but has working chapters located in Italy, Spain, Portugal, the Czech Republic, Israel, South Korea, and Taiwan.

Websites: www.iisbe.org/sbmethod; www.iisbe.org/iisbe/gbc2k2/gbc2k2-start.htm

### 1.4.1.5 Labs21®

**United States**

Cosponsored by the US Environmental Protection Agency (EPA) and US Department of Energy (DOE), Laboratories for the 21st Century (Labs21®) was implemented in 2002 when 15 private and US public–sector laboratories joined the program as Pilot Partners. A broad cross-section of the laboratory community, Labs21® organizations include a voluntary partnership of universities, pharmaceutical companies, microelectronic firms, high schools, and federal agencies that are dedicated to improving US laboratory environmental performance. Some of the programs and responsibilities for Labs21® have been transferred to the International Institute for Sustainable Laboratories ($I^2SL$).

The main principle of Labs21® is to improve energy efficiency and environmental performance from a "whole building" approach. Applying these principles can achieve reduced emissions, streamlined energy and water use, and a decrease in overall operating costs. Labs21® is dedicated to the pursuit of sustainable, high-performance, and low-energy laboratories that are designed to:

- Minimize overall environmental impacts.
- Protect occupant safety.
- Optimize whole building efficiency on a life cycle basis.
- Establish goals, track performance, and share results for continuous improvement.

Laboratories adopting the Labs21® approach are encouraged to:

- Make capital investment decisions based on life cycle cost savings.
- Pursue advanced, energy-efficient HVAC technologies.

- Design systems that recover and exchange waste heat and other forms of free energy.
- Incorporate renewable energy systems.

Labs21® Partners are committed to:

- Adopt energy and environmental performance goals.
- Assess opportunities from a "whole building" approach.
- Use life cycle cost decision making.
- Commission equipment and controls in new construction and retrofit projects.
- Employ a broad range of sustainable energy and water efficiency strategies.
- Measure energy and water consumption and track emission reductions.
- Evaluate on-site power generation, combined heat and power technologies, and renewable power purchases.
- Specify "green" construction materials.
- Promote energy and water efficiency operation and training efforts.
- Explore sustainable design opportunities beyond the building site.

Websites: www.epa.gov/lab21gov/index.htm; www.i2sl.org/about/index.html

### 1.4.1.6 Green Globes

**United States and Canada**

Green Globes for Existing Buildings, known as BOMA BESt in Canada, was adopted in 2004 by the Building Owners and Managers Association of Canada (BOMA). Green Globes was based on earlier efforts by the Canadian Standards Association (CSA) "BREEAM Canada for Existing Buildings," issued in 1996 and modeled on the UK's Building Research Establishment's Environmental Assessment Method (BREEAM). In 2005 the Green Building Initiative (GBI) purchased the rights to distribute Green Globes in the United States, and was also accredited by the American National Standards Institute (ANSI).

Green Globes functions as a web-based interactive system that encourages ongoing inputs to maintain a current green building assessment. Instant feedback from these environmental factor inputs helps inform the building owner where future improvements and owner resources may be optimally directed. One Green Globes tool is the EPA Target Finder (www.energystar.gov/index.cfm?c=new_bldg_design.bus_target_finder) database of existing building performance, which is used to evaluate the project's energy design.

Participants can receive ratings of one, two, three, or four globes based on data submitted online by a creditable, independent third party, usually a trained and licensed engineer or architect with significant experience in building sciences and sustainability.

Green Globes is applicable to new and existing commercial and residential buildings. Large developers, property management companies, and government agencies in particular utilize Green Globes. The Canadian federal government has adopted and uses BOMA BESt for its entire real estate portfolio.

Location: The Green Building Initiative offices are located at 2104 SE Morrison in Portland, Oregon, and in Toronto, Ontario, Canada.

Websites: www.greenglobes.com and www.TheGBI.org

### 1.4.1.7 Living Building Challenge

**United States / Canada / Mexico / Ireland**

The Living Building Challenge program was initiated in 2006 by the International Living Building Institute (ILBI), now known as the International Living Future Institute (ILFI), and the Cascadia Green Building Council, one of the first three chapters of USGBC. ILBI is a nongovernment organization committed to the creation of sustainable built environments in all countries around the world. The current Version 2.0 of the Living Building Challenge was released in November 2009 with errata published April 2010. The Living Building Challenge is a complementary added layer of stringent sustainable requirements that may be applied in concert with the USGBC-LEED, GBI Green Globes, or other green building rating programs.

The Living Building Challenge is a philosophy, an advocacy tool, and a certification program that addresses sustainable development at multiple levels. It contains seven performance areas called "Petals" that are further subdivided into a total of 20 focused "Imperatives."

**SITE Petal:**

- Limits to Growth
- Urban Agriculture
- Habitat Exchange
- Car-Free Living

**WATER Petal:**

- Net Zero Water
- Ecological Water Flow

**ENERGY Petal:**

- Net Zero Energy

**HEALTH Petal:**

- Civilized Environment
- Healthy Air
- Biophilia

**MATERIALS Petal:**

- Red List
- Embodied Carbon Footprint
- Responsible Industry
- Appropriate Sourcing
- Conservation + Reuse

**EQUITY Petal:**

- Human Scale + Humane Places
- Democracy + Social Justice
- Rights to Nature

**BEAUTY Petal:**

- Beauty + Spirit
- Inspiration + Education

Projects can be certified as "Living" if they prove to meet all of the program requirements after 12 months of continued operations and full occupancy. "Petal Recognition," a partial program certification, is available after achieving all of the requirements of a minimum three Petals that include at least one of the Water, Energy, or Materials Petal areas.

The Living Building Challenge certification program encompasses buildings at multiple scales and includes single buildings, parks, college campuses, and complete neighborhood communities. The Living Building Challenge provides a framework for design, construction, and the symbiotic relationship between people and multiple aspects of the built environment.

There are a maximum of 20 "Petal" Imperatives to be met for a project, at any scale, anywhere in the world. It is not a checklist of best practices but established key performance–based goal-markers.

**Two rules govern the rating system:**

- All Imperatives assigned to a Typology are mandatory.
- Certification is based on actual, rather than modeled or anticipated, performance.

**There are four Typologies:**

- Renovation
- Landscape or Infrastructure (nonconditioned development)
- Building
- Neighborhood

It is a requirement that project teams identify the Typology and Imperatives that best apply to the project.

Location: The Living Building Challenge has offices in Portland, Oregon; Seattle, Washington; and Vancouver, British Columbia.

Websites: https://ilbi.org/ and www.living-future.org/

### 1.4.1.8 Building Energy Quotient

Figure 1.2 Building Energy Quotient logo

The Building Energy Quotient (bEQ) Labeling Program "In Operation" Rating Version 1.0 was first released in the United States and Canada in March 2012 by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). The "As Designed" Rating Version 1.0 and "In Operation" Rating Version 4.0 are both available in the United States and Canada as of the date of publication.

bEQ is a building energy labeling program developed for the general public, building owners and tenants, potential owners and tenants, and building operations and maintenance staff.

The bEQ label provides:

- An "As Designed" label and an "In Operation" label for side-by-side comparisons.
- A Level I Energy Audit as part of the In Operation rating process.
- Energy rate reduction recommendations.

- Indoor Environmental Quality (IEQ) screening with specific measurements in representative building spaces.
- Information on operational features including renovations, commissioning activities, and energy efficiency improvements.
- Recommendations for energy savings measures along with estimated costs and savings potential.

bEQ is intended for commercial and institutional buildings and facilities. It allows building owners and facility managers to compare data between their building and other equitable facilities. The information can be used to feature the value of higher performing buildings when marketing to potential buyers or tenants while instructing them regarding long-term building costs. The documentation provided with the label (certificate and dashboard) can be used to comply with disclosure requirements.

bEQ results also facilitate operations and maintenance staff in prioritizing maintenance activities, and building owners on purchasing equipment upgrades while demonstrating a return on investment from energy efficiency projects.

Location: ASHRAE headquarters is located at 1791 Tullie Circle, N.E. in Atlanta, Georgia.

Website: www.buildingenergyquotient.org

### 1.4.1.9 STARS

**United States**

Figure 1.3 AASHE logo

The Sustainability Tracking, Assessment, and Rating System™ (STARS) program was developed by the *Association for the Advancement of Sustainability in Higher Education* (AASHE) at the request of the *Higher Education Associations' Sustainability Consortium* (HEASC) in 2006. The pilot program held in 2008 had participation by close to 70 higher educational institutions and now includes more than 350 institutions. STARS Version 1.2 is current as of the date of publication.

STARS is a transparent and self-reporting framework to help colleges and universities measure their sustainability performance. This includes *environmental, social, and economic indicators.* STARS is divided into four categories:

- Education & Research
- Operations
- Planning, Administration & Engagement
- Innovation

There are five possible levels of achievement using the following scale:

- Reporter: scores not published
- Bronze: 40–49 points
- Silver: 50–59 points
- Gold: 60–79 points
- Platinum: 80 points and above

Location: AASHE headquarters is located at 1536 Wynkoop St., Suite 100, in Denver, Colorado.

Website: https://stars.aashe.org

## 1.4.2 International Systems

### 1.4.2.1 BREEAM

**United Kingdom**

The Building Research Establishment (BRE) and *Energy and Environment Canada* (ECD) co-developed the BRE Environmental Assessment Method (BREEAM) and released it in 1990 for use in the United Kingdom. BREEAM was the world's first environmental rating system and has over 140,000 certified buildings.

The initial motivation of BREEAM's development was to feature buildings of reduced environmental impact in the marketplace; encourage best environmental practices in design, operation, management, and maintenance; set environmental criteria and standards; and raise the environmental awareness of owners, occupants, designers, and building operators. Protocols and standards for Life Cycle Environmental Assessment (LCA) and ISO 14000 were later incorporated into the BREEAM Standard.

The 49-item BREEAM checklist assesses building environmental performance during the design and procurement stage, and the management/operation stage. BREEAM criteria are organized under the following environmental sections:

- Energy: Operational and $CO_2$ issues
- Transport: Transport-related $CO_2$ and location issues
- Land Use & Ecology: Greenfield and brownfield site issues, plus ecological diversity
- Health and Well-Being: Indoor and external issues
- Water: Consumption- and leakage-related issues
- Waste: Waste management, recycling, operational waste, floor & ceiling finishes
- Materials: Environmental implications of materials selection
- Pollution: Air and water pollution (excluding $CO_2$)
- Management: Overall environmental policy and procedural issues
- Innovation: New technology, process, and practices

BREEAM-licensed assessors use a checklist to review each building's environmental impact against a range of environmental issues to determine credits achieving the benchmarked performance level. Credit values were derived from a multi-stakeholder consultation process that included expert panels of academics and researchers, materials and product suppliers, government, local authorities, activists and lobbyists, developers and investors, and designers (architects & engineers). BRE Global completes the third-party review and issues certificates for assessment credit scores that range as follows:

| BREEAM Rating | Percent Score | Stars Awarded |
|---|---|---|
| Unclassified | < 30 | None |
| Pass | ≥ 30 to < 45 | 1 star |
| Good | ≥ 45 to < 55 | 2 stars |
| Very Good | ≥ 55 to < 70 | 3 stars |
| Excellent | ≥ 70 to < 85 | 4 stars |
| Outstanding | ≥ 85 | 5 stars |

The BREEAM environmental rating system can be applied to new construction (www.breeam.org/BREEAM2011SchemeDocument/), refurbishment and fit-out, shell and core, postconstruction, or operations and maintenance for commercial (offices, industrial, retail), public (nonhousing including education, healthcare, prisons, law courts), single- and multi-residential, other (residential, nonresidential, border stations, sports assembly and leisure, transports hubs, R&D visitor centers, fire stations, data centers), and neighborhood development.

Location: BRE Global is located on Bucknalls Lane, Watford, Hertfordshire WD25 9XX, United Kingdom, but also has offices in Manchester, Scotland, Wales, and Ireland.
Website: www.breeam.org

### 1.4.2.2 HEQ/HQE®

**France**

High Environmental Quality/Haute Qualité Environnementale (HEQ/HQE®) originated in 1996 at the initiative of the French Ministry of Equipment to set environmental and health criteria for buildings which was defined by the Atelier Technique et Environnement (Technical Workshop and Environment) (ATEC). ATEC brought together engineers, architects, and specialized consulting firms to develop a common language and reference values that lead to the approach based on 14 "targets," or environmental criteria. HQE® is also ISO 9001–certified.

HQE has three primary components:

- An Environmental Management System (EMS) where the client sets its objectives and the precise roles for each different player
- 14 targets to determine the client's technical, architectural, and economic objectives
- Performance indicators

The five principles of HQE are:

- Owner's program sets the milestones
- Instituting a management system that motivates each stakeholder to achieve the objectives
- No architectural and engineering solution is to be imposed; the choice is to be justified and appropriate to the context
- Create a healthy and comfortable environment while minimizing environmental impacts
- Evaluate performance

HQE® is a national certification system for residential and nonresidential buildings that has defined performance criteria which are then implemented through a series of management requirements. HQE® program versions include new Retail, Schools, Residential, Hospitality, Commercial Offices, In Use (Existing), Healthcare, Sports, and Industrial facilities.

The 14 environmental target criteria fall into four main areas:

- Site and Eco-Construction (Exterior):
  - Relation between the building and its immediate surroundings
  - Integrated choice of construction products

  - Low-impact construction site
- Eco-Management (Exterior):
  - Energy management
  - Water management
  - Activity waste management
  - Maintenance, environmental performance conservation
- Comfort (Interior):
  - Hygrothermal comfort
  - Noise and acoustics
  - Lighting
  - Odors
- Health (Interior):
  - Health condition of spaces
  - Indoor air quality
  - Sanitary quality of the water

There are three performance ratings assigned to each target criteria: "Basic," "Good," and "Very Good." To receive certification, a minimum of three "Very Good," four "Good," and a maximum of seven "Basic" must be earned.

Location: The Association HQE® is located at 4 Avenue du Recteur Poincaré, 75016 in Paris, France.

Website: http://assohqe.org/hqe/

### 1.4.2.3 HK-BEAM

**Hong Kong**

The *Hong Kong–Building Environmental Assessment Method* (HK-BEAM) Society initiated two schemes in 1996 covering new and existing buildings. HK-BEAM was based largely on the UK BREEAM environmental assessment method but modified for Hong Kong's densely populated infrastructure. The HK-BEAM Society is a not-for-profit organization with members from professionals and interest groups from the building construction and real estate sectors.

HK-BEAM is a voluntary assessment method that requires independent certification of actual performance criteria only upon completion of building construction, which is required prior to issuing a certificate. Management, operation, and maintenance practices are included with analysis for a wide range of sustainability performance criteria as applied to the building's life cycle.

Key categories of building performance that HK-BEAM assesses include:

- Site Aspects: Location, planning and design, site emissions
- Material Aspects: Efficient use of materials, material selection, and waste management
- Energy Use: Annual energy use, energy efficient systems and equipment, facility commissioning, and management
- Water Use: Water quality, conservation and recycling, and effluent discharge
- Indoor Environmental Quality: Safety, hygiene, indoor air quality, ventilation, thermal comfort, lighting quality, acoustic and noise, and amenities for the disabled and IT provisions
- Innovations and Additions: Innovative techniques and performance enhancements

HK-BEAM award classifications and required minimum point grades are:

| Overall | Percent | IEQ |
|---|---|---|
| Platinum: | 75–65 | (Excellent) |
| Gold: | 65–55 | (Very Good) |
| Silver: | 55–50 | (Good) |
| Bronze: | 50–45 | (Above Average) |

HK-BEAM schemes are intended to cover all types of new and existing buildings including single and multiple high-rise residential, commercial, and industrial buildings.

Location: The HK-BEAM Society co-locates offices with the Business Environmental Council located at 77 Tat Chee Avenue, Kowloon, Hong Kong.

Website: www.beamsociety.org.hk/general/home.php

### 1.4.2.4 Minergie®

**Switzerland**

Switzerland implemented the original Minergie® energy efficient standard in 1998. Chartered ten years and 14,000 certified buildings later in 2008, the Minergie® Association (AMI) is supported by the Swiss Confederation, all 26 Swiss Cantons, and the Swiss Trade and Industry.

Minergie® evolved with the addition of the more rigorous PassivHaus-based Minergie-P, added ecological requirements in Minergie-ECO, and offering a combined Minergie-P-ECO standard that were issued in 2006 and 2007. Released in 2009 were the Net Zero–based Minergie-A and Minergie-A-ECO Standards.

Minergie's primary goals for the construction of sustainable buildings are:

- Providing healthy, comfortable buildings
- Achieving high energy efficiency and the drastic reduction in the use of oil, gas, and coal fossil fuel
- Using inexpensive systems with a long life cycle value

One rule is that additional costs for implementing Minergie® are not to exceed 10 percent of building costs.

Minergie® is broken down into providing 10 key elements that make a Minergie®-certified building:

- Compact building form
- Airtight building shell construction
- Low U-factor walls and roof thermal insulation
- Low U-factor windows with coated multiple glazing panes
- Energy efficient, draft-free ventilation system providing a high-quality indoor environment that includes more than adequate amounts of filtered fresh air
- Hydronic heating and cooling using chilled/heated floors, walls, beams, and/or ceilings providing an even and efficient distribution
- Integrated use of geothermal, solar, wind, and/or wood-based renewable energy
- Capture and use of waste heat

- Careful selection of nontoxic materials that also promote green values
- Furnishing energy efficient household appliances and lighting

Minergie® certification is not based on point scoring but on passing a threshold level in all key environmental performance criteria. This makes underperforming buildings unable to achieve Minergie® certification without addressing each critical environmental factor.

The Minergie® environmental rating systems are applicable to new and modernized buildings including single-family homes, apartment buildings, administration, schools, sales, restaurants, meeting venues, hospitals, industry, store, sport installations, indoor pools, and special construction.

Location: The Minergie® Association (AMI) head office is located at Steinerstrasse 37, CH-3006 in Bern, Switzerland.

Website: www.minergie.ch/home_en.html

### 1.4.2.5 Green Building Label

**Republic of China (Taiwan)**

The Taiwan Architecture & Building Center (TABC), a nongovernment agency, was authorized in September 1999 by the Republic of China (Taiwan) Organization Act of the Architecture and Building Research Institute (ABRI) to process the applications for "Green Building" using an inspection and evaluation system for building materials and to certify buildings in Taiwan. ABRI "Green Building Policy" is to construct healthy living spaces with ecological amenities, and ensure environmental friendliness through energy savings, natural resource conservation, waste reduction, and low pollution.

The TABC "Green Building Evaluation System" has nine indicators for assessing approval to achieve a "Green Building Label," which are:

- Biodiversity
- Greenery
- Soil water content
- Daily energy saving
- $CO_2$ emission reduction
- Waste reduction
- Indoor environment
- Water resource
- Sewage and garbage improvement

The TABC "Green Building Label Review Committee" reviews project applications (www.tabc.org.tw/tw/modules/news/article.php?storyid=278&uid=0) with successful applicants awarded a Green Building Label by the Taiwan Minister of Interior. TABC also officially reviews projects for fire and life safety criteria.

All new and existing buildings are eligible to apply for a Green Building Label including department stores, hospitals, hotels, schools, and residences.

Location: The Taiwan Architecture & Building Center headquarters is located at 10F-1, No. 43, Fusing Rd., Sindian, Taipei 23150 TAIWAN.

Websites: www.tabc.org.tw/ (Taiwanese); www.cabc.org.tw/en/index.htm

### 1.4.2.6 GBCS

**Korea**

The Green Building Certification System (GBCS) was developed based on the GBC GBTool (see 1.4.1.4) by the Korea Institute of Energy Research (KIER), and launched in 2000 under the oversight of the (South) Korean Ministry of Land, Transport and Maritime Affairs, and the approval of the Ministry of Environment. Adherence to the GBCS for new construction has been made mandatory by the South Korean government.

GBCS program objectives are:

- Evaluate environmental performance of buildings
- Promote dissemination of green buildings in Korea

GBCS is applied toward all new construction of South Korean multiunit residential buildings, mixed-use dwellings, office buildings, schools, stores, and hotels. The four GBCS rating systems in use are:

- Multi-Unit Residential Building (120 possible points)
- Mixed-Use Dwellings (128 residential + 115 nonresidential = 243 possible points)
- Office Buildings (136 possible points)
- Schools (124 possible points)

Issues and points specific to the Office Buildings Program are:

- Land Development (7 points)
- Commuting Transportation (5 points)
- Energy (23 points)
- Materials and Resources (21 points)
- Water Resources (14 points)
- Atmosphere Pollution (6 points)
- Management (10 points)
- Ecological Environment (19 points)
- Indoor Environmental Quality (31 points)

GBCS grade point levels are:

| | |
|---|---|
| Best: | 85 points or more |
| Excellent: | 65 to 84 points |

Website: www.greenbuilding.or.kr/eng/html/sub02_1.jsp

### 1.4.2.7 TQ Building Assessment System

**Austria**

The Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT) launched the Austrian Program on Technologies for Sustainable Development (at:sd) with its "Haus der Zukunft" ("Building of Tomorrow") subprogram in 1999, followed in 2000 by the "Fabrik der Zukunft" ("Factory of Tomorrow") subprogram. BMVIT

then completed the "Ecobuilding—Building Optimization with Total Quality (TQ) Assessment" in 2001, which was based on the 1998 Austrian response to the international Green Building Challenge (GBC).

The TQ Program supports a number of activities including initiating pilot demonstration projects, and the following subprograms:

- "Building of Tomorrow" applies to residential and office buildings.
- Phase II, "Building of Tomorrow Plus," focuses on new office and factory buildings, and on modernizing existing buildings.
- "Energy Systems of Tomorrow" is aimed toward research and development of renewable energy sources and energy efficiency, specifically, aspects of an efficient overall system using structural, social, and technological innovations.
- "Factory of Tomorrow" is the result of Austria's participation in the 2004–2008 European ERA–Net Project entitled SUSPRISE (SUStainable EnterPRISE), in coordination with ten other European countries (Belgium, Denmark, Germany, Finland, United Kingdom, Ireland, the Netherlands, Sweden, Switzerland, and Spain). Factory of Tomorrow addresses the trade industry as well as service enterprises that produce and provide products.

The aim of TQ is to design and construct high-quality buildings in Austria that provide for optimized technical systems and energy-conservation in the use and management of each program building. The primary goals of subprograms such as Building of Tomorrow are to save as much energy as possible while significantly improving functionality and the quality of living, all at an acceptable cost.

Most subprograms are based on Germany's "Passive Haus" approach of an air-sealed, super-insulated envelope with low U-factor openings, photovoltaic array (PVA) –generated power, equipped with a ventilation system that supplies filtered fresh-air that exchanges heat with exhaust-air, and with the fresh-air further heated or cooled using one of the following research-proven optimal methods:

- Decentralized heat pump air heating system and domestic solar hot water with storage
- Central brine heat pump and water heating system
- Central pellet-burner boiler and water heating system

"Eco-Building" is the classic real estate appraisal process completed with environmental criteria of new construction or renovation projects. Documented compliance with the TQ environmental criteria and planning objectives is the basis for issuing the building document, and award of a TQ building quality certificate. The five-volume "TQ Information Package" is available at: www.nachhaltigwirtschaften.at/results.html/id1772.

Location: BMVIT is located at Renngasse 5, 1010 Vienna, Austria
Website: www.nachhaltigwirtschaften.at/english/index.html

### 1.4.2.8 CASBEE®

**Japan**

In April 2001 Japan initiated the Comprehensive Assessment System for Built Environment Efficiency (CASBEE®) as a joint industrial/government/ academic project

with the support of the Housing Bureau; Ministry of Land, Infrastructure, Transport and Tourism (MLIT), leading to the establishment of a new organization, the Japan GreenBuild Council (JaGBC)/Japan Sustainable Building Consortium (JSBC), administered by the Institute for Building Environment and Energy Conservation (IBEC). JaGBC/JSBC and subcommittees jointly work together on all CASBEE® research and development.

CASBEE® was developed according to the following policies:

- Ensure superior buildings are awarded high assessments as an incentive to designers and others
- A simple assessment system
- Applicable to buildings in a wide range of applications
- Consideration for issues and problems specific to Japan and Asia

CASBEE® covers four basic assessment fields:

- Energy Efficiency
- Resource Efficiency
- Local Environment
- Indoor Environment

The CASBEE® rating system was developed to accommodate the architectural design process from predesign through design and postdesign. The "CASBEE Family" is the name for the four assessment tools that correspond to the building life cycle and to serve at each stage of the design process, specifically:

CASBEE® for Pre-design
CASBEE® for New Construction
CASBEE® for Existing Building
CASBEE® for Renovation

Each tool is designed to accommodate a wide range of facility uses (offices, schools, apartments) in the evaluation of buildings.

The following CASBEE® tools have been compiled since 2001:

CASBEE® for New Construction (Full + Brief versions)
CASBEE® for Existing Building (Full + Brief versions)
CASBEE® for Renovation (Full + Brief versions)
CASBEE® for Heat Island
CASBEE® for Urban Development
CASBEE® for an Urban Area + Buildings
CASBEE® for Home (Detached House)
CASBEE® Property Appraisal

CASBEE® reorganized these four CASBEE Family fields and classified them into:

BEE = Q (Quality)/L (Load)

Where BEE (Building Environmental Efficiency) equals numerator Q (Building Environmental Quality and Performance) divided by denominator L (Reduction of Building Environmental Loadings)

Quality (Q) is divided into three items for assessment:

- Q1 Indoor Environment
- Q2 Quality of Services
- Q3 Outdoor Environment on Site

Load (L) is separated into:

- L1 Energy
- L2 Resources & Materials
- L3 Off-site Environment

A building's final environmental performance rating is ranked using five grades:

- Excellent (S)
- Very Good (A)
- Good (B+)
- Fairly Poor (B–)
- Poor (C)

Location: The Japan Sustainable Building Consortium (JSBC) is headquartered at Zenkyoren Kojimachi Building, 3–5–1 Kojimachi, Chiyoda-Ward, Tokyo 102–0083 Japan.

Website: www.ibec.or.jp/CASBEE/english/index.htm

### 1.4.2.9 Green Star/Green Star NZ/Green Star SA

**Australia / New Zealand / South Africa**

The first Green Star environmental rating system was launched in 2003 by a nongovernment organization, the Green Building Council of Australia (GBCA). Green Star NZ followed in 2007 with a rating system modified by the nongovernment organization New Zealand Green Building Council (NZGBC) in partnership with the building industry. Green Star SA, based on Australia's Green Star rating system, was released in 2008 by the nongovernment organization Green Building Council of South Africa (GBCSA).

A comprehensive, national, voluntary environmental rating system, Green Star is intended to evaluate the environmental design and construction of buildings. Green Star rating tools were created to assist the property industry in reducing building environmental impacts, improving occupant health and productivity, and achieving operating cost savings, while publicizing sustainable building practices. Green Star was developed with the aim of:

- Establishing a common language
- Setting a standard of measurement for green buildings
- Promoting integrated, whole-building design
- Recognizing environmental leadership
- Identifying building life cycle impacts
- Raising awareness of green building benefits

Green Star is applicable to commercial offices (design, construction, and interior fit-outs), retail centers, schools and universities, multiunit residential dwellings, industrial facilities, and public buildings.

Green Star is divided into the following nine categories that evaluate the environmental impacts of site selection, design, construction, and maintenance for each project:

- Management
- Indoor Environment Quality
- Energy
- Transport
- Water
- Materials
- Land Use & Ecology
- Emissions
- Innovation

Green Star credits are assigned to each category with points awarded for actions that demonstrate compliance with prescribed environmental objectives. Claimed credits are submitted and evaluated, calculated, and then weighted to the varying environmental factors of the states and territories.

Achievable Green Star Certified Ratings are:

- 4 Star Green Star Certified Rating (a score of 45–59) that signifies "Best Practice" in environmentally sustainable design and/or construction
- 5 Star Green Star Certified Rating (a score of 60–74) that shows "Australian Excellence" in environmentally sustainable design and/or construction
- 6 Star Green Star Certified Rating (a score of 75–100) that denotes "World Leadership" in environmentally sustainable design and/or construction

Green Star Location: The Green Star Program is managed by the Green Building Council Australia, with headquarters on Level 15 of 179 Elizabeth St. in Sydney NSW, Australia, and also has offices in Brisbane and Melbourne, and Sydney.

Green Star Website: www.gbca.org.au/green-star/

Green Star NZ Location: The Green Star NZ Program is managed by the New Zealand Green Building Council, which is located on Level 2 of the Old Sofrana House on 18 Custom Street East, Auckland CBD, New Zealand.

Green Star NZ Website: www.nzgbc.org.nz/main/greenstar/

Green Star SA Location: The Green Star SA Program is managed by the Green Building Council of South Africa, which is located in Spire House, Tannery Park, at 23 Belmont Road in Rondebosch, Cape Town, South Africa.

Green Star SA Website: www.gbcsa.org.za/greenstar/ratingtools.php

### 1.4.2.10 SBAT®

**South Africa**

The South African Council for Scientific and Industrial Research (CSIR) made their Sustainable Buildings Assessment Tool (SBAT®) available for use in 2004. SBAT® was

developed specifically to operate in a resource-scarce developing country to support sustainable development.

CSIR describes a Sustainable Building Life Cycle as a nine-stage process based on the typical structured approach to the life cycle of a building.

- Briefing (programming)
- Site Analysis
- Target Setting
- Design
- Design Development
- Construction
- Handover
- Operation
- Reuse/Refurbish/Recycle

SBAT consists of 15 key environmental criteria organized under three headings for assessment to determine a facility's level of sustainability. SBAT was developed to assess not only the sustainability performance of buildings but also the extent of the building's contribution to facilitating additional sustainable systems around it.

SBAT criteria consists of:

- Environmental:
  - Water
  - Energy
  - Waste
  - Site
  - Materials & Components
- Economic:
  - Local Economy
  - Efficiency of Use
  - Adaptability & Flexibility
  - Ongoing Costs
  - Capital Costs
- Social:
  - Occupant Comfort
  - Inclusive Environments
  - Access to Facilities
  - Participation & Control
  - Education, Health & Safety Local Contractors

Each criterion is given a rating of from 0 to 5 with:

0–1 = Very Poor
1–2 = Poor
2–3 = Average
3–4 = Good
4–5 = Excellent

CSIR compiles a report for the developer that includes a representative graphical chart using the sustainable building assessment tool (SBAT) (www.csir.co.za/Built_environment/Architectural_sciences/sbat.html).

The SBAT tool can be applied to new residential and commercial buildings including light industrial development.

Location: CSIR has multiple offices throughout South Africa. However, the CSIR Division of Building and Construction Technology, Facilities Planning and Management, Sustainable Buildings Group, is located in Pretoria.

Website: www.csir.co.za/Built_environment/Architectural_sciences/sbat.html

### 1.4.2.11 NABERS

**Australia**

Operational since 2005, the National Australian Built Environment Rating System (NABERS) is a government program of the New South Wales (NSW) Department of Environment, Climate Change and Water.

NABERS was created as a performance-based rating system for existing buildings. Environmental impacts from building operations are measured with the data rated against comparable and local facilities. Property owners, occupants, investors, and other stakeholders are given a consistent method of assessing the operational environmental impacts of buildings.

The NABERS environmental rating system is applicable to commercial office, hotel, and residential buildings with separate ratings available for:

- Office Buildings
- Office Tenancy
- AAA-rated Hotels
- Shopping Centers over 15,000 $m^2$
- Single-Family Homes
- Ratings for Hospitals, Schools and Data Centers are under development.

Location: NABERS is managed by the NSW Department of Environment, Climate Change and Water located on Level 14 of 59 Goulburn Street, in Sydney, New South Wales, Australia.

Website: www.nabers.com.au

### 1.4.2.12 LiderA

**Portugal**

Liderança para o Meio Ambiente (LiderA), or in English "Leadership for Environment," is a voluntary green building assessment system that has been in use in Portugal since 2005. LiderA was developed by Professor Manuel Duarte Pinheiro of the Universidade Tecnica de Lisboa, Departamento de Engenharia Civil e Arquitectura, who organized LiderA into six categories and 43 criteria to guide and evaluate the project's level of sustainability.

LiderA categories are:

- Site and Integration: Enhance local dynamics and promote proper integration of Soil, Natural Ecosystems, and Landscape and Heritage

- Resources: Promote efficient use of Energy, Water, Materials, and Food Production
- Environmental Loadings: Reduce the magnitude and toxicity of Wastewater, Atmospheric Emissions, Waste, Noise Emission, Thermal Pollution, and Light Pollution
- Environmental Comfort: Ensure environmental quality in the areas of Air Quality, Thermal Comfort, Lighting, and Acoustics
- Socioeconomic Experience: Promote sustainable socioeconomic experiences that include Accessibility, Economic Diversity, Amenities and Social Interaction, Control and Participation, and Life Cycle Costs
- Sustainable Use: Ensure the best use of built environments using environmental management and innovation

The 43 LiderA criteria are phase dependent, whether prescriptive (as in the initial phase) or performance based (in detail design, or construction, or operation). LiderA performance criteria are scaled beginning with usual practice (Class E) and adjusting toward a progressively higher incremental environmental performance rating:

| | | |
|---|---|---|
| 12.5 percent | (Class D) | |
| 25 percent | (Class C) | |
| 37.5 percent | (Class B) | |
| 50 percent | (or factor 2) | (Class A) |
| 75 percent | (or factor 4) | (Class A+) |
| 90 percent | (or factor 10) | (Class A++) |

The LiderA system (www.irbdirekt.de/daten/iconda/CIB11671.pdf) is applicable to all private and public sector sustainable design and construction.

Website: www.lidera.info/?p=MenuPage&MenuId=29

### 1.4.2.13 BCA Green Mark

**Singapore**

Green Mark was introduced in January 2005 by the Singapore Building and Construction Authority (BCA).

The Green Mark rating system evaluates buildings for environmental impact and performance, and promotes sustainable design, construction, and operational practices throughout the City-State Republic of Singapore. BCA assigns one Green Mark Assessor to a project for the duration. The BCA Assessor, or public official, conducts the preassessment, assessment, and site verification audits.

The Green Mark assessment criteria cover the following key areas:

| | |
|---|---|
| Part 1: | Energy Efficiency |
| Part 2: | Water Efficiency |
| Part 3: | Environmental Protection |
| Part 4: | Indoor Environmental Quality |
| Part 5: | Other Green Features (Innovations) |

Green Mark scoring points are awarded for incorporating environmentally friendly features that are better than normal practice. The total number of points obtained provides an indication of the environmental friendliness of the building design and operation.

Depending on the overall assessment and point scoring, the building will be certified to have met one of the following Green Mark ratings:

| Score | Rating |
|---|---|
| 50 to < 75 | Certified |
| 75 to < 85 | Gold |
| 85 to < 90 | Gold$^{Plus}$ |
| 90 and above | Platinum |

Green Mark is applicable to new buildings, existing buildings, office interiors, landed houses, infrastructure, and districts.

Location: The Building and Construction Authority (BCA) is located at 5 Maxwell Road, #16–00 Tower Block MND Complex, in Singapore.

Website: http://bca.gov.sg/GreenMark/green_mark_criteria.html

### 1.4.2.14 Three Star

**China**

The Three Star local credit-based green building standard was introduced in 2006, and implemented by the People's Republic of China (PRC) Ministry of Construction Green Building Evaluation Standards in 2007 with the first buildings being rated in 2008.

Three Star was formulated in order to implement China's national technological and economic policies for resource saving and environmental protection, promote sustainable development, and standardize the evaluation of a green building. The program is overseen by the PRC Ministry of Housing and Urban-Rural Development (MOHURD) in Beijing.

Developers can pursue a Three Star rating for existing and new Residential and Public (commercial office, hotel, mall, and supermarket) buildings. One-Star, Two-Star, or Three-Star ratings are awarded from verified performance reviews after one year of operation by the local authority, and a Three-Star rating only by MOHURD in Beijing.

Three Star credits incorporate the following six general environmental criteria:

- Land Savings and Outdoor Environment
- Energy Savings
- Water Savings
- Materials Savings
- Indoor Environmental Quality
- Operations and Management

A "Preferential Items" multiplier is applied to account for regional differences and special local emphasis.

Residential buildings have 76 total options that include 27 controlling criteria, 40 general criteria, and nine prior criteria. Public buildings encompass 83 total options including 26 controlling criteria, 43 general criteria, and 14 prior criteria.

To achieve a One-Star, Two-Star, or Three-Star rating all controlling criteria must be satisfied along with all listed general option and prior option requirements.

Website: http://chinagreenbuildings.blogspot.com/2009/02/ministry-of-construction-green-building.html

### 1.4.2.15 Pro*mis*E

**Finland**

Suomen Ympäristöministeriö (the Finnish Ministry of the Environment), Tekes (the National Technology Agency), Motiva Oy, and many construction projects participated in the implementation of the Pro*mis*E system, which was completed in 2006. Real estate and new construction assessment criteria and tools were developed between 1999 and 2004 in collaboration with Sisäilmayhdistys Ry (Indoor Air Association), VTT (Technical Research Centre of Finland), and JPTalotekniikka Oy (JP Building Engineering Ltd).

Pro*mis*E uses an alternative method of listing the results of environmental assessment where environmental efficiency is expressed as the formula:

Efficiency = Property Value (Financial)/(Property Cost + Environmental Impact)

The Pro*mis*E environmental classification is a tool for real estate marketing and development that focuses on four main environmental categories:

- Health of Users
- Consumption of Natural Resources
- Environmental Loadings
- Environmental Risks

The rating system is a five-stepped classification that labels buildings as an A, B, C, D, or E-class to indicate the achieved level of "environmental friendliness."

Pro*mis*E uses an Internet-based environmental assessment tool and classification system for new and existing residential, office, and retail buildings. Key classifications and categories include:

- User's Health: Indoor air objectives, indoor air quality, moisture management, and lighting (offices).
- Natural Resources Flows: Energy, water, land use, materials, and service life.
- Ecological Impacts: Emissions into the atmosphere, solid wastes, sewage wastes, biodiversity around the site, and traffic.
- Environmental Risks: Site, building, and the construction site.

Key Websites:
www.promise-luokitus.fi/
www.motiva.fi/rakentaminen/rakentamisen_projekteja/promise_rakennusten_ymparistoluokitus

### 1.4.2.16 TERI-GRIHA

**India**

The Energy and Resources Institute (TERI) Green Rating for Integral Habitat Assessment (GRIHA) was established as the national rating system of India in 2006. GRIHA was developed jointly by TERI with the Indian Ministry of New and Renewable Energy. "Griha" is also a Sanskrit word meaning "Abode."

GRIHA is a voluntary scheme that is characterized as a "green building 'design evaluation system,' and tool to design, operate, evaluate and maintain resource-efficient

'healthy' and 'intelligent' building" (www.hareda.gov.in/TERI.PDF) that is suitable for all building types to be found in the different climate zones of India.

The GRIHA rating tool is based on accepted energy and environmental principles that assess building environmental performance over the entire building life cycle against specific nationally acceptable benchmarks. Guideline criteria may be updated every three years to incorporate the latest scientific developments.

The TERI-GRIHA system covers new offices, retail spaces, institutional buildings, hotels, hospital buildings, healthcare facilities, residences, and multifamily high-rise buildings. Systems for industrial complexes and housing colonies are under development.

The 32-criterion system (www.hareda.gov.in/TERI.PDF) is organized as follows:

- Site Planning:
  Criterion 1–6: Conservation and efficient utilization of resources
  Criterion 7–8: Health and well-being aspects
- Building Planning and Construction Stage:
  Criterion 9–18: Conservation and efficient utilization of resources
  Criterion 19–20: Recycle, recharge, and reuse of water
  Criterion 21–24: Waste management
  Criterion 25–29: Health and well-being
- Building Operation and Maintenance:
  (Criterion 30–32)

TERI-GRIHA uses a three-tier evaluation process with the preliminary review for the ten mandatory and 22 optional criteria completed by a TERI professional and expert Technical Team. The Technical Team report is then sent to an Evaluation Committee consisting of renowned experts from the fields of landscape architecture, lighting and HVAC design, renewable energy, water and waste management, and building materials. The Evaluating Committee awards points and makes recommendations to the Project Proponent, which can then make modifications to increase the score and resubmit within one month to the TERI Technical Team which reports to the Evaluation Committee for a final point score determination. This final score, based on the 100-point system, is then reviewed by an Advisory Committee of eminent people and renowned professionals in the field for approval and award of five-year GRIHA star rating.

The star rating system is broken down as follows:

| **Rating** | **Points** | **Scored** |
|---|---|---|
| One | Star | 50–60 |
| Two | Stars | 61–70 |
| Three | Stars | 71–80 |
| Four | Stars | 81–90 |
| Five | Stars | 91–100 |

Location: The TERI main office is located at Darbari Seth Block, IHC Block, Lodi Road, New Delhi 110 003, India

TERI Website: www.teriin.org

GRIHA Website: www.grihaindia.org

### 1.4.2.17 AQUA

**Brazil**

Instituted in December 2008, Alta Qualidade Ambiental (AQUA), which translates as "High Environmental Quality," is Brazil's adaptation of the French Démarche HQE green rating system, and contains additional requirements to the HQE Enterprise Management System (EMS) and performance criteria from the Environmental Quality of Building (QAE) categories.

The AQUA process establishes the project's high environmental quality using independent audits. Benefits of an Enterprise Process Certificate from AQUA are:

- Enhanced quality of life for users
- Water use efficiency
- Energy efficiency
- Efficient low-impact waste disposal, and reduced nontoxic maintenance
- Socioeconomic and environmental contribution to the region

Developers must have complete control of all phases of the project in order to be eligible for AQUA building certification including the Program, Design (Project), Output (Work), and Operation (Use) phases.

AQUA is intended to be applied to new and renovated office and school buildings, hotels, and housing. AQUA for Commercial, Transportation, Health, Sports & Entertainment, and Industrial Buildings are under development. AQUA is the first green label program in Brazil to take the Brazilian climate into account when modifying these 14 French Demarche HQE criteria:

- Relationship building with its surroundings
- Choice of integrated products, systems, and construction processes
- Construction site with low environmental impact
- Energy management
- Water management
- Management of waste use and operation of the building
- Maintenance—Permanence of environmental performance
- Hydrothermal comfort
- Acoustic comfort
- Visual comfort
- Olfactory comfort
- Building environmental quality
- Air quality health
- Sanitary water quality

AQUA participants are required to apply the HQE Enterprise Management System to achieve the 14 QAE performance criteria. Criteria are evaluated by Fundação Vanzolini, the designated Brazilian assessor, from site audits taken during the programming, design, and construction phases.

Website: www.processoaqua.com.br/noticias.html (Portuguese only)

### 1.4.2.18 DGNB®

**Germany**

Launched in 2009, the DGNB Certification System was developed by the Deutsche Gesellschaft fur Nachhaltiges Bauen e.V. (DGNB®), or German Sustainable Building Council, together with the German Federal Ministry of Transport, Building, and Urban Affairs (BMVBS).

DGNB is a high-performance, transparent tool for the assessment and certification of sustainable buildings. DGNB uses a broad quality concept, pursuing equal weighting of economic, ecological, and sociocultural aspects based on a holistic view of a building's life cycle.

The DGNB core system criteria break down sustainable building into six "Quality" fields:

- Ecological
- Economic
- Sociocultural and Functional
- Technical
- Process
- Site

An independent auditor, planner, or architect scores the performance-based points to determine if a DGNB Gold, Silver, or Bronze Certificate can be awarded. Each individual criterion is weighed to measure fulfillment of requirements with the sum producing a score for the six topical categories and the overall project. The minimum scoring requirements for the first five topical categories are: 65 of the minimum 80 percent to achieve a Gold Certificate; 50 of the minimum 65 percent for a Silver Certificate; and 35 out of the minimum 50 percent required for a Bronze Certificate; all prior to adding points for Site Quality.

DGNB systems include new office and administration buildings, new retail buildings, new industrial buildings, new educational buildings, modernized office and administration buildings, new residential buildings, new hotels, city districts, and existing office and administrative buildings. DGNB certification working groups are developing and planning on implementing occupancy profiles for branches/tenant improvements, new hospitals, new laboratory buildings, design objects, public assembly buildings, new industrial complexes, new infrastructure facilities, new sports facilities, new parking structures, and new airport terminals.

Location: DGNB has offices at Kronprinzstraße 11, 70173 Stuttgart, Germany.
Website: www.dgnb.de/_en/index.php

### 1.4.2.19 GBI Malaysia

**Malaysia**

The Malaysian Institute of Architects (PAM) and the Association of Consulting Engineers Malaysia (ACEM) together founded Greenbuildingindex Sdn Bhd (GSB) in 2009, which administers the Green Building Index (GBI) voluntary green building rating tool which was issued February 2010.

GBI Malaysia was developed specifically for the Malaysian tropical climate, environmental and developmental context, cultural, and social needs.

The GBI Malaysia process has three stages:

1. Application and Registration
2. Design Assessment
3. Completion and Verification Assessment

Design Assessment is coordinated by a GBI facilitator working with the design team and their client. Completion and Verification Assessment verifies performance data taken by GSB within 12 months of owner occupancy, and awarding a full three-year certification when the project's target scoring is achieved.

The six primary GBI Non-Residential New Construction (NRNC) parts and environmental assessment criteria are:

- (EE) Energy Efficiency: Design; Commissioning; Verification & Maintenance
- (EQ) Indoor Environmental Quality: Air Quality; Thermal Comfort; Lighting, Visual & Acoustic Comfort; Verification
- (SM) Sustainable Site Planning & Management: Site Planning; Construction Management; Transportation; Design
- (MR) Material & Resources: Reused & Recycled Materials; Sustainable Resources; Waste Management; Green Products
- (WE) Water Efficiency: Water Harvesting & Recycling; Increased Efficiency
- (IN) Innovation

GBI Classifications are as follows:

- Platinum: 86+ points
- Gold: 76–85 points
- Silver: 66–75 points
- Certified: 50–65 points

GBI applies to new and existing commercial and residential buildings in Malaysia.

Location: The Greenbuildingindex Sdn Bhd (GSB) headquarters is located at 4 & 6 Jalan Tangsi, 50480 Kuala Lumpur, Malaysia.

Website: www.greenbuildingindex.org/

### 1.4.2.20 GBCe VERDE

**Spain**

Available since 2010, VERDE is a methodology for environmental evaluation and certification for buildings that was developed by GBC España or the Green Building Council Spain (GBCe) Technical Committee.

The GBCe VERDE evaluation system is a performance-based approach that incorporates the European Union Technical Building Code and Directives, and the base principles of bio-architecture. The building must be built to be compatible with and respect the environment, and to embody a high level of user comfort and quality of life.

VERDE's 49 assessment criteria are divided into 15 categories, and the following six key areas:

- Place Selection, Location and Planning of Project
- Energy and Atmosphere
- Natural Resources
- Interior Space Quality
- Service Quality
- Socioeconomic Impact

Scoring is established where:

0 = value given for standard compliance with regulations
3 = value defining good sustainable practice
5 = value corresponding to achievement of the best sustainable practice possible within an acceptable cost

VERDE measures the reduced local, regional, and global environmental impacts relative to the building meeting regulations. A GBCe Accredited Assessor must evaluate documentation with GBCe assessing the application to accredit for certification.

There are six levels of certification available for new and existing residential and office buildings. Methods are being developed by GBCe to expand certification to other building types.

Location: GBC España is headquartered at Paseo de la Castellana nº 114, 4º 7, 28046 Madrid, España.

Website: www.gbce.es/pagina/certificacion-verde

### 1.4.2.21 Estidama

**United Arab Emirates**

The Estidama—Pearl Community Rating System was initiated in 2010 by Abu Dhabi, the capital city of the United Arab Emirates (UAE). Estidama is overseen by the Abu Dhabi Urban Planning Council (UPC). As the Arab World's first sustainability rating system, Estidama was specifically tailored to the hot climate and arid environment of Abu Dhabi.

The following Estidama "Pearl Community Rating Systems" (PCRS) design and construction-based systems have been released:

- Estidama-PCRS, Pearl Community Rating System
- Estidama-PBRS, Pearl Building Rating System
- Estidama-PVRS, Pearl Villa Rating System

Estidama is divided into the following environmental categories:

- IDP: Integrated Development Process
- NS: Natural Systems
- LC: Livable Communities

- PW: Precious Water
- RE: Resourceful Energy
- SM: Stewardship Practice
- IP: Innovative Practice

Estidama applications are prepared by the design team and Pearl Qualified Professionals (PQP), and are further assessed by a UPC Pearl Assessor (PA). Pearl Community Certification Rating levels must meet the following scoring requirements:

| **Requirement (159 total possible points)** | **Pearl Rating Achieved** |
|---|---|
| Achieve each mandatory credit | 1 Pearl |
| Achieve each mandatory credit + 55 credit points | 2 Pearl |
| Achieve each mandatory credit + 75 credit points | 3 Pearl |
| Achieve each mandatory credit + 100 credit points | 4 Pearl |
| Achieve each mandatory credit + 125 credit points | 5 Pearl |

Estidama is applicable to all office, retail, multi-residential, school, and mixed-use facilities. Achieving a minimum one pearl rating is required as part of the Abu Dhabi planning approval and permitting processes.

Location: The Pearl Community Rating Systems (PCRS) are overseen by the Abu Dhabi Urban Planning Council (UPC) with an address of P.O. Box 62221, in Abu Dhabi, United Arab Emirates.

Website: http://estidama.org/

# Chapter 2
# Roles and Expectations of the Design and Construction Team

Each member of the design and construction team must understand their individual roles and responsibilities in order to be able to function properly within the team. Each member of the team must also understand and respect the roles and responsibilities of the other members of the team for the project to be successfully completed. The concept of teamwork and mutual accountability in the construction industry is not new. However, the actual practice of teamwork and mutual respect is still a challenge for some. Progress toward true integration of the team is advancing rapidly in today's design and construction industry, and the positive results of that progress are being recognized by owners, design teams, product and material suppliers, and contractors across the spectrum of the industry.

This section includes a discussion of each primary member of the design and construction team, with regard to its role and responsibilities as a member of the team. In addition to performing individually within the team structure, each team member should also be able to reliably expect certain performance from the other members of the team. These expectations are also discussed in this section with regard to each primary member of the design and construction team. All discussions in this section include an emphasis on sustainable design and construction issues and concerns.

## 2.1 Owner Team

### 2.1.1 Roles and Responsibilities

The owner is, by definition, the initiator of a design and construction project in response to an identified need or purpose for the development of a facility. In that role, the owner is obligated to either have or retain the expertise and capabilities needed to fully implement the project and accomplish its successful completion. The owner must also be able to bring all necessary financial resources to the project in order to fund its implementation.

This usually involves retaining the services of development advisors, financial consultants, environmental consultants, surveyors, and a host of other specialists to assist with the land acquisition and the investigation of all existing conditions which may affect the implementation of the project. The owner must then retain the services of various design professionals (architects, engineers, specialty consultants), either during the course of the development assessment previously outlined, or immediately thereafter. Then, the construction team must be selected in order to establish the anticipated and final cost of the project, and to implement the construction of the facilities. All of the members of the design and construction team may be in place simultaneously, or may be retained sequentially, to suit the goals and objectives of the owner. Refer to Chapter 5 of this Practice Guide for a complete and detailed discussion of various Project Delivery methods; all of which may be employed effectively by the owner in the development of projects and facilities.

The owner, as project initiator, is required to establish a comprehensive and realistic set of goals and objectives for the project. These goals and objectives typically include the following, among potentially many others:

- Invest for financial profit (corporate or individual)
- Provide goods and services to the market
- Construct productive work environments for staff to serve clients and customers
- Facilitate vehicular and pedestrian circulation in the environment (local through global)
- Provide amenities that enhance the built environment
- Implement sustainable design and construction practices that minimize the impact on the environment

In the context of sustainable design and construction, the owner should endeavor to clearly define sustainable design and construction goals for the project, and should have a commitment to sustainability that is impressed on the design and construction team. Based on that commitment, the owner should expect to:

Include appropriate funds within the project budget to pay for additional design team fees, construction phase fees and surcharges, hard construction costs to achieve the intended sustainable design and construction criteria, and similar items.

Retain supplemental design consultants, commissioning and testing agencies, and contractors in a timely manner as may be necessary to allow the design and construction team to achieve the sustainable goals for the project.

Respond to sustainable design compliance items, which may include site selection, parking requirements, green energy resources, interior and exterior facility maintenance products and processes.

## 2.1.2 Owner's Expectations

When the owner is the initiator of the project with the intent to develop a facility to meet a specific need or purpose, and is bringing the financial resources necessary to implement the project, it is reasonable to presume that the owner will expect that the established goals and objectives of the project will be fulfilled. Of all the project team members, the owner has the greatest risk in initiating the project, and correspondingly, the potential rewards should be equal to that level of risk.

However, the owner usually cannot fully implement a design and construction project on its own without the need for extensive professional assistance. An exception to this would be a very large corporation that develops facilities on a routine basis using in-house design, construction, and facility management personnel to accomplish its facility development objectives. Regardless of whether or not these professional services are employed separately or in-house, the owner should retain design and construction professionals, construction trade personnel, and facility management professionals who are skilled, competent, and capable of performing the services and construction activities required on the project.

As the owner makes the commitment and assumes the attendant risks associated with the implementation of a project, including an appropriate commitment to sustainability, the owner should also expect:

- The design team to be knowledgeable about how to achieve the required sustainability goals for the project.
- The project to achieve the sustainability goals for the project.
- The cooperation and collaboration of all of the members of the design and construction team throughout the design and construction process.
- The construction team to be familiar with the application of sustainable practices that can be implemented during the construction process.

## 2.2 Design Team

### 2.2.1 Roles and Responsibilities

The design team, including the architect/engineer, and various design and specialty consultants who may be retained by the owner directly, is the owner's most influential initial resource in the implementation of the project. The design team must take the owner's stated goals and objectives for the project, translate them into performance metrics that are a quantifiable and achievable design "program," and then design a site-specific facility that meets those goals and objectives in very specific ways. Unlike processes used in the product manufacturing industry that use prototypes and trials, a site-specific facility is expected to perform and function according to the expectations of the owner without the benefit of a "test model" on which to verify the intended results. The closest approximation of the prototype process is the use of a sufficiently developed building information model (BIM) is developed by the design and construction team for review and coordination prior to the commencement of construction.

The fulfillment of the owner's "program" is not a single task, but is rather a complex and interrelated series of activities which take place in the context of a Project Delivery Process (refer to Chapter 5 of this Practice Guide) that must be integrated with the activities of many tens or hundreds—even thousands—of other individuals and business entities that provide goods and services to the project.

The design team is also the owner's most essential resource in the pursuit of a sustainably designed project. The ability of a constructed facility to perform according to established sustainable design and construction goals and objectives starts with the fundamental concept for the design of the facility. For example, if the building is not

configured and oriented properly with regard to the sun path across the sky, the building may consume more energy than would otherwise be necessary due to excessive heat gains or losses through the building envelope.

The design team's sustainable responsibilities are to design facilities that meet the owner's fundamental goals and objectives for the project, while also addressing the following:

- Optimize the use and reuse of water resources.
- Optimize energy consumption, with a possible goal to minimize or eliminate the net consumption of energy.
- Enhance the quality of the atmosphere within and in the immediate vicinity of the project.
- Minimize the consumption of natural resources that are not rapidly renewable.
- Make the best utilization of the transportation infrastructure.
- Avoid the use of toxic materials and products in the built environment.
- Full utilization of sun and wind resources to heat, cool, and light the facility.
- Updates and new developments in sustainable codes, standards, and regulations.

In that role, the design team should:

- Have an established and ongoing commitment to sustainable design as a professional practice standard.
- Have experienced sustainable design professionals on the firm's staff, or employ the services of capable and experienced consultants who can serve the needs of projects and clients accordingly.
- Maintain a current database of sustainable products, materials, and systems for incorporation into project documentation.
- Maintain current knowledge of sustainable design strategies that are effective and that will provide potential alternative strategies to achieve the sustainable design and construction goals of their clients' projects. With respect to sustainable design rating systems such as LEED®, this includes maintaining a working knowledge of current credit interpretations, documented innovation credits, and similar items.
- Maintain current knowledge and understanding of updates and new development in sustainable codes, standards, and regulations.

## 2.2.2 Design Team Expectations

As with all projects, the design team should approach sustainable design and construction projects with a high level of commitment and expertise. The members of the design team should be engaged in a continuous process of gaining knowledge and expertise in the field of sustainable design and construction practices, implementation strategies, and innovative approaches to facility design that advance the art and science of sustainable design. There are a wide variety of programs and learning opportunities available in the industry that provide opportunities for all participants in the development of the built environment to acquire the knowledge and expertise necessary to become effective leaders in the practice of sustainable design and construction.

With that commitment, the design team should have similar expectations of the owner, other design and construction team members, material suppliers and product manufacturers, jurisdictional authorities, and other participants in the process of facility development. While the level of each individual's commitment to environmental stewardship may vary, it should be expected that all participants be committed to doing what they can to help create built environments that are sensitive and responsive to the natural environment to the greatest extent possible within the context of the other goals and objectives of the project.

In that context, the design team should expect:

- The cooperation and collaboration of all of the members of the design and construction team throughout the project delivery process.
- The owner to understand that the design team cannot exclusively warrant or guarantee the performance of others in the implementation of specified sustainable design and construction requirements.
- The individual members of the design and construction team to understand that the design team cannot exclusively warrant or guarantee that the project will achieve a certain sustainable design goal or certification level; this can only occur as the result of the efforts of all members of the design and construction team working together and fulfilling each member's responsibilities in a mutually supportive working environment.
- Exceptional project team communications.

## 2.3 Product Manufacturers and Representatives

### 2.3.1 Role and Responsibilities

The market transformation of the green building movement has increased roles and responsibilities for product manufacturers and representatives regarding environmental and sustainability information. The additional environmental and sustainability reporting of products, materials, assemblies, functional performance, compliance, and other product selection and evaluation criteria has emerged along with the green building movement. The US Green Building Council's LEED® Green Building Rating System, Green Globes, the emerging "green" codes, ASHRAE Standard 189.1, CSI's GreenFormat™, GreenSpec®, and other global "green" design and construction guidelines require specific reporting, compliance, and specification of environmental attributes. Material suppliers and their representatives should assist and educate design and construction team members regarding environmental information and related implementation into project specifications and submittals.

Manufacturers should reference the Federal Trade Commission's (FTC's) "Green Guide," which establishes the acceptable use of product certifications and seals of approval, "renewable energy" claims, "renewable materials" claims, and "carbon offset" claims. The Green Guide cautions manufacturers not to make general claims such as "environmentally friendly" or "eco-friendly" because the FTC's consumer perception study confirms that such claims are likely to suggest that the product has specific and

far-reaching environmental benefits. Very few products, if any, have all the attributes perceived from such claims, making these claims nearly impossible to substantiate. If a manufacturer makes an environmental claim, it must be independently substantiated with creditable and verifiable data. Making unsubstantiated environmental claims, or claims that meet one environmental criterion while otherwise having significant environmental impacts, is known as "greenwashing."

Additional responsibilities of product manufacturers and representatives include participation in standards development through the ASTM International E60 Committee on Sustainability, various ASHRAE standards development groups, USGBC–LEED MRTAG (Materials and Resources Technical Advisory Group), participation in code development through the International Codes Council (ICC), and CSI's GreenFormat™ Maintenance Task Team. Participation can be as a committee member or commenter during public review periods.

#### 2.3.1.1 Product Reporting

Responding to reporting requirements for environmental and sustainability attributes typically involves two interdependent but distinctly different documentation tracks:

- Integration of environmental performance requirements into product specifications and submittals.
- Separate documentation required for various "green" building rating programs or code compliance requirements.

Environmental and sustainability reporting requirements have largely focused on single attributes for materials or products such as volatile organic compounds (VOCs) and recycled content reported. However, industry is currently being required to submit more comprehensive assessments of multiple attributes. An educational goal of the environmental and sustainability movement is to help design and construction team members better understand the environmental impacts of manufacturing processes, including upstream supplier impacts, manufacturing processes, and end-of-life (life cycle) through transparent processes.

#### 2.3.1.2 Life Cycle Assessment

Life Cycle Assessment (LCA) is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service by:

- Compiling an inventory of relevant energy and material inputs and environmental releases
- Evaluating the potential environmental impacts associated with identified inputs and releases
- Interpreting the results to help make more informed decisions

(Source: www.iso.org/iso/iso_14000_essentials)

Multiple-attribute environmental and sustainability evaluation of materials has led to utilizing established life cycle assessment standards according to International Standards Organization (ISO) 14040, Environmental Management, Life Cycle Assessment, Principles and Framework.

(Source: www.iso.org/iso/iso_14000_essentials)

ISO 21930, Sustainability in Building Construction–Environmental Declaration of Building Products, is also part of the LCA framework. LCA multiple attributes can then be reported by manufacturers to the construction industry by developing Environmental Product Declarations (EPD) according to ISO 14025. For global manufacturers, managing the LCA requirements of multiple geographies requires understanding each region's reporting requirements and complying with multiple schemes, measures, and protocols related to LCA. There are various approaches to LCA reporting, and before a manufacturer begins its specific product LCA, it is advised to research what LCA its related associations might be developing.

Several other areas of information related to LCA that are in the process of standards development include:

- Chain of Custody: Includes tracking and documenting materials from extraction to installed product
- Manufacturers Extended Responsibilities: Involves concepts on end-of-life that could include manufacturer "take-back" programs and deconstruction/recycling programs

Developing, executing, and implementing environmental material information should, if not mandated, be third-party reviewed and verified by a scientific approach, and substantiated with creditable and verifiable data.

Some manufacturers may not be able to conduct a full LCA and may rely on other reporting tools such as ISO 1402, Environmental Labels and Declarations, Self-declared Environmental Claims (Type II Environmental Labeling) and ASTM E 2129 Standard Practice for Data Collection for Sustainability Assessment of Building Products. Independent verification of self-reporting by third-party organizations is highly recommended for greater creditability. Benchmarking or contributing to the U.S. Life Cycle Inventory Database (www.nrel.gov/lci) hosted by the National Renewable Energy Laboratory may also be useful.

## 2.3.2 GreenFormat™

CSI's GreenFormat™ is another tool that allows manufacturers to self-report environmental attributes, certification, labels, and LCA in a consistent format for the purposes of specifying environmental performance requirements. GreenFormat™ consists of six defined categories, each containing individual subcategories of information about the sustainability of products produced and materials and processes used. The structure supports common methods of specifying and addresses the product's characteristics across its life cycle. GreenFormat™ is consistent with ASTM E2129, Standard Practice for Data Collection for Sustainability Assessment of Building Products. GreenFormat™ works in conjunction with MasterFormat® and UniFormat® and can be applied to all construction products and product categories. Similar to MasterFormat®, it is an outline listing of numbers and titles for categorizing specific types of information regarding the sustainability features of a product:

1. Product General Information
   1.1 Manufacturer Information
   1.2 Product Description

- 1.2.1 MasterFormat® Section number
- 1.2.2 Product Identification
- 1.2.3 Product Description
- 1.2.4 Product Photo(s) or Drawing(s)

2. Product Details
   - 2.1 Standards and Certifications
     - 2.1.1 Third-Party Certification
     - 2.1.2 Second-Party Certification
     - 2.1.3 Self-Declaration of Compliance
   - 2.2 Sustainable Performance Criteria
     Product specific sustainability criteria organized according to MasterFormat® Specifications Group and Division number.
   - 2.3 Sustainable Composition of Product
     - 2.3.1 Composition
     - 2.3.2 Chemical Composition
     - 2.3.3 Recycled Content
     - 2.3.4 Rapidly Renewable Materials
     - 2.3.5 Reused Materials
     - 2.3.6 Emissions
3. Product Life Cycle
   - 3.1 Life Cycle Assessment
   - 3.2 Materials Extraction and Transportation
   - 3.3 Manufacturing
   - 3.4 Construction
   - 3.5 Facility Operations
   - 3.6 Reuse, Recycling, Disposal

Categories 4–6 reserved for Future Use

7. Manufacturer Sustainability Policies
   - 7.1 Environmental Stewardship
   - 7.2 Social Responsibility
   - 7.3 Manufacturing
   - 7.4 Transparency of Information
8. Manufacturer Support Documentation
   - 8.1 Marketing Material
   - 8.2 Standards and Certification Reports
9. Manufacturer Certification
   - 9.1 Authorization of Information
   - 9.2 Technical Representative

Category 3, Product Life Cycle, describes the "phases of a construction material's life cycle, which a design professional may evaluate when selecting a sustainable product. It is not an attempt to collect all the information necessary to perform a life cycle analysis of a product, but only to identify sustainability questions that relate to each phase of a product's entire life."

Category 7, Manufacturer Sustainability Policies, includes information describing the manufacturer's sustainability impacts beyond the specific product being described. It includes initiatives the manufacturer has implemented to improve the environmental impact of its entire operations and initiatives to improve the quality of life for its employees and the communities where their manufacturing operations are located.

Category 9, Manufacturer Certification, provides for identification of the person in the manufacturer's organization who authorized the information presented in GreenFormat compliant product data. It also provides for identification of a technical contact who can respond to specific questions about the information provided in the product data.

(Source: www.greenformat.com/about)

### 2.3.3 GreenSpec®

The online GreenSpec® Product Guide lists over 2,200 environmentally preferable products selected by editors at BuildingGreen, Inc. The Guide includes key insight on the green attributes of each product and the most critical green issues for each product category. Editors at BuildingGreen conduct their own independent research in assessing manufacturer claims, ensuring that the directory contains unbiased, quality information. GreenSpec® does not charge for listings or sell ads. GreenSpec® product listings are accessed on BuildingGreen.com with a subscription to BuildingGreen Suite.

(Source: www.buildinggreen.com/menus)

### 2.3.4 Environmental and Sustainability Product Information

There are many third-party "green" building rating, labeling, and certification programs discussed in Chapter 1 of this Practice Guide regarding the environmental and material sustainability that may be reported by manufacturers. Reporting environmental claims requires subject matter expertise, corporate commitment, and a dedicated team leader. Due to the proliferation of so many environmental "green" labels and product claims, reporting requires clarity and independent third-party verification.

Manufacturers and product representatives are responsible for presenting environmental and sustainability information in a balanced assessment that includes functional performance along with other characteristics of assessment, performance, and compliance. Presenting all product attributes allows for a balanced discussion on trade-offs concerning environmental considerations and functional performance requirements.

### 2.3.5 Corporate Sustainability Reporting

Another emerging reporting method for manufacturers is consideration of corporate sustainability reporting. A sustainability report refers to a single, consolidated disclosure that provides a reasonable and balanced presentation of performance over a fixed time period. Such a report includes social, economic, and environmental footprints (baselines) and goals to improve as part of corporate strategy. One accepted methodology for corporate sustainability reporting is based on Global Reporting Index (GRI) reporting guidelines.

(Source: www.globalreporting.org/AboutGRI/)

# 2.4 Contractor Team

## 2.4.1 Roles and Responsibilities

The contractor has several roles throughout a sustainable design and construction project. The key to understanding these specific roles and responsibilities relies upon the delivery method that is chosen by the owner, which is discussed in Chapter 5 of this Practice Guide. For the purpose of this discussion, it is assumed that the contractor is an integral part of the integrated design and construction process.

### 2.4.1.1 Preconstruction Phase

Preconstruction services provided by the contractor are vital to the success of a sustainable project. When materials and systems are analyzed either through life cycle cost analysis and investment paybacks or for aesthetics, the contractor can provide real-time estimating throughout the design process. This process of pricing materials or systems within a few hours or days at current market conditions and projected maintenance costs, not only maintains budgets throughout the design, but more importantly, allows the owner to make decisions in a timely fashion.

As the design team investigates various mechanical, structural, and architectural systems, the contractor should also provide the team with accurate scheduling information. This does not mean a start and finish date for the project, but includes much more detailed analysis for each system being proposed. The flow and sequence of construction can impact how the building will be built and the costs associated with general conditions and general requirements.

Another preconstruction role that relates to evaluation of sustainably designed systems and project scheduling is a constructability review. The contractor should have comprehensive knowledge of sustainably designed systems and details for various components that have (and have not) worked in the past. It is important through the design process that the contractor (in cooperation with the design team's construction contract administrator) review the construction documents in detail prior to their completion by the design team. This allows for innovation and sharing of sustainable design best practices with the entire team. Making sure that the construction documents are coordinated will provide the owner the best value when the final construction documents are bid to various subcontractors. Understanding the systems and scheduling through constructability reviews will ensure that subcontractors fully understand their responsibility and that pricing between competing subcontractors is optimally competitive.

Sustainable product and material selection begins through collaboration in the preconstruction (design) phase of the project. As the design team defines certain materials, the contractor's input is valuable to the entire team. The contractor may have had successful or unsuccessful experiences with various materials with respect to installation, availability, or replacement, the knowledge of which can benefit the entire team when selecting products and materials. The cost of these products and materials may become another consideration, and the contractor is responsible for providing the design team with current budget pricing information so that appropriate material selections can be made.

The contractor may also be required to document the necessary information to ensure that products specified meet the intent of a sustainable design criterion or green building rating system. The contractor is responsible to ensure that submittal information

is provided so that it can be reviewed and approved by the design team in a timely fashion. Once the submittals are approved and materials are ordered, it is the responsibility of the contractor to verify correct and compliant subcontractor installation. The contractor should take photographs of these products once installed and ensure that products specified are the actual products installed.

Two additional responsibilities of the contractor before the project begins construction are the development of construction waste management (CWM) plans and indoor air quality (IAQ) management plans. Both of these plans are implemented from the start of construction through project completion.

The CWM plan must identify the construction waste and debris that will be diverted from the landfill, the waste recycler, and hauling location, and describe how the waste will be diverted from the landfill. To ensure that waste materials are properly separated, proper signage on dumpsters and waste collection containers is necessary to identify what materials can be disposed of in a compliant manner. The contractor is also required to monitor the recycle containers to ensure that foreign or noncompliant debris does not contaminate the recycle containers. Waste should be tracked by weight or volume through waste hauling tickets. The key to success with construction waste management is educating the subcontractors, to maximize percentages of recycled construction waste and debris, thus meeting contract requirements and best practices policies.

The IAQ management plan helps ensure that future building occupants will not be exposed to construction dust or contaminants in the indoor atmosphere, and may flush out the building with outside air to allow installed products and materials to off-gas prior to occupancy. The contractor should stress the importance of the Sheet Metal and Air-Conditioning Contractors' National Association (SMACNA) Indoor Air Quality subcontractor requirements, which include:

- Protecting HVAC ductwork and equipment.
- Source control or tracking of mud and debris into the building.
- Pathway interruption from a completed area of the building to areas of activity.
- Housekeeping to maintain a clean and safe work site.
- Scheduling material deliveries to minimize stored materials on the site.

The building flush-out procedure needs to be coordinated by the contractor during the preconstruction scheduling efforts. Understanding the required amount of outside air and the time frame to provide off-gassing of materials will also be critical to scheduling and occupancy.

#### 2.4.1.2 Construction Phase

Various sustainable design rating systems have specific requirements for site disturbance, material selection, recycling of construction debris, and overall indoor air quality after construction is completed. It is important for the contractor to comply with the specified sustainability requirements and to implement specified temporary and permanent construction phase controls throughout the entire building process.

Stormwater contamination is a stated concern of the Environmental Protection Agency. Therefore, contractors are required to comply with state, federal, and local erosion and sedimentation control (ESC) requirements. Preventing erosion and sedimentation from entering watersheds is very important, and contractors are to constantly monitor construction means and methods, and make corrections to ensure that

site runoff is not entering receiving streams or storm sewers. The design team will evaluate a variety of measures during the design phase, but the contractor is often required to provide its own ESC plan.

## 2.4.2 Contractor's Expectations

The contractor has expectations of the owner, design team, and its subcontractors and suppliers. It is important to understand these expectations, which must be addressed early in the project delivery process to ensure a successful sustainable construction outcome.

### 2.4.2.1 Preconstruction Phase

Expectations during the design phase begin with identification of sustainable attributes that may be incorporated in the building. These products and materials are to meet sustainable building criteria and be cost effective. The goal with any project is to design it to the established budget and avoid late in the project "value engineering." Working closely with the contractor's real-time costing and scheduling, the design team can make decisions quickly and effectively, and continue to focus on the details.

Another expectation of the contractor is cooperation from the design team when alternative material selections are suggested for cost savings. These discussions are expected to be open and honest, with the owner's best interest kept in mind at all times.

One of the first steps during the design process is to list the sustainable design strategies that will be implemented, and to define the building structure and HVAC systems. The contractor and the design team should work collaboratively on the life cycle cost analysis. The expectation from the contractor is that the design team is proposing cost-effective HVAC systems that will properly address sustainable design issues in relation to the proposed building type. The contractor also expects that the life cycle cost uses the real-time cost provided to the design team instead of square foot "budgets" or "estimates" derived from outside resources. This process will ultimately drive the architectural design, structural components, and electrical requirements. Having this accurate information can keep the project on budget throughout the design process.

### 2.4.2.2 Construction Phase

When the contractor is ready to procure subcontractors, the contractor has certain expectations of its construction partners. First, a subcontractor should well understand the requirements of the documents and required information that will need to be submitted to the design team for approval. Subcontractors are obligated to provide accurate information during the submittal process, including all necessary sustainable attributes pertaining to the product or material they are proposing for installation. The contractor also expects subcontractors to understand the project schedule as it relates to their individual products and services. Establishing dates for completion of work and meeting those dates are crucial to the entire sustainable building process, especially if whole-building commissioning or building flush-out is required.

Additional contractor expectations of the subcontractors include compliance with construction waste management procedures and indoor air quality management plans, use of low-VOC materials, providing products or systems that are highly energy-efficient, and materials specified with proper recycled content and regionally sourced products and materials. Compliance with these items may require the contractor to educate and oversee

subcontractors that have not previously worked on a sustainable construction project. Subcontractors should be required to provide sustainability backup documentation from manufacturers, suppliers, and vendors, including material safety data sheet (MSDS) information. In compliance with Federal Law, the MSDS is in the process of being replaced by a Safety Data Sheet (SDS), which will be complete by 2015.

The contractor should also expect the following from the other members of the design and construction team:

- Construction documents that are complete, concise, correct, and constructible with regard to sustainable design criteria (and all other aspects of the project).
- Achievable project sustainability design requirements, which are specified in a manner that is clear, concise, and correct.
- Sustainable design requirements that are specified to be enforced effectively down the chain of responsibility to subcontractors, suppliers, manufacturers, and other subcontracted entities under the control of the contractor.
- The cooperation and collaboration of each member of the design and construction team throughout the project delivery process.

# 2.5 Commissioning Authority/Agent

## 2.5.1 Roles and Responsibilities

The commissioning process is an integral part of project delivery and contributes significantly to the high performance of a well-designed building. It begins at the programmatic phase by ensuring that the Owner's Project Requirements (OPR) are defined and that the Basis of Design (BoD) captures those goals. The purpose is to verify that the design and construction team achieve those requirements by implementing a comprehensive documented verification process. The net effect is a contribution to the sustainable design and construction process by applying real-world experience in an educational manner, with in-field observation, to ensure design reductions in energy consumption are realized. This value is maximized and more effective when it begins at programming and continues through warranty, providing input and oversight at all project phases.

The underlying reasons why owners would be inclined to contract a commissioning authority or agent (CxA) for their new construction project starts with the likely gap in knowledge that many owner's project managers have concerning the technical details of the MEP systems. While the design team is certainly qualified to provide that expertise and has a contractual obligation to the owner's best interest, the architect/engineer (A/E) is sometimes perceived as being too close to the design. When positioned as a third-party entity, the CxA is solely focused on meeting the owner's project requirements, and can therefore challenge the A/E team to develop more creative solutions in a collaborative environment.

The CxA is defined as the facilitator of the whole building or enhanced commissioning process. It includes peer review activities in the programming and design phase, installation verification in the construction phase, operational verification and oversight of training and closeout documentation in the acceptance phase and persistence of performance in the warranty period. The primary role of the CxA is to validate optimum

operability in meeting specified high-performance design parameters for all building equipment and systems. To accomplish this, there is an obvious technical aspect that is necessary, but just as important is the insight into the human relations and team dynamics in executing the work. The CxA serves as the entity that consistently reinforces each team member's roles and the coordination between them at each phase of the design and construction process. The ultimate goal in that regard is to influence an orderly procedure for all design, construction, and start-up activities.

The commissioning authority/agent's responsibilities include the following:

- Ensure the design documents adhere to energy efficiency goals and owner's requirements.
- Ensure good coordination among team members and provide a framework for construction and start-up-related activities.
- Coordinate the CxA process with the construction.
- Motivate each team member to deliver a fully functional building that meets the owner's project requirements.
- Document that the installed systems meet manufacturers' recommendations and the design team intent.
- Verify installation and test all systems in scope to ensure optimum functionality.
- Ensure that the owner's operating personnel are adequately trained on the operation and maintenance of the building to ensure persistence.

The CxA contributes to the sustainable design and construction process by providing a guiding influence and validation with dynamic and enduring results. When applied correctly and administered with synergy, the CxA contributes greatly to the success of the project as it relates to those systems being commissioned.

The outcomes impacted include:

- Definition and adherence to the owner's requirements
- Clarity of contract documents
- Design and contractor team liability
- Schedule
- Cost
- Constructability
- Maintainability
- Energy savings
- Life cycle
- Ongoing operations

#### 2.5.1.1 Programming and Design Phase

By defining the owner's expectations early in the process, decisions can be made with confidence and the design process is better able to meet schedule and budget and consequently focus on determining the best systems to achieve high performance. The CxA also facilitates the project goals by posing questions for the owner to consider relative to their expectations for energy consumption and environmental responsiveness, and to test the design team's response. Many, if not all, of the above factors are positively influenced through design review by offering thought-provoking comments to inspire a design

which is more energy efficient and easier to maintain and operate. The review consistently refers to the owner's project requirements to ensure the design is in alignment with those goals and the strategies selected offer the most effective system integration.

Once conceptual design and systems approach are reviewed, their associated control sequences are made a priority. Here the CxA offers real-world experience to provide additional insight on reliable, energy-saving programming strategies. The design review also provides an extremely useful set of comments early in the process by discovering gaps in scope or errors. Through a focused peer review, many of those oversights are noted, which reduces risks associated with the design and minimizes the need for construction phase modifications and the potential consequences of added time and cost. The result for the building operator and facility manager is a facility with fewer unknown consequences of erroneous or missed information from the design process.

Lastly, the design review activity provides oversight on specified control points and meters to support real-time data used to continuously monitor system performance and energy consumption. This synergy in benefits among the owner team, design team, and contractor team contributes to a more efficient project delivery process by optimizing design iterations and minimizing misinterpretations.

#### 2.5.1.2 Construction Phase

The construction phase commissioning (Cx) activities begin with finalizing the Cx plan, which is used to ensure that all construction activities and start-up procedures have an orderly process with well-defined responsibilities and required documentation. Also included in this plan is a set of milestone activities with durations for inclusion in the construction schedule. As the process continues, impacts are made by verifying that the equipment submittals meet the design criteria and that those systems, when installed, are in accordance with the construction document requirements and manufacturers' recommendations. Through these construction processes and observations, the coordination of construction trades is enhanced, not only for the specific issue but for future work, by highlighting the importance of trade synchronization. Further, a well-leveraged Cx schedule can minimize unforeseen costs by informing the contractor of issues early before they are repeated.

#### 2.5.1.3 Acceptance Phase

The CxA's role is to ensure that the building is turned over fully functional and the maintenance staff is well trained from early participation through to the formal training. Those characteristics are additionally enhanced through the documentation provided by the CxA.

As part of the Systems Manual (Recommissioning Manual), the CxA provides blank Functional Performance Test (FPT) plans for future recommissioning. With inevitable operator manipulation in response to comfort complaints and other factors, every building deviates from its intended operation over time. These tests reflect the baseline design condition for the systems and so provide the building operator with a repeatable test and protocol to bring the building back to its intended operation so that the persistence of the energy-saving and sustainable design decisions continue through the life of the building.

#### 2.5.1.4 Warranty Period

During the warranty period, the CxA role provides further verification of intended energy savings and optimized operation through a seasonal testing activity that ensures the

system is performing as designed in a fully loaded mode specific to a particular season. The final activity performed by the CxA is perhaps the most important to the sustainable design process. It entails an analysis that provides a verification of persistent optimized performance. This measurement and verification scope includes a process whereby the building is measured for power, temperature, pressure, and other indicator values over the course of a year. The data is then analyzed and compared against the original functional performance tests to validate the systems are continuing to operate in accordance with the design intent. In addition to that operational verification, the data is also analyzed to provide a feedback loop of key values applied to the original modeling design tool. The model is periodically calibrated to reflect actual building operation and use so actual consumption can be analyzed for possible upgrades or retrofits to maximize energy efficiency. The CxA role supports this process by establishing baseline operation criteria so that the data gathered can be used to assess whether actual operation reflects the design intent.

## 2.5.2 Systems Subject to Commissioning

For any given building the defined commissioning process is applied to a variety of systems. The systems selected for commissioning vary depending on the owner's requirements. Typically, they include:

*HVAC Systems:* The HVAC systems and the controls represent one of the largest energy contributors. A properly designed, executed, and operated HVAC system requires a significant amount of coordination between many parties. On most projects this category requires the most intensive effort.

*Domestic Hot Water Systems:* The hot water requirements of a building vary greatly depending on the use type. Hotels, recreation centers, labs, and food service facilities require significant energy and installation of large equipment requiring more oversight. Also, solar domestic water heating systems are now prevalent and require thoughtful integration.

*Automated Lighting Systems:* Except for process buildings, lighting often represents the largest energy consumption; implementing daylighting design that includes sophisticated lighting control systems and various sensors requires full oversight.

*Renewable Energy Systems:* With the cost of renewable solar, wind, hydro-, and geothermal energy systems decreasing and the options increasing, it is important to have a deliberate design and execution of the systems selected.

*Envelope Systems:* A building designed with energy-efficient HVAC systems are only as effective as the building envelope in which they serve. As the built environment has become more focused on energy use, design strategies and product availability for envelope systems have become extensive. Proper placement of construction system components in the building envelope is the focus of this CxA process.

These are the less typical systems to be selected for commissioning, but are worth considering for inclusion based on how they align with the owner's project requirements:

*Electrical Systems:* Power systems run all of the energy-producing equipment installed in a building. Electrical systems can be operating inefficiently while still delivering the power necessary for the building operations. It is therefore advantageous

to commission those systems, particularly when renewable energy generation is installed including batteries, inverters, and net metering.

*Emergency Generators:* Emergency generators are life safety features, but are still important in the commissioning process. When the power grid is off-line, installing renewable energy–powered batteries can replace the need for emergency generators.

*Life Safety Systems:* All life safety systems are critical in assuring that the occupants are unharmed in the event of fire, earthquake, and other disastrous scenarios. Those systems typically include fire suppression and fire alarm enunciator systems, emergency egress lighting, and water booster pumps for fire hoses and sprinklers.

*Food Service Systems:* In buildings where there are extensive food services, efficient energy consumption and effective water systems can be a very high priority. The technology for efficient food service hoods and gas burning equipment has become very sophisticated. Commissioning ensures a proper system setup and installation.

*Irrigation Systems:* Water conservation is important also as it relates to energy consumption. Water collection design, drip technology, and other more advanced irrigation systems are being designed and installed with more frequency, requiring special maintenance oversight.

*Laboratory Systems:* Most facilities supporting laboratory facilities require extensive plumbing systems such as vacuum, reverse-osmosis water treatment, and various process gases. These systems are critical to the success of the science being applied and are a key commissioning item.

Systems listed above are not exhaustive. It is up to the owner, with consideration of the design and construction team recommendations, to decide which systems require validation through commissioning. It should be noted that the qualifications of the CxA can vary, and not all commissioning agents have extensive experience with every type of system. The commissioning agent provides a comprehensive scope of services within a defined process that can be applied to almost every building system type. If the CxA doesn't have direct experience with a particular system, they may subcontract the scope for that system, or otherwise incorporate a learning curve to ensure proper training to become proficient enough to accomplish a comprehensive professional verification.

All of the information provided in this section is intended to educate the reader on the role of the CxA as it relates to sustainable design and construction. The role of the CxA is integral to the sustainable design and construction process, which represents a holistic approach with feedback loops and momentum from one step to the next, resulting in an enhancement of synergies within the design and construction team. This value contributes greatly to influencing good design practice, involvement and training of building operators, and verification of optimized functionality. The lessons learned endure to the next project so that an even better optimized design and construction can be achieved on future projects.

# 2.6 Facility Manager

## 2.6.1 Roles and Responsibilities

The facility manager in many situations could be considered the "owner" of any given building or facility. The facility manager is ultimately responsible for the care and

maintenance of the facility—be it a vertical structure, a roadway, a sewer line, or such intricate structures as central utility plants and fuel farms. In this role, the facility manager must have an ability to influence design and construction projects for the facilities he/she is responsible for. Facility managers understand what it takes to care for the constructed assets that are a part of their portfolio.

Facility managers have a multitude of choices in maintaining their portfolio: in-house or outsourced services? Consultants can serve as extensions to the facility management staff. Specialty contractors can service specific items of equipment/components such as elevators and escalators, boilers, chillers, cooling towers, and security cameras. These specialists become little different from the regular in-house staff, performing duties supposedly in a flawless manner.

The in-house staff could include administrative support personnel, accounting and contracting or procurement personnel, human resources, and then the "shop" staff (carpentry, HVAC, electrical, plumbing, and so forth). All members of the facility management department must work in harmony with the outsourced vendors and contractors to provide a seemingly flawless operational facility.

The facility manager and staff must establish specific goals, roles, and responsibilities for not only the outsourced contractors but the in-house staff. These objectives should target:

- Focus on facilities management skills to manage—maintenance activities
- Embrace a "total cost of ownership" mentality
- Provide services to the tenants of the facilities
- Operate and maintain the buildings and infrastructure as a team in a manner that lessens disruptions to everyday business activities
- Implement sustainable practices in everyday activities in order to minimize the impact on the environment
- Improve project management skills to include the administration: accounting, progress scheduling, and budget
- Train staff to take over not only over time but in order to deal with emergencies

## 2.6.2 Facility Manager's Expectations

A facility manager's decision to embrace a sustainability program may be the result of numerous factors. One might be because of regulatory requirements regardless of whether they are federal, state, or local directives. As a result, a facility might be required by law or ordinance to develop and have a sustainability program or to incorporate certain sustainable practices into their development projects and operations. Some building owners and facility managers have undertaken a sustainability program because it is simply the "right thing" to do.

Overall, specific factors that are driving facility managers to become more operationally sustainable include:

- Worldwide awareness (e.g., global warming discussions)
- Financial and other pressures
- Rising energy costs
- "Green" and environmental mandates
- Aging existing infrastructure

- Facility life cycle costs (e.g., total cost of ownership)
- Enabling technologies
- Enhanced stewardship philosophies

Within any given building or university campus, office building development, apartment complex, a bus, train, or airport terminal context, "sustainability" has broad implications throughout the entire system. Initiating and implementing a sustainability program often results in numerous benefits to the facility manager and ultimately to the facility owner, including:

- Reduced operating costs
- Greater asset utilization
- Lower life cycle costs
- Reduced environmental footprint
- Enhanced customer service
- Optimization of new and better technologies
- Reduced costs of asset development
- Improved bond ratings
- Improved benefits to the community

Implementing any capital improvement program to meet future needs is difficult in the best of circumstances. Owners and facility managers that undertake sustainability programs can often document and take credit for the sustainable initiatives and the benefits that have accrued. Communicating these initiatives to the community, decision-makers, regulators, and interested others can illustrate that the owner/facility manager is proactively responding to mitigate known or even perceived environmental impacts and that they are a good steward within the community.

When considering the initiation of a sustainability program, the rationale for undertaking the effort must be understood throughout management and reporting staff that will be responsible for development and operational activities. The ability to control the daily activities and operations conducted by anyone who utilizes the facilities are often limited.

The facility manager of large, campus-type facilities should expect that the effectiveness of the sustainability program can only be enhanced through the extensive cooperation and involvement of those who inhabit the facilities—the tenants. Consideration should be given for how to train the tenants for successful implementation of the sustainability program. This is a critical component to the successful implementation and maintenance of a sustainability program.

There are numerous definitions of sustainability. Sustainability has been described as a holistic strategy that strives to balance the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainability can encompass many goals and objectives, including environmental stewardship, economic viability, operational efficiencies, and social responsibilities. A sustainability program can incorporate one or all of these components.

A drive for sustainability may result from new management, the community, regulatory requirements, or simply a desire to become more operationally sustainable in order to reduce costs.

When embarking on a sustainability program, it is critical for each facility manager to determine their specific definition of sustainability. This is an important step that establishes the groundwork for future planning and implementation.

# Chapter 3
# Sustainable Design and Construction Best Practices

The expertise of those qualified project team participants identified in Chapter 2 is utilized throughout all phases of design, construction, and occupancy. From the earliest project planning stages, including historic building preservation studies, site optimization is the primary step to a sustainable project development. Once the site is selected, the project team should focus on optimizing the site design; reducing building, site, water, and energy demand; reducing material consumption and waste production; and improving both indoor and outdoor environmental quality for building occupants.

This chapter will review the current industry sustainable design and construction best practices, indicate who is responsible for the strategy and when to implement the strategy on a project, and offer suggestions regarding opportunities for operational data to provide clients or owners a better understanding of the life cycle value of any specific sustainable strategy. Ensuring long-term building operational success is important to the continued improvement of advanced technology designs and new system efficiencies. Sustainable building success starts with the design, is realized during construction, and is most severely influenced by operation and maintenance practices. Paybacks, return on investments, and financial energy incentives can be strong supporting cases to invest in sustainable building design and construction best practices for both new construction and historic preservation projects.

## 3.1 Site Optimization

A sustainable design and construction development's ability to reduce the environmental impact starts well before the facilities are designed. One of the earliest opportunities for environmental impact reduction starts with proper site selection and appropriate land use planning. It is important to properly evaluate the surrounding community, resources, and built environment against the owner's program, including identifying site-specific opportunities and limitations for sustainability.

## 3.1.1 Site Selection Best Practices

Successful project owners incorporate valuable input early from financiers, partners, realtors, developers, architect/engineer (A/E) firms, local authorities or permitting officials, and specialty consultants like geotechnical experts, civil engineers, hydrologists, archeological surveyors, solar or wind consultants, and others to determine if a selected site meets the project's goals and facility requirements. Owners or tenants use the expertise of these consultants to determine a site's suitability for the proposed use and occupants.

Unless it is already preselected as part of a master plan, site selection occurs in the early stages of a project, such as master planning or the conceptual design phase. Multiple criteria can influence a site's sustainable appeal, along with other project constraints like budget and schedule. Connectivity, revitalizing urban areas, building orientation, and existing infrastructure can contribute significantly to the sustainable aspects of a building or development project.

### 3.1.1.1 Links and Connectivity

Selecting a site with links to existing infrastructure and amenities can significantly reduce the overall impact of a development project. Sites located within dense urban communities minimize sprawl, protect vegetated open space, and may reduce the need for personalized vehicular traffic. Building occupants, both commercial and residential, benefit from close proximity to dense existing development through increased access to services and resources.

Valuable features of sustainable connections for previously developed sites include:

- Joint-use facility
- Using existing utility and possibly building infrastructure
- Shared infrastructure costs
- High development density
- Master planned communities
- Links to mass transportation
- Pedestrian paths
- Stimulating proximity to complementary or competing business
- Promoting local economic development
- Links to cultural landmarks, schools, churches, libraries

Smart Growth initiatives (Source: www.smartgrowth.org/) are at the heart of the concept of building development links and connectivity. Some municipalities have implemented Smart Growth initiatives that encourage development, enhance communities, and protect the environment. Smart Growth initiatives promote affordable housing, jobs, services, and transportation within easy access of each other. Constructing a high-efficiency building on a remote site will still have negative environmental impacts if the occupants can only arrive by car and will use that car to access basic services.

The HUD-DOT-EPA Partnership for Sustainable Communities has six Livability Principles:

- Provide more transportation choices
- Promote equitable, affordable housing

- Enhance economic competitiveness
- Support existing communities
- Coordinate and leverage federal policies and investment
- Value communities and neighborhoods

(Source: www.epa.gov/dced/partnership/#livabilityprinciples)

Many cities also have corresponding initiatives such as Living Streets (Source: http://denverlivingstreets.com/) and Strategic Parking Plans (Source: www.denvergov.org/Portals/681/documents/The_Strategic_Parking_Plan_Final.pdf). Living Streets is about making our transportation corridors safe for pedestrians, cyclists, and motorists. In addition, the Living Streets program encourages transportation corridors to be vibrant, welcoming places and not just means to get from one place to another. Strategic Parking plans implement concepts such as shared or centralized parking. For instance, if a church is located along a transit route and its parking lot has minimal use except for Sundays, then that is a prime opportunity for this parking amenity to be shared with weekday commuters. Parking should be located so that in running errands, a person could park once and on foot safely access schools, services, and businesses from that original lot rather than driving to and parking at each destination.

Selecting a site that has access to multiple forms of transportation, where pedestrians and cyclists can arrive safely, reduces the reliance on the single passenger vehicle. The site design should capitalize on connecting with adjacent multimodal transportation services, providing a safe path to interior sidewalks, bicycle storage, and the building entrance.

Connectivity isn't just about transportation and access to services, but is also concerned with tapping into and possibly sharing infrastructure and facilities. Even with on-site renewable energy strategies, most buildings and developments may need to connect to public utilities for power, gas, and water. Selecting a site where these utility services are readily available and can meet the load demands of your project are important criteria in site selection. Putting physical costs aside, the environmental impact of bringing utilities to an undeveloped area or having to increase the capacity of existing utilities will disturb soils, ecosystems, air quality, and require the use of fossil fuels to deliver and install utility components.

School districts are more and more frequently creating Kindergarten through 12th grade (K–12) campuses to capitalize on the economy of scale, joint use of facilities, and shared burden of infrastructure needs. Rather than having elementary, middle school, and high schools located at individual sites within a community, K–12 campuses eliminate the need to provide multiple facilities such as gymnasiums, libraries, parking, athletic fields, transformers, and generators.

#### 3.1.1.2 Orientation—Site and Building

Generally, in the northern hemisphere, to maximize on passive solar heating and natural daylighting, a building should be oriented so that it is long and narrow, with maximum clear exposure to the south and minimum clear exposure to the east and west. This isn't to say that in the year 2030 we will be living in a world of long, skinny buildings all facing in the same direction. Climate, occupancy, building use, drainage patterns, prevailing winds, views, active solar energy systems, street frontage, lot shape, and surrounding topography and construction are all factors that will influence the orientation of your building. The optimal shape and height of a building for a specific site should be determined through a series of studies supported principally through energy modeling.

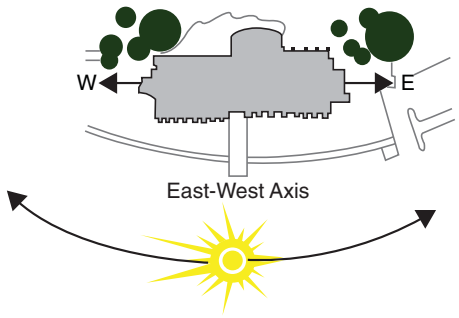


Figure 3.1 Solar orientation

Working with the natural features of a site rather than against them is also a key component of sustainable site design. Balancing excavation and fill of soils to eliminate import or export saves fossil fuels by avoiding efforts to haul soils off-site. As part of the site selection process, a geotechnical survey should be performed to collect information on the suitability of the soils for on-site compaction and backfill. The costs and efforts of developing a site with poor soils should be weighed against the benefits.

Historic drainage patterns should be maintained and stormwater should be conveyed from the site by natural rather than manmade means wherever possible. Berming, retaining ponds, landscape, and pervious surfaces are all natural means of surface drainage. A rainwater collection system for graywater use is one sustainable design consideration with a measurable impact on stormwater runoff.

### 3.1.1.3 Environmental Site Assessment

Site assessments can range from formal environmental impact studies for sensitive areas like wetlands, wildlife, runoff or drainage areas, or even open space buffer zones, to financial analyses that investigate the life cycle cost of the proposed facility and available funding. Increased attention to sustainable redevelopment practices has enforced reforestation, stream protection, erosion control, and surface water runoff containment as minimum project standards for most US regions.

It is also important to identify a proposed project's potential impacts on each utility system. Utilities and service systems can include water service, waste water conveyance and treatment, solid waste conveyance, and electrical, natural gas, telephone, and cable service. Common evaluation questions can include:

- Can the capacity of the existing utilities meet the loads of the proposed project?
- Will the municipal infrastructure need to be upgraded or upsized to serve the new project?
- Do improving and expanding existing utilities have a beneficial result for the surrounding community?
- What utilities are not available and need to be site generated?

New technologies in utility infrastructure can enhance efficiency and energy performance. For instance, the efficiency and security of electricity delivery systems are enhanced by state-of-the-art sensors and system automation software. Much like a building automation system, power outages can be located and repaired from a central control system rather than in the field. As part of the entitlement process to gain zoning approval

for a proposed project, utility districts will review the utility plans and specifications for compliance with their standards and utility master plans.

#### 3.1.1.4 Existing Facility or New Building Site

Evaluate proposed project goals with consideration for both new building sites and existing facility reuse. Benefits and constraints will exist for all project types, and must be closely evaluated with the facility's future needs. In most cases, sustainable best practices encourage the rehabilitation or reuse of existing structures. Location and connectivity, rehabilitation expenses, project schedule, disruptions to existing client business, site-specific constraints like security, future expansion, access, and use type will all influence the selection of a previously developed or undeveloped project site.

#### 3.1.1.5 Local Codes, Regulations, Standards, and Incentives

Investigate local codes, standards, and zoning for each prospective site. These local land use, design, and construction governing authorities establish a project's baseline for performance. To deliver a sustainable high-performance building project, project teams are expected to exceed or significantly improve upon the local codes and standards referenced for a particular project and site location. The degree to which a project exceeds local or referenced standards and codes often indicates the ability to successfully integrate sustainable features into a project.

For every site-specific zoning code, reference standard, or permitted land use requirement, there is a sustainable best practice to consider when developing the site. Based on the typical local jurisdictions, the following best practices are recommended for sustainable site development:

- Provide more vegetated, pervious open-space area than required by code to promote stormwater management, recharge the local aquifer, enhance biodiversity, restore habitats and ecosystems, increase development density ratio, and reduce the surrounding heat island effect.
- Provide mass transit service as a trade-off to submit for a variance to allow less parking than mandated by local code to reduce heat island effect, minimize emissions from personal vehicular traffic, and decrease impervious surfaces that contribute to stormwater pollution.

Provide more covered (stacked) parking than specified by local code to reduce the local heat island effect, minimize stormwater runoff, and increase development density ratio and allowable vegetated open-space area.

Some sustainable site best practices may present challenges to particular projects. For example, local code may include a building height restriction. Development height restrictions exist for any variety of reasons, like preserving available sight lines, compliance with local aviation or airport requirements, or protecting solar access, or even to maintain uniformity or consistency in a surrounding building area according to a set urban plan. In this example, although best practice for site development would include increased building density with more floors, the project must adhere to local height restrictions and limit the design height or apply for special variances to increase the project's development density ratio to preserve vegetated open-space area to more effectively manage stormwater.

## 3.1.2 Site Design Best Practices

Site design has usually already commenced during the site selection process. A site was selected based on balancing the pros and cons of various criteria as discussed above. Sites were test-fitted using those criteria. However, when the A/E team does not have input on the site selection, then those criteria should be carefully reevaluated to identify optimum or adequate conditions, and problematic constraints.

### 3.1.2.1 Previously Developed Sites

Previously developed sites can present great challenges and opportunities. A previously developed site may be the best choice because the existing conditions are favorable to the project goals and requirements. There may be little need for demolition of the existing site hardscape, landscape, and even more importantly, the existing building. Demolition and new construction contribute significantly more to greenhouse gas emissions, so rehabilitating existing building stock and developed sites reduces the environmental impact of construction. In addition, previously developed sites are often equipped with existing utilities or development infrastructure, therefore minimizing project cost for overall site development.

### 3.1.2.2 Brownfield Sites and Remediation

Rehabilitating an environmentally damaged site (brownfield) in lieu of selecting an undeveloped site (greenfield) can have immense environmental and community benefits. An environmental health engineering consultant should be retained to perform hazardous materials surveys of existing facilities, environmental testing and site assessments, as well as developing abatement and remediation plans to be executed by licensed abatement contractors. ASTM E 1527 Standard Practice for Environmental Site Assessments and ASTM E 1903 Standard Guide for Environmental Site Assessments are both procedural guides recognized and accepted by local jurisdictions to evaluate your site's qualification as a brownfield.

### 3.1.2.3 Site Lighting

Site lighting should be just that, lighting your site and not the sky or adjacent properties. Site lighting is important for safety, security, and way-finding before and after daylight hours, but it should not be a nuisance. Poor lighting strategies can disrupt nocturnal ecosystems and biological cycles for humans, animals, and plants. Other effects of poor lighting, like glare, can even create safety hazards and decreased market value to surrounding properties. Lighting is a significant operational cost; therefore, project measures to reduce associated electric loads should be acceptable with an effective investment payback.

Most municipalities require full cutoff fixtures for site lighting, to shield the emitted light, to keep site lighting from polluting the night sky.

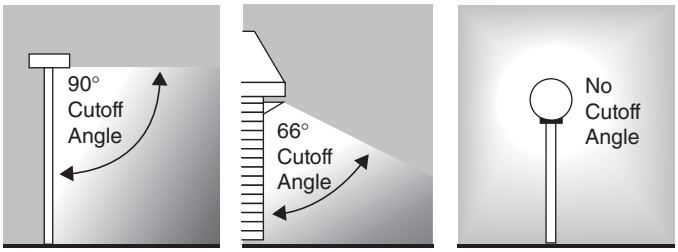


Figure 3.2 Lighting cutoff diagram

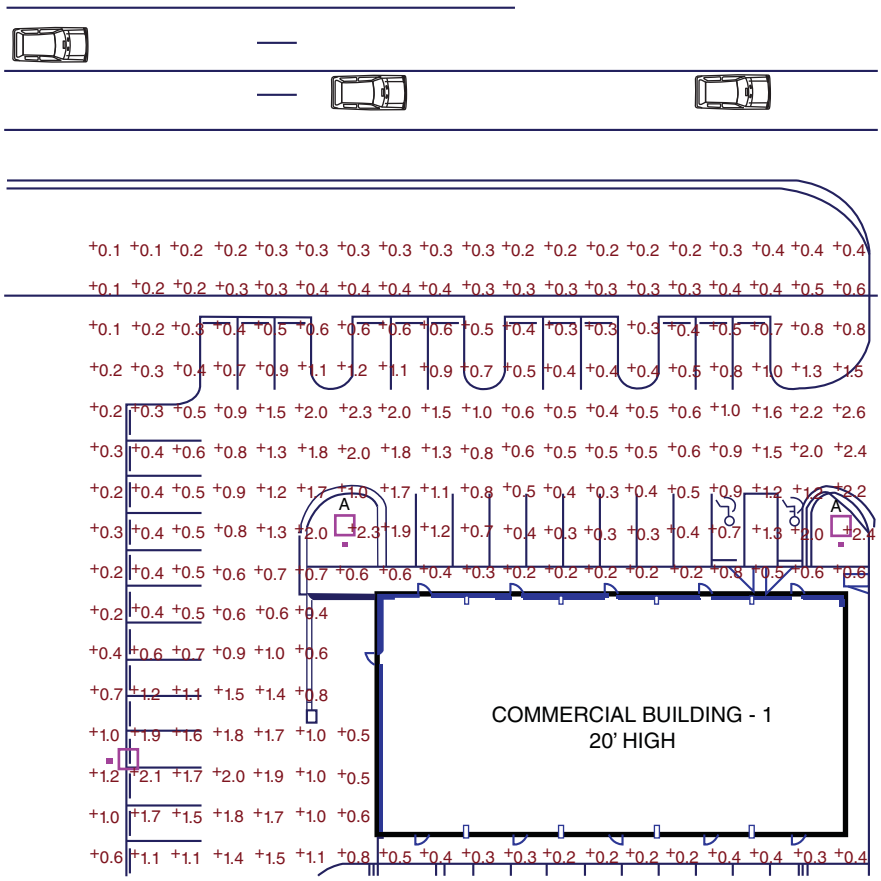


Figure 3.3 Site lighting photometric plan; shows building, exterior light fixtures, and grid pattern of lighting foot candle levels for the entire site plan.

The height and light output of fixtures at the perimeter of the site should be designed and located so that no more than 1 foot candle of lighting level can be measured at or beyond the property line. Most municipalities require that a site lighting photometric plan and lighting fixture cut sheets be submitted for zoning approval before a site can be approved for development.

### 3.1.2.4 Hardscape Surfaces

It has been shown that dark surfaces such as paving and roofing contribute to the heat island effect of developed areas. An urban center can have its own microclimate due to black roofs and asphalt paving that raise the ambient temperature several degrees. To reduce the impact that the manmade environment has on the surrounding climate, the amount of dark surfaces should be minimized or mitigated using shading devices or trees and other vegetation. Substituting pervious paving material types for conventional hardscape areas may also aid in reducing the heat island effect. Examples of alternative hard surface material types may include pedestrian walkways made of wooden decking, well-spaced paver stones, permeable pavers, or crushed gravel, or fire lanes and overflow parking areas made of open-grid, reinforced turf paver systems or pervious concrete paving.

### 3.1.2.5 Stormwater Management

Civil engineers are responsible for designing the site's watershed plan. Processing, storing, and treating stormwater on-site before it enters the stormwater sewer, or other municipal

wastewater system, reduces the burden of new development on the existing infrastructure and preserves existing stormwater hydrology. If stormwater is detained or retained on-site, then the quality of the stormwater is improved and the quantity is reduced. Some of the following are means to improve postdevelopment quality and reduce quantity leaving the site:

- Infiltration basins
- Pervious paving
- Open-grid pavement systems
- Rainwater harvesting
- Retention basins
- Detention basins
- Drywells
- Detention vaults
- Vegetated green roofs
- Vegetated swales

Site constraints may limit available space for detention ponds or other large stormwater management strategies. In all instances, optimize the site's ability to absorb rain into groundwater by filtering it through soil or other pervious materials, and ultimately draining slowly into local streams, rivers, and natural bodies of water well after the actual storm event.

## 3.1.3 Site Construction Best Practices

Local climate and regional environmental concerns will influence the specific site compliance standards for each project. The on-site general contractor is the responsible party for managing site-related construction best practices, including oversight of all participating subcontractors. It is important for the design and owner teams to incorporate these practices into the contract documents to ensure contract compliance for project site participants.

### 3.1.3.1 Stormwater Protection and Pollution Prevention

Commonly referred to as the "SWPPP" on a jobsite, or the Storm Water Protection and Pollution Plan, the civil engineer specifies best erosion and sedimentation controls for the general contractor to implement during construction, including:

- Silt or filter-fabric fencing
- Straw-bale dams and jute netting
- Inlet protection
- Site runoff treatment
- Soil stabilization
- Geotextiles and bio-engineering
- Sediment traps
- Temporary or permanent hydroseeding
- Vehicular track-off or soil tackifiers
- Concrete wash-out
- Stockpiling requirements
- Slope protection

**Figure 3.4** Inlet and back of curb protection
Big Red Curb Inlet Protector by ASP Enterprises

- Plant protection zones around tree driplines
- Guarding against stream siltation or groundwater contamination
- Ensuring site clearing does not go beyond a minimum distance from the building perimeter
- Low-impact site clearing and grading methods

### 3.1.3.2 Best Neighbor Construction Practices

Project construction sites within existing dense urban communities come with an extra challenge to minimize impacts on neighbors and their businesses. Early community reach-out programs, including holding public meetings, can help facilitate project acceptance and approval. Best practices to consider when developing a neighbor-friendly site logistics plan include:

- Dust or airborne particulate control
- Noise control
- Limiting construction work hours to acceptable times
- Rules regarding use of public facilities
- Soil erosion and local street cleaning
- Preventing local waterway sedimentation
- Construction emissions reduction including no truck idling

### 3.1.3.3 Contractor's Footprint

Projects seeking to reduce their overall environmental footprint may also encourage or require the site contractor to provide sustainable construction management services. Contractors may consider alternative site power supply sources like biodiesel generators, photovoltaic solar panels on top of construction trailers, portable fuel cells to serve as

temporary site power supplies, and other technologies like fuel cell forklifts. Construction administration on-site can be made further environmentally conscious by incorporating recycled content paper, recycling waste disposables, and EnergyStar®–rated office printers, copiers, computers, and monitors. Additional strategies may include restrictions for employee or worker parking to help minimize the transportation impacts associated with workers or laborers traveling to and from the jobsite and even requirements for biofuel or alternative fuel power–supplied construction equipment.

## 3.2 Energy Performance and Conservation

At a minimum, the energy performance of a proposed structure must comply with current energy codes. The following best practices are means to increase energy performance beyond code compliance. Energy performance is enhanced when applying integrated design, enhanced commissioning, and measurement and verification. Programs and organizations are available to assist facility managers and design teams to increase energy performance for design and building operation.

### 3.2.1 Energy Demand

Reducing external and internal loads is critical to improving energy performance. Integrated project delivery is a process through which load reduction is most successful.

External loads are primarily climatic, and include:

- Sun
- Wind
- Water and water vapor
- High- and low-temperature extremes

The effects of external loads on a building's energy performance are mitigated by several factors: the size and mass of a building; shape and orientation; glass to wall ratio; glazing performance; opening treatments; thermal performance of the building envelope; and shading.

Internal loads include:

- Lighting
- Plug loads
- Process loads, which may include: washers and dryers; kitchen dishwashers, ovens, stovetops, and other appliances
- Elevators and escalators

#### 3.2.1.1 External Load Demands

Energy modeling can give feedback on the optimal mass, shape, materials, finishes, and orientation of a building on a particular site. Glass to wall ratio, glazing properties, daylighting design parameters, and building envelope performance are the data that can

be manipulated in energy modeling to get answers to building mass and orientation. Keep these parameters to a minimum to simplify the early phases of design. It is recommended to manipulate one data point at a time to discover what component has the most impact.

In most climate zones and construction types, the International Energy Conservation Code (IECC) requires a minimum R-value of continuous insulation. Increasing R-values of continuous insulation in wall and roof assemblies will net the greatest external load reduction over higher R-values in between stud batt insulation. ASHRAE Standard 90.1 prescribes a maximum window to wall ratio of 40 percent. A higher window to wall ratio means more solar heat gain and loss with a low R-value for the wall assembly. There is also a threshold of glazing percentage where too little will impact natural daylighting goals and increase the required lighting power density (LPD). Glazing for natural daylighting is located a minimum of 5′-6″ above the floor level. Depending upon orientation and shading, glazing below 3′-0″ above floor level can cause glare and be detrimental to building envelope performance.

To reduce solar heat gain during the cooling season, use shading devices to keep the sun out when it is high in the sky. The sun is lower during warming seasons, so the length of the shading devices should allow winter sun to penetrate when passive solar heating is desired.

#### 3.2.1.2 Internal Load Demands

Lighting Power Density (LPD) is one of the internal loads which a design team has the most ability to manipulate. LPD is measured in watts per square foot, which is energy consumption versus lumens or foot candles that are a measure of lighting levels. Provide the greatest lighting levels where required. For instance, an office space could have an overall lighting level of 30 foot candles, and individual task lighting at desks can boost the lighting levels where they are most needed, at the work surface. Other strategies to reduce lighting energy consumption include:

- *Task Lighting.* Select high-efficiency fixtures that provide the greatest lumens per watt.
- *Surrounding Surfaces.* Design spaces with surfaces that have high reflectance levels for ceilings and 80 percent of wall surfaces in spaces that would benefit from high light levels. Save darker finishes for accent areas and spaces where lighting levels aren't as critical.
- *Lighting Controls.* Use occupancy sensors for private offices, areas not occupied consistently like toilets and storage rooms, under-cabinet lighting, and task lighting. Daylight photosensor systems can take advantage of available natural daylight, turning off electric fixtures when they are not needed and operating shading and reflecting systems to optimize conditions. Provide dimming for lights that are within 20 feet of windows to integrate with daylighting controls.

Plug loads are computers and other appliances. Energy consumption of these loads can be reduced by installing controllers at the electrical outlets to eliminate phantom energy loss when equipment is not in use.

Other internal loads are process loads and conveyance equipment. Process loads can be reduced by selecting high-efficiency equipment, providing 25 percent or greater efficiency over standard options.

Beyond integrated design and reducing external and internal loads, ventilation and load shifting can also increase energy efficiency, but to a lesser extent. Carbon dioxide

($CO_2$) and occupancy sensors are a means of controlling variable air volume HVAC systems (VAV) so that ventilation is only provided on demand, assuming that spaces served are not occupied 100 percent of the time. In temperate climates, recycling system-produced energy or leveraging temperature differences to improve efficiency through the use of economizers are cost effective. In climates with periods of extreme heat and cold, using energy recovery ventilators (ERV) to exchange energy between the exhaust stream and the supply stream are a better option. For optimal energy performance, both economizers and ERVs may be installed.

## 3.2.2 Renewable Energy Supply

Technological advances and government incentive programs have made solar power more accessible to commercial and residential construction. Building integrated systems (BIS) allow for the solar technology to serve a dual purpose: to be a wall or roof component and a means of generating energy. BIS panels weigh less and are more aesthetically pleasing than conventional solar panels. Solar energy can be used for generating electricity, heating water, passive heating, and newly emerging technologies for thermally driven air conditioning.

Wind technology is generally used to provide power to large industries, farms, and municipalities. Large wind turbines provide 1 megawatt (MW) of power whereas small turbines provide 100 kilowatts (KW). Mid-sized turbines generating electricity between these capacities are less common but available. Small turbines are more useful as an educational tool for hands-on learning about wind technology. Unless your project is very large-scale, to reap the benefits of wind power and promote further advances in wind technology, the most effective course of action may be to enroll in a green power program. Some utility companies offer the choice to pay an additional premium for wind power. But if the project is located where the wind is consistently blowing at a speed that averages from 25 to 35 miles per hour (mph), then installing wind turbines can be cost effective.

Hydroelectric generation systems, at a smaller scale than large dam infrastructures, are available that take advantage of the energy in moving water from flowing rivers and waterfalls to ocean wave and tidal action. Waterpower has been used before specifically during America's early history to create mechanical power for use by mills and factories. Municipalities and industries are again revisiting taking advantage of the local natural features to install small hydroelectric generators to augment their power supply, which can also be used for reliable carbon-free emergency power.

Geothermal power plants are located in places of sustained volcanic activity, like the geysers in northern California (source: www.geo-energy.org/plants.aspx), that take advantage of the local geothermal energy to generate electricity (source: http://geo-energy.org/Basics.aspx). Most other places can harvest geothermal energy using the constant 45°F (7°C) to 70°F (21°C) average temperature of the earth depending on latitude. This is done with geothermal or ground-sourced heat pumps (GHPs/GSHPs) using open-loop or closed-loop systems, installed horizontally under the frost line or vertically in standing columns, for facility heating and cooling needs.

GHPs have heating efficiencies of 50 to 70 percent higher (source: GHPs/GSHPs efficiencies: www.igshpa.okstate.edu/geothermal/faq.htm) than other heating systems and cooling efficiencies 20 to 40 percent higher than available air conditioners. The US EPA and DOE (source: EPA & DOE info: www.igshpa.okstate.edu/geothermal/residential.htm and "Space Conditioning: The Next Frontier," EPA 430-R-93–004, April 1993)

estimates that GHPs are 48 percent more efficient than the most efficient gas furnace and 75 percent more than the best oil furnace. GHPs require 25 to 50 percent less energy than other HVAC systems and reduce operation and maintenance costs by 40 percent.

## 3.2.3 Performance Maintenance and Improvement

The efficiency of building systems such as HVAC and lighting can be monitored and adjusted postoccupancy by way of measurement and verification protocols and commissioning. These strategies ensure that the building systems perform as designed. They are also a means for tracking and decision making for modifications to ensure consistent energy savings.

### 3.2.3.1 Building Automation Systems

A Building Automation System (BAS) integrates the controls and gauges of building equipment that are capable of being monitored. It is a centralized computer system that monitors building systems and delivers the information to facility managers and building maintenance staff in an accessible and easy to understand format, and may also be used to automatically send signals to stop, start, or adjust equipment to preprogrammed settings and schedules. Even operable windows can be integrated into the BAS to take advantage of natural ventilation during temperate weather or ensure the windows are closed when mechanical ventilation/heating/cooling is required. Monitoring all building systems capitalizes on sustainable strategies such as solar/wind power flow, $CO_2$ monitors, daylight photosensors, water temperature, air temperature, and humidity so that each works in harmony with the HVAC system to expend energy only where and when it is needed.

### 3.2.3.2 Commissioning

Commissioning should begin early in the design phase of a project. The Owner's Project Requirements (OPR) and Basis of Design (BoD) are tools for establishing a performance measuring stick. These tools are developed by the owner, A/E team, and the commissioning agent (CxA). The owner's project requirements are the performance expectations, sustainability goals, and intended use for the completed project. Climate, operations, occupancy, and required standards and codes form the basis of design.

A CxA will review the drawings and specifications to ensure that the systems are designed, detailed, and specified to be bid and built in compliance with the OPR and BoD. These are elements of the Commissioning Plan which is started during design and updated throughout the construction phase. During construction, the CxA will review MEP submittals from the contractor for compliance. The CxA will periodically visit the construction site to monitor and inspect the installation of the MEP systems and controls. Another component of the commissioning plan is building operation and preventative maintenance demonstration and training for maintenance staff. The CxA is also integral to the system start-up and closeout procedures at the end of construction, just prior to occupancy. Closeout procedures include testing, adjusting, and cleaning so that the systems are operating within the design parameters of performance. Postoccupancy performance reviews are imperative, as they are a means of checking and balancing the efforts expended in design and construction to ensure the owner's goals and requirements are met.

# 3.3 Water Use and Conservation

A project's regional location will largely influence the concern for water conservation for most projects. In other words, strategies for reuse, recapture, and reduction of water supply sources may be more easily accepted or approved for projects located in arid, dry, desert-type regional climates, if regulation allows. No matter the level of local concern regarding water conservation, every project should enforce the best water-conserving strategies possible.

Water conservation can be generally categorized by the following:

- Outdoor Water Use Reduction
- Indoor Potable Water Use Reduction
- Process Equipment Water Use Reduction

## 3.3.1 Outdoor Water Use Reduction

Irrigation is the largest outdoor potable water demand for most projects. Landscape architects and irrigation control specialists can provide valuable expertise during the early design development stages to help reduce total potable water applied to the site and landscape features. Projects should incorporate the following best practice strategies to help reduce the use of water for outdoor irrigation needs:

Specify a native landscape and use regional plant species (Xeriscape™ principles; defined by trademark reference as "water-efficient choices in planting and irrigation design like well-adapted plants, soil and climate analysis, reduced turf areas, passive solar design, Evergreen trees as year-round sun and wind protection").

When required, specify high-efficiency drip irrigation systems (weather-sensored, climate data input).

Consider alternative nonpotable water source supply (municipally provided nonpotable water or on-site recapture and reuse of either rainwater and/or graywater).

Provide continuous metering of landscape water use to monitor the need for operational maintenance requirements like fixing leaks or repairing irrigation equipment.

In most cases, a quantifiable reduction of potable water for the site can be detected with the simple combination of landscape Xeriscape design plant specifications, and significant reduction for irrigation water by using alternative nonpotable water sources. If this is to be implemented, the design team should evaluate possible alternative supply sources early in the project design phase. Strategies like rainwater capture and reuse, garden roof water capture, process equipment water recapture and reuse, or even municipally provided nonpotable water supply (commonly called "purple pipe"), all require intense coordination between the landscape architect, civil engineer, structural engineer, plumbing engineer, mechanical engineer, general contractor, and even the permitting inspectors and local code officials.

## 3.3.2 Indoor Potable Water Use Reduction

Although many different or unique building features may consume water on a project, like artistic fountains or water walls, the most frequently specified water savings

**Table 3.1** Fixture Flow Rates for Standard Baseline, Average Conserving, and Maximum Conserving–Water Fixtures

| Fixture Type & Baseline Use* | Average Water-Conserving Alternate | Potential Water Savings Approach |
|---|---|---|
| Water Closet (1.6 gpf) | Dual-Flush WC (1.6 gpf and 0.8 gpf flush options) or Low-Flow WC (1.28 gpf) | Composting or Waterless WC (0 gpf) |
| Urinal (1.0 gpf) | Low-Flow Urinals (0.12 gpf or pint flush or 0.5 gpf) | Waterless Urinal |
| Kitchen Sink (2.2 gpm) | Reduced Flow Kitchen Sink (1.5 – 2.0 gpm) | Ultra-Low-Flow Kitchen Sink (0.5 gpm) |
| Public Lavatory Sink and Aerators (0.5 gpm* @ 60 psi) | Reduced Flow or Metered Sinks (0.25 – 0.5 gpm) | Ultra-Low-Flow Lavatory Sink with Aerators or Metering (0.25 gpm) |
| Private Lavatory Sink and Aerators (2.2 gpm* @ 60 psi) | Reduced Flow Sink (0.5 – 2.0 gpm) | Ultra-Low-Flow Lavatory Sink with Aerator (0.25 – 0.5 gpm) |
| Shower Heads (2.5 gpm* @ 80 psi) | Reduced Flow Shower Head (1.5 – 2.2 gpm) | Ultra-Low-Flow Shower Head (0.5 – 1.0 gpm) |

*UPC & IPC Standards

gpf = gallons per flush; gpm = gallons per minute; psf = pounds per square inch

strategies are targeted to the traditional water closet, urinal, faucets, and shower. Flow fixtures, like showers, lavatories, and kitchen sinks, can be specified with reduced flow, often designated as a "WaterSense Label" product. WaterSense Label–qualifying fixtures are 20 percent more efficient than average products in the same category, according to the EPA.

(Source: www.epa.gov/WaterSense/about_us/watersense_label.html)

Flow fixtures may also feature additional water savings functions like autosensor timing. Flush fixtures come in a variety of options to reduce the overall potable water demand, including dual-flush, low-flow, ultra-low-flow, waterless, and composting models. Flush fixtures can also be classified as WaterSense Label signifying the product meets third-party testing verification for water savings.

## 3.3.3 Process Water Use Reduction

Process water is defined as the water loads necessary to support mechanical or energy-related building equipment. Common examples of process water include wastewater, and chiller blowdown, from a condenser or conditioning system. Mechanical equipment, kitchen equipment, and industrial equipment like water-jet cutting of stone or metal, and for washing farm produce, medical equipment, and even specialty equipment like car-washing would be classified as process water use loads.

Best practices to conserve water demand related to process water loads is to specify EnergyStar®–rated (source: www.energystar.gov) equipment and integrate meters for each piece of equipment to continuously monitor and verify equipment performance standards.

### 3.3.4 Reused, Recycled, and Reclaimed Water Use

In all of the water applications listed above, outdoor irrigation water use, indoor flow and flush fixture water use, and even certain equipment process water use, opportunity may exist to apply reclaimed or reused water within the design. "Reclaimed" water could range from collected rainwater on-site to recycled wastewater from showers or mechanical equipment inside the building. Confirm with local building officials regarding reclaimed and reuse water applications within a building, or even for on-site applications, to ensure appropriate permit compliance and approval. The likely presence of hazardous chemicals in various soaps, shampoos, and cleaners used in a shower requires mitigating treatment before introducing the used water into the landscape.

Common examples of water reuse on a project may include:

- Captured rainwater used for landscape irrigation or filtered and used for flush fixtures
- Reclaimed and treated graywater from showers used for landscape irrigation, or filtered and used for flush fixtures
- Recycled chiller condensate used for landscape irrigation, or filtered and used for flush fixtures

## 3.4 Materials and Resources

Sustainable materials and systems are by definition great performers. Durability, constructability, safety, maintainability, and life cycle costs are all sustainable material performance criteria as well. Green products selection and system evaluation are covered in more detail in the following chapter.

### 3.4.1 Material Design

#### 3.4.1.1 Reused Materials

Reused materials can be salvaged items from an existing building or materials that have been repurposed from another source. Reuse of existing materials reduces the impact that manufacturing, shipping, and installation have on the environment. Reused materials should be evaluated for their durability, safety, and ease of application along with meeting project requirements. Preservation and reuse of historic building materials are covered in further detail in the final section of this chapter.

### 3.4.1.2 Chemical Sources

Construction materials and finishes contribute significantly to indoor environmental quality. The manufacture and disposal of construction materials also has significant environmental impact. There are federal, state, and local environmental standards and regulations that govern the allowable quantities of certain chemicals and compounds in building materials. Beyond meeting government regulations, there are options that meet more stringent established standards that can improve indoor air quality and occupant health:

- Low or Zero Volatile Organic Compounds (VOC) of hazardous air pollutants (HAP)
- No added urea formaldehyde (NAF)
- Mercury, lead, cadmium, and copper-free products
- No persistent organic pollutants (POPs)
  (Source: http://chm.pops.int/convention/ThePOPs/The12initialPOPs/tabid/296/language/en-US/Default.aspx)
- No persistent, bio-accumulative, and toxic chemicals (PBT)
  (Source: www.epa.gov/pbt/pubs/fact.htm)
- No halogenated organic compounds

### 3.4.1.3 Recycled Content

Recycled content is defined in accordance with the International Organization of Standards document, ISO 14021, Environmental Labels and Declarations—Self-declared Environmental Claims (Type II environmental labeling). Recycled content can be post-consumer and/or preconsumer.

More and more manufacturers are sourcing recycled content for their products and recycling their own manufacturing waste by returning it to the production stream. Construction materials that commonly have recycled content are:

- Steel, aluminum, and other metals
- Gypsum board
- Glass
- Carpet
- Concrete and masonry
- Ceramic, porcelain, and glass tile
- Plastics
- Cellulose, fiberglass, and other insulation types

### 3.4.1.4 Regional Sourcing

Regionally sourced materials are those whose contents are extracted, harvested, or recovered and manufactured within a specified distance of the project site. LEED Version 3.0 defines regionally sourced materials as those that meet the above criteria and can be found within a 500-mile radius of the proposed project. For instance, a project in Denver, Colorado, would source regional materials anywhere within the state and the adjacent areas of New Mexico, Oklahoma, Kansas, Nebraska, Wyoming, Arizona, and Utah that fall within the 500-mile radius of Denver (Figure 3.5). Regionally sourced materials reduce the environmental impact of transportation and support regional economies and the local workforce.

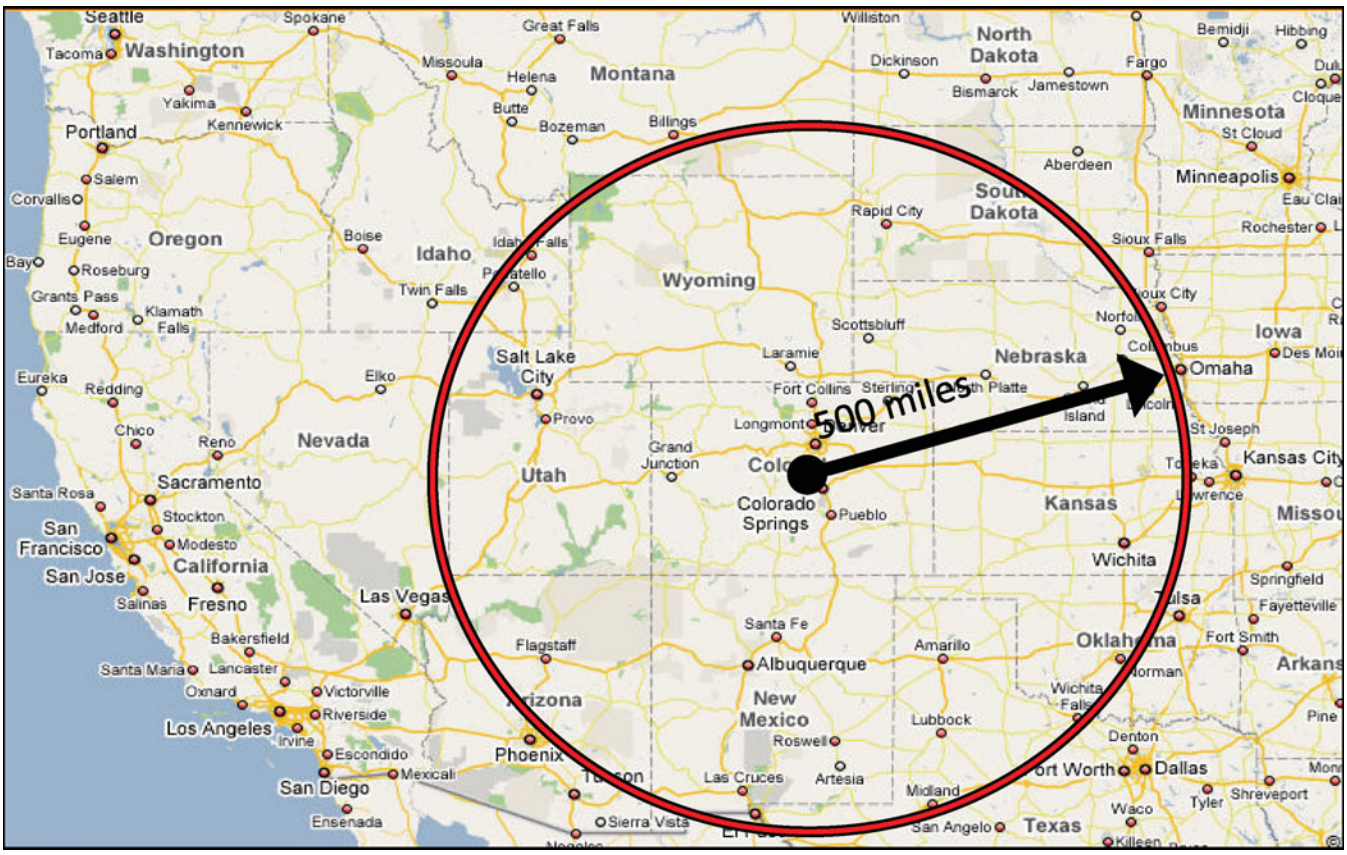


Figure 3.5 Regional map showing 500-mile radius from Denver project site

The proposed LEED Version 4.0 Rating System takes regional sourcing a step further. It encourages the use of products and materials that have been extracted or sourced in a responsible manner and that have life cycle information available. Under the proposed system, the use of products that are sourced—i.e. extracted, manufactured, or purchased—within 100 miles of a project site are included in the credit achievement calculation.

### 3.4.1.5 Rapid Resource Renewal

Rapidly renewable materials are those manufactured from plant crops or sources that are planted and reharvested on a 10-year or shorter cycle. Rapidly renewable materials should be selected based on their life cycle cost analysis, proven durability, maintainability, and meeting project requirements as some rapidly renewable materials may not be appropriate for certain climates or applications. Examples of rapidly renewable materials include:

- Bamboo
- Cork
- Cotton Batt Insulation
- Hemp
- Natural Linoleum
- Strawboard
- Wheatboard

- Wheatsheet
- Agrifiber Products
- Wool
- Carpet

### 3.4.1.6 Sustainable Harvesting

The Forest Stewardship Council (FSC) Principles and Criteria define responsibly managed forests as those that are managed to meet the social, economic, ecological, cultural, and spiritual needs of present and future generations. The FSC is one of many sustainable forestry certification programs, and currently the only one officially recognized by the US Green Building Council's LEEDv3 rating systems. Sourcing sustainably harvested wood encourages environmentally responsible forest management and helps to protect this natural resource for future generations.

Illegally sourced wood is typically harvested using unsustainable harvesting methods with devastating environmental and local socioeconomic impacts. The United States regulates wood products based on the Lacey Act as amended in 2008 (7 CFR 340.6(d)), which specifically combats trafficking in illegal plants including timber and wood products sourced both domestically and internationally. Internationally sourced timber and wood products are governed by the referenced lists maintained by the Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora.

The one other established sustainable forestry program that competes globally with FSC is PEFC, the Geneva-based Programme for the Endorsement of Forest Certification schemes that includes as members the North American programs: the Sustainable Forestry Initiative (SFI); the American Tree Farm System (ATFS); and the Canadian Standards Association (CSA). FSC includes measuring sustainable socioeconomic impacts of sustainable forestry practices while PEFC member systems do not currently do so.

References:


- PEFC. Programme for the Endorsement of Forest Certification schemes; based on PEFC Annex 4 Chain of Custody standard; www.pefc.org
- SFI. Sustainable Forestry Initiative, Washington, DC; www.sfiprogram.org
- ATFS. American Tree Farm System Certified; www.treefarmsystem.org
- CSA. Canadian Standards Association; http://certifiedwood.csa.ca


### 3.4.1.7 Furnishings and Furniture Systems

Many furniture manufacturers provide furniture and modular systems that feature recycled content, low VOC, increased durability, flexibility, and a manufacturer's buy-back program. These options are a key component to ensuring healthy indoor air quality and a reduced environmental impact associated with the tenant or owner's furniture package buy-out.

Although furniture, fixtures, and equipment (FF&E) are commonly part of the owner's responsibility or scope on a project, the design team may support the client's selection of appropriate furnishing systems to coordinate with occupant views and to specify sustainable qualities or attributes.

### 3.4.1.8 Waste Recycling

It is typically up to the tenant to determine if they want to recycle the operational waste from a building. Occupant participation and training can influence the success for most

waste reduction programs. Operational policies like environmentally preferred purchasing programs (EPPs) and hazardous waste disposal programs for batteries and lamp ballasts are growing in popularity in the US market.

Architects should consider how the building design impacts the waste production cycle for typical building operations. Consider an additional area at the loading dock to accommodate a recycling program, or a millwork layout in the break room that allows easy access to alternative waste diversion streams. Depending on the project's end use, special consideration may be required for facilities with potential food waste composting, organic matter recycling, or medical waste recycling.

Commonly recycled and recyclable occupant waste:

- Aluminum
- Office paper
- Cardboard
- Plastic or glass bottles and food containers
- Plastic bags
- Chipboard
- Junk mail and magazines

Compostable occupant waste:

- Coffee grinds and filters, tea bags
- Bread, rice, and other baked products
- Napkins, paper towels, paper plates
- Bio-based plastic cups, forks, knives, and spoons
- Flowers
- Vegetable and fruit peels, seeds, and cores

## 3.4.2 Material and Resource Construction

In any development project, waste results from the use of materials during the construction phase. In addition, waste is continuously produced in facilities as the occupants operate their businesses and the building serves its intended use. Waste management and mitigation start in the design process and continue through construction and into the occupancy phase.

### 3.4.2.1 Construction Waste Recycling

During the construction phase, the general contractor develops a site Construction Waste Management Plan and requires all site participants to comply. The site construction team promotes the minimization of construction waste through salvage and reuse of existing materials and by recycling. Subcontractors and suppliers can contribute through prefabrication, factory assembly, and other shop fabrication methods that reduce on-site waste. Designers may also contribute with a building design that incorporates standard modular material and product dimensions.

Contractors are encouraged to implement commingled waste management strategies to help reduce subcontractor "sorting" labor time and the potential for contaminated and rejected hauls. If commingled site waste management is not available, the contractor

should then consider the available site space necessary to accommodate separate material receptacles for recycling.

A project's safety program can be impacted by jobsite recycling. Waste reduction and jobsite recycling promotes a clean jobsite, which contributes to an increased safety factor. Safe projects are efficient jobsites, which directly relate to improved schedule and cost savings. From estimating, to mobilization, and even to scheduling the work through project completion, sustainable site management practices should be integrated into a contractor's construction means, methods, and protocols.

### 3.4.2.2 Training the Trades

A site's success with implementing sustainable construction management best practices is greatly influenced by subcontractor and supplier buy-in participation. Trades and specialty contractors have the ability to reduce the negative impacts of construction through:

- Optimizing material transportation
- Optimizing material packaging to adequately protect and be reusable or recyclable
- Prefabrication
- Contributing to clean jobsites
- Reducing waste and scrap generation on-site
- Protecting work in place
- Participating in on-site Sustainable Waste and IAQ Management Plans
- Participating in rideshare programs to and from the site
- Minimizing the site footprint with efficient temporary utilities and site offices
- Operating low-emissions construction equipment on-site
- Providing sustainable documentation submittals efficiently and accurately

A trained workforce is critical for providing cutting-edge technologies and systems that are often specified in energy-efficient buildings. Sustainable projects emphasize the need for specific advanced technology tradespeople and training. Professional certificates or credentials exist now for specialty trades related to sustainable buildings, including the commissioning agent (CxA), energy modeler, indoor air quality specialist, recycling hauler, biodiesel equipment operator, certified energy auditor, certified solar site assessor or installer, and many more.

## 3.5 Environmental Quality

Airborne allergens and particulates, organic and chemical biohazards, combustion products, and machine-generated irritants negatively affect indoor air quality (IAQ). Best practices for protecting IAQ include natural and mechanical ventilation with the use of green building materials. Air quality is just one component of a healthy building environment. Other factors that impact Indoor Environmental Quality (IEQ) include thermal comfort, lighting, views, and acoustics. A healthy building environment has been proven to increase productivity in schools and businesses, increase retail sales in stores, reduce absenteeism due to illness, and increase staff retention.

## 3.5.1 Indoor Environment

### 3.5.1.1 Mechanical and Natural Ventilation Systems

ASHRAE 90.1 requires all buildings to be provided with mechanical ventilation. The amount of ventilation required is based upon the occupancy of each individual room. Areas of assembly require more ventilation than individual offices. Ventilation requirements are also based on use and equipment operation. Ventilation can be designed to exceed code requirements or be supplemented by natural ventilation. Ventilation systems should be integrated into the building controls.

Although the mechanical engineer is the predominant responsible party to verify airflow calculations meet, or exceed, minimum ventilation requirements, input from the owner and architect is also valuable to understand space programming and occupancy schedules within the building. Early input during the design stage is valuable to minimize the negative impacts associated with the trade-offs of increased ventilation and energy consumption.

### 3.5.1.2 Thermal Comfort

Air velocity, temperature, path of air flow, and relative humidity all impact thermal comfort. At a minimum, HVAC zones are designed to recognize that exposure, occupancy, and use should be treated differently. Energy recovery ventilators can take rejected heat from one area and supply to another. For instance, a west-facing zone may call for cooling in the afternoon/evening hours, whereas an east-facing zone is calling for heat. Individual controls provide even greater opportunity for the thermal comfort of building occupants. As part of maintaining and improving building performance, occupants should be surveyed on a quarterly basis as to whether their thermal comfort needs are being met, in order for adjustments to be made accordingly.

### 3.5.1.3 Acoustics

The quality of acoustics affects an occupant's ability to communicate, concentrate, and retain information. Acoustic quality can be impacted by noise from HVAC and other equipment, plumbing, the exterior, and from building occupants. Mechanical equipment is a major contributor to background or "white" noise in a building. Because of this, ASHRAE standards for sound and vibration control provide guidelines for the selection, placement, and installation of mechanical equipment. Abating noise from other equipment and occupants is achieved through the selection of tested wall assemblies with a Sound Transmission Class (STC) rating of 50 or greater and acoustic ceiling materials (including lights and diffusers) that have a Noise Reduction Coefficient (NRC) of 0.70 or higher. Exterior noises and vibrations are addressed with the application of weather seals on openings, the addition of vestibules, and isolation caulks, pads, springs, and gaskets.

### 3.5.1.4 Daylight

Illumination by natural daylight has been proven to increase productivity in schools and businesses and retail sales in stores. Natural daylighting reduces the dependence on the use of artificial light with a related reduction in power use and heat gain. Daylighting is achieved through several parameters such as building shape and orientation, location

and height of glazing, and glazing properties tailored to each circumstance. The negative impacts of glare, heat gain, and fluctuations in daylight availability must be addressed by the design. Daylighting is also a strategy for reducing external loads on a building's energy system.

#### 3.5.1.5 Views

In conjunction with daylighting, occupant views contribute to a healthy indoor environment and contented building occupants. Views should be provided in regularly occupied areas to provide the occupants with a connection to the outdoors, to be able to see sky, trees, changes in the weather, sunrise, sunset, in order to generally support human circadian rhythms. Views from the interior can look out onto places of respite, a landmark in the distance, or pedestrian activity. Research shows that people experience positive health benefits from having access and views to nature. Interior spaces can gain access to vision glazing at the exterior through partial-height walls and interior borrowed light glazing.

#### 3.5.1.6 Low-Emitting Materials

The following interior building materials and finishes commonly contribute to indoor air quality:

- Adhesives and Sealants
- Paints and Coatings
- Flooring Systems
- Composite Wood and Agrifiber Products
- Furniture and Furnishings
- Ceiling and Wall Systems

To benefit long-term indoor air quality, specify these items with a low or zero VOC content. Occupants can be physically sensitive in varying degrees to potential off-gassing from these building components. Independent certification organizations establish limits and provide product data on low and zero VOC options. Chapter 4 lists examples of these organizations.

## 3.5.2 Outdoor Environment

### 3.5.2.1 Tobacco Smoke Control

Many cities and states have passed laws that make it illegal to smoke in public facilities and spaces. Where these laws do not exist, implementing their regulations as a best practice contributes to indoor air quality. Essentially, tobacco smoking is prohibited throughout all interior spaces of a building, except those designated as smoking rooms that are sealed off from the remainder of the building and provided with a dedicated exhaust system. LEED prohibits smoking around the exterior of a building within 25 feet of building entrances, intake louvers, and operable windows. A designated smoking area should be carefully planned during site design and layout so that tobacco smoke is prevented from entering the building through openings or the ventilation system.

#### 3.5.2.2 Connection to Outdoors

Providing building users with access to nature such as places of respite and healing gardens also contributes to an overall healthy building environment and satisfied occupants. Taking a break to get some fresh air and sunshine, to watch clouds and clear the head are all means of relieving stress and providing mood-lifting benefits. These components of the site design should be considered early on in the process and integrated along with views, stormwater drainage, hardscaped and landscaped areas.

### 3.5.3 Construction Indoor Air Quality

During construction, the general contractor instructs the field team in the best Indoor Air Quality Management practices for the building. The contractor is encouraged to enlist the support of the mechanical subcontractor to ensure the site is compliant with the SMACNA (Sheet Metal and Air Conditioning Contractors' National Association (source: www.smacna.org) IAQ Guidelines for Occupied Buildings under Construction, 2007, Chapter 3 standard. SMACNA outlines five steps to improve construction indoor air quality:

Protect the HVAC ventilation system from dust and contaminants during transport, construction, and final installation with plastic or protective covering. Additional strategies for HVAC protection may include temporary filtration during construction and replacement of all filter media prior to occupancy.

Source control examples include careful specification for low-emitting materials, avoiding exhaust from idling or gasoline-fueled tools and equipment, and ventilating toxic materials that have been isolated.

Pathway interruption focuses on preventing dust and odors from transferring to clean or occupied spaces. Isolate areas with temporary barriers and depressurize the work area during construction to prevent cross-contamination to clean spaces.

Housekeeping helps to control contaminants. Vacuums with high-efficiency filters, dusters with wetting agents, and environmentally friendly cleaning chemicals and supplies should be used during construction cleaning.

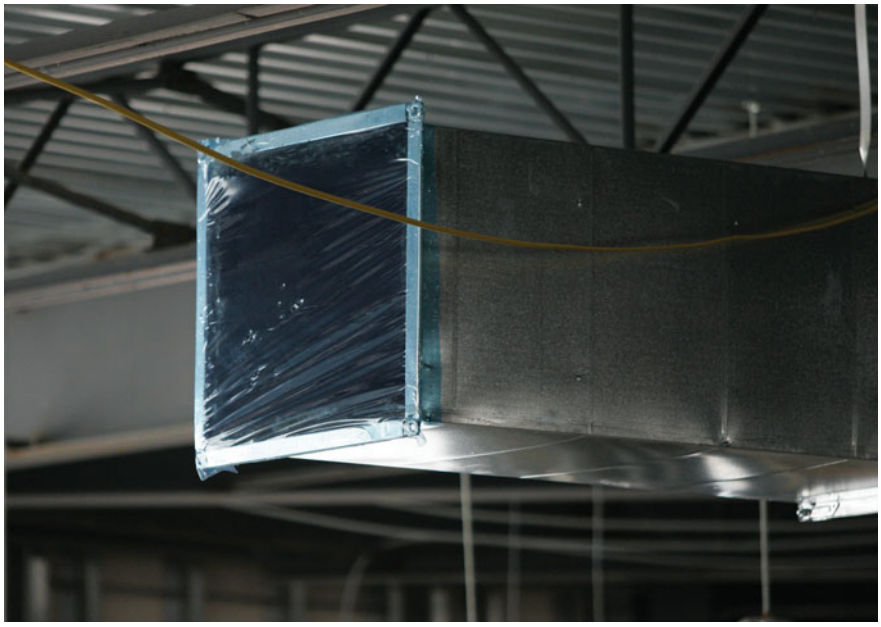

**Figure 3.6** Duct protection
Courtesy of Eaton

**Figure 3.7** Covered cement board

Photo courtesy of USG Corp. (Jackie Peterson, photographer)

Schedule and sequencing is managed by the general contractor. Consider off-hour installation times for processes or systems that involve high pollution potential. Avoid scheduling absorptive material installation immediately after high-polluting or off-gassing activities. Schedule equipment installation to correspond to delivery dates to avoid on-site storage, damage, and potential contamination to new equipment and material, commonly referred to as the Just-in-Time delivery method. Provide specifications for product storage and handling requirements for owner-furnished products that arrive on-site to allow for potential off-gassing or cleaning. Instruct and manage trades and subcontractors to perform required IAQ best practices in regular site field meetings.

**Points to consider for a construction indoor air quality management plan include:**

- Purpose or Goal of Construction IAQ Plan
- SMACNA Best Management Practices: HVAC Protection, Source Control, Pathway Interruption, Housekeeping, Scheduling
- Identify Strategy or SMACNA Practice
- When will it be implemented?
- Where will it be implemented on the project?
- Who is responsible for implementing it?
- Who is responsible for maintaining it?
- How will quality measures be controlled?
- Will permanent ventilation equipment be used during construction?
- Will the subcontractors participate in IAQ meetings?
- Who is responsible for documenting practices with time-stamped photos?
- How will communication between general contractor and subcontractors be managed?
- Have all phases of preconstruction, construction, and postoccupancy or closeout been considered?

#### 3.5.3.1 Testing

At the end of construction, before occupancy, a general contractor can conduct an indoor air quality test to sample the building atmosphere to confirm or identify possible hazardous off-gassing agents or particulate matter. The air sampling test may be conducted by a third-party testing agency or even the project's mechanical subcontractor if they provide the service and own the equipment. If a project fails an IAQ test, the team can be required to conduct a controlled flush-out to provide the project with clean air quality.

#### 3.5.3.2 Building Flush-Out

A project building flush-out is a purge of a specified volume of outside air to assist in eliminating toxic fumes, gases, volatile organic compounds, and particulates from the air at the end of construction, prior to occupancy. Flush-outs should be specified to comply with specific temperature and humidity ranges, as well as meet a certain volume of air or duration of air to validate the activity is complete. The general contractor is typically responsible for conducting and managing the project flush-out, with assistance from the mechanical contractor. A commissioning agent should be employed to observe the flush-out. All subcontractors are expected to comply with stipulated IAQ management plan requirements.

#### 3.5.3.3 Filtration During Construction

Sustainable design and construction standards strongly promote the use of filters during construction and throughout occupancy. Projects should specify proper filtration during the construction period, and high-quality filter media for the operations phase of the facility. Project specifications should include clear instructions regarding permanent equipment use during construction to condition the building including filter change-out schedules and filtration media rating requirements.

Filter performance is commonly referred to as the MERV rating, or Minimum Efficiency Reporting Value. MERV is a filter rating established by ASHRAE Standard 52.2. A typical office building may only have MERV 6 or 8 filters, whereas a hospital may have MERV 16–rated filters for improved air quality. Increased air improvement related to filtration media can have an inverse effect on energy use, so be aware of increased motor fan power to push larger volumes of air through increased filtration levels.

## 3.6 Historic Preservation and Rehabilitation

The rehabilitation of our existing buildings is a fundamentally sustainable and "green" endeavor. From the recapture of the embodied energy (refer to Section 1.1.3 in Chapter 1) found in our existing buildings to the repurposing of historic and perhaps functionally obsolete buildings and structures to the maintenance of the architectural heritage of our communities, the rehabilitation of our existing buildings is a critical component in any long-term strategy for sustainable design and development. In a social context, it can also be argued that both the basic rehabilitation of our existing architectural heritage and

the design of those rehabilitation projects using sustainable strategies is the most socially responsible approach.

The idea that the existing fabric and built form should be preserved wherever possible, and that new energy efficient systems and sustainable materials should be incorporated into the project as part of a new sustainable design, are sometimes in conflict with each other. The question is not really whether these concepts are mutually exclusive however, but rather how the project design team can take advantage of and incorporate the best of each of these approaches into a cohesive and holistic design that is environmentally, socially, and fiscally responsible. As with any project, it should be understood at the outset that not all sustainable strategies may be available or appropriate and that flexibility on both the historic and sustainable sides is necessary. Remember that an integrated design approach will often lead to a successful solution.

## 3.6.1 Historic Rehabilitation Opportunities

The key to development of a successful sustainable rehabilitation project is striking a balance between the requirements of the rehabilitation project versus the sustainable project. This balance is best achieved by examining those features inherent in the historic preservation/rehabilitation projects that are also fundamentally sustainable in nature.

### 3.6.1.1 Nature of Preservation Projects

As noted above, the rehabilitation of our existing buildings is a fundamentally sustainable pursuit. As such, there are both historical and aesthetic issues that will need to be addressed—"historical" in the sense that existing fabric and building characteristics need to be retained and worked with in a coherent manner, and "aesthetic" in the sense that new work must function and coexist in harmony with the historic original.

**3.6.1.1.1 Urban Projects** Historic preservation and rehabilitation projects tend to be found in areas that have long been developed. Redevelopment of these areas is basically Smart Growth at its most basic (refer to Section 3.1.1.1). Generally, sustainable opportunities such as Site Selection, Development Density & Community Connectivity, and Access to Public Transportation (in the LEED Version 3.0 rating system) are readily achievable and should be pursued. The proposed LEED Version 4.0 rating system recognizes the importance of neighborhood development by adding a new category called "Location and Transportation." The credits in this category are closely related to the LEED for Neighborhood Development Rating System. It should be further noted that these opportunities are sensible whether or not a project is historic in nature.

**3.6.1.1.2 Restoration of Historic Fabric** The requirements for historic preservation and rehabilitation projects as outlined in the Secretary's Standards for Rehabilitation (refer to Section 3.6.2.3) generally will require preservation and maintenance of existing historic fabric that contributes to the character of the building. This requirement is completely in agreement with a sustainable design approach, contributing to sustainability opportunities for building and materials reuse, and even construction waste management. In addition, thermal insulation can often be unobtrusively added as part of the reroofing and exterior wall renovation portions of the project, which results in an overall increased energy efficiency of the building envelope.

**3.6.1.1.3 Natural Ventilation and Daylighting** Historic buildings of a certain vintage were constructed before the advent of air conditioning systems and, in some cases, even electricity. As such, these buildings were designed to take advantage of fundamentally sustainable features such as natural building ventilation and daylighting. Sustainable opportunities for these components, such as increasing energy efficiency by adding new thermal storm sashes to restored operable windows (or even through the use of high-efficiency thermal windows where appropriate), can and should be pursued wherever possible.

**3.6.1.1.4 Material Selection** As with any sustainable project, new construction or rehabilitation alike, the selection of materials will play an important role and can be pursued with complete consistency between sustainable and historic preservation goals. Ecologically friendly, local, and renewable materials can easily be selected, as can low-VOC materials. In the reroofing portion of the project, high reflectivity roof materials can usually be specified without compromising the historic nature of the building.

### 3.6.1.2 Mechanical/Electrical/Plumbing Systems

Although natural ventilation and daylighting are often effective "low tech" approaches in a sustainable historic rehabilitation project, there are also a number of opportunities for the incorporation of sustainable principles as part of the mechanical/electrical/plumbing (M/E/P) portions of the project. Historic rehabilitation projects often present the opportunity for complete replacement of the M/E/P systems, which at minimum allows the selection of new highly energy efficient systems and equipment.

**3.6.1.2.1 New Technologies** The substantial or complete replacement of M/E/P systems also provides the project design team the opportunity to consider the use of new cutting-edge technologies for the project. The use of solar, geothermal, and other alternative energy supply sources can often be incorporated into the project without affecting the historic aesthetic of the building. In fact, these new technologies are often developed to be unobtrusive and so not only allow for better energy use and efficiency, but also allow for the ready incorporation of the new technology into the physical plant and systems of the rehabilitated historic building.

**3.6.1.2.2 Indoor Environmental Quality** In addition to the many advantages obtained by the increased use of natural ventilation and daylighting inherent in many historic projects, there are a number of other opportunities related to the improvement of indoor environmental quality that can be pursued without compromise of the historic nature of the rehabilitated building. For example, the design and installation of $CO_2$ monitoring sensors, the introduction of daylight photosensors to monitor and control the output of artificial lighting sources, and the implementation of thermal comfort and lighting systems that allow user control are all types of advanced systems controls that can be readily incorporated into the renovated project without visual intrusion.

**3.6.1.2.3 Water Conservation and Efficiency** Opportunities for sustainable design in the area of water efficiency that may also be pursued without discernible aesthetic effect on the historic project, include rainwater harvesting, graywater reuse, and the specification and use of reduced-flow plumbing fixtures and waterless urinals. The goal again is to take advantage of technologies that can be used with minimal effect on the historic aesthetic of the building versus what would usually be used in any given project.

## 3.6.2 Financial Opportunities

### 3.6.2.1 Historic Rehabilitation

In today's economic climate, it is often necessary for building owners to obtain project financing by a widening variety of methods. For historic buildings, this can often be through the use of state and federal Historic Investment Tax Credits (HITCs). (Refer to Section 1.1.9 in Chapter 1.)

The federal tax credit is administered by the Department of the Interior and is currently provided as the rate of 20 percent of qualified project rehabilitation costs. Information on the requirements of the federal HITC program can be obtained from the National Park Service (source: www.nps.gov/hps/tps/tax/ incentives/essentials_1.htm).

State credits are currently offered in 30 states, with the value of the credits varying from state to state. A good source of general information on using state tax credits is the National Trust Community Investment Corporation (source: http://ntcicfunds.com/tax-credit-basics/state-basics/), a subsidiary of the National Trust for Historic Preservation. Although the various state programs are generally based on the federal program model, the state programs vary widely regarding participating project qualifications and program conditions. Because of this, it will be important to contact the State Historic Preservation Officer (SHPO) in the subject project's state to obtain current information on the applicable state's programs. Contact information for your project's SHPO can be obtained from the National Conference of State Historic Preservation Officers (source: www.ncshpo.org/).

In an HITC project, the owner/developer can use these anticipated credits as financial equity in the project, which helps offset the project financing requirements and can also make the project more attractive to potential lenders and investors.

### 3.6.2.2 Sustainable Opportunities

Similarly, sustainable projects can help to offset project costs by allowing the owner/developer to take advantage of certain energy incentives and other credits for sustainable design. Some current financial energy incentives are illustrated in Table 3.2. It should be noted that these types of incentives often have "sunset" expiration provisions, so it will be important to get current information on available energy incentives early in the project. In addition, sustainable design features built into a project can provide a longer-term life cycle building cost incentive in the form of lower energy and maintenance costs over the full life of the building which, although not a first cost incentive, will also improve the project's overall financial feasibility.

### 3.6.2.3 Secretary of the Interior Standards

In exchange for the opportunities made available to owner/developers via the use of Historic Investment Tax Credits (HITCs), the federal and various state governments have adopted standards to govern the design and development of these projects. At the federal level, these standards are those promulgated by the Department of the Interior, known as The Secretary of the Interior's Standards for Rehabilitation. The various states have generally adopted the federal standards, and in some cases have supplemented the federal standards with additional state requirements for the use of state HITCs.

(Source: The Secretary of the Interior's Standards for Rehabilitation www.nps.gov/hps/tps/tax/rhb/index.htm)

Table 3.2 Financial Energy Incentives

| Type | Incentive | Managing Entity | Purpose |
|---|---|---|---|
| Tax Deduction | $0.30 to $1.80 per square foot | U.S. Internal Revenue Service | To encourage development of energy-efficient commercial buildings |
| Tax Deduction | Up to 30% of equipment cost | U.S. Internal Revenue Service | To offset construction costs associated with implementation of new energy technologies, such as active solar equipment, fuel cells, and microturbines |
| Loan | Variable | U.S. Department of Energy | Loan guarantees to encourage the development and use of new or significantly improved energy technologies |
| Rebate | Variable by jurisdiction | Local power company | To offset construction costs associated with implementation of new energy technologies, such as new refrigerants and energy efficient lighting |
| Tax Credit | Credit on real estate taxes. Variable by jurisdiction | Local tax authority | To encourage development of energy-efficient buildings. Credit for 30% energy savings. |
| Energy Savings Account (ESA) | 100% of eligible costs up to 25% of total project cost | Efficiency Vermont | Allows large businesses in Vermont who pay over $5,000 in Energy Efficiency Charges (EEC) to use those payments to offset the cost of projects to improve energy efficiency |

(Current as of May, 2013)

### 3.6.2.4 Sustainable Design Guidelines

Unlike the HITC guidelines, which were developed at the federal level but are generally consistent from state to state, the guidelines for sustainable design features have been developed and are administered by the various rating agencies and programs. A comprehensive discussion of these rating agencies and programs is included in Chapter 1, Section 1.4 of this Practice Guide.

# Chapter 4
# Green Product and System Evaluation

Buildings are constructed of products, materials, and systems. The design selection process for these is based on the consideration of aesthetic qualities, performance characteristics, and life safety contributions. Sustainable design and construction additionally requires that consideration of "greenness" or environmental friendliness be added to the list of considerations for product selection and evaluation.

The expanded list of considerations includes environmental factors such as energy consumed and thereby embodied in the manufacture of products, materials, and systems. Also included is consideration of chemical components that give the products and materials their aesthetic appeal, waterproof capabilities, or ability to resist fire. A further consideration is an examination of certain practices that occur during the process of constructing the project, for instance, on-site fabrication of components, method of transporting materials to the project site, and field finishing of unfinished materials. Any of those processes can contaminate the project site by creating pollution, waste, and noise.

The dilemma for the building design and construction professional is how to deal with environmental concerns and still create and build a project within the budget and time constraints. Dealing with environmental considerations during design and construction is the subject of this chapter. Included are discussions of the various considerations and suggestions of strategies for dealing with them that enable all members of the design and construction team to contribute to a resolution.

The process of product and system evaluation through the added lens of sustainability begins with identifying project criteria and ends with the resultant impact of these choices.

## 4.1 Identify Project Criteria

### 4.1.1 Owner's Project Requirements

The owner's project requirements (OPRs) need to be developed in the predesign phase of the project to assist the design team in understanding the owner's objectives and criteria for the project. Information about the project's program is gathered from various sources and provides the groundwork for the designers' efforts at programming. The

owner's project requirements form the basis for all design and construction decisions. These requirements are often changed during the design process as the owner's objectives and criteria are clarified when the owner selects the building systems and products.

The owner's project requirements document details of the functional requirements for the project as well as the owner's expectations of how it will be used and operated. It includes project and design goals, performance criteria, material, product and system preferences, budget information, schedules, and supporting information. The project requirements also capture information provided by the designers and is used to define the owner's project objectives and specific criteria for selecting materials, products, and building systems.

Performance categories typically used in the process of identifying and documenting material, product, and system preferences include:

- Structural requirements
- Fire and life safety
- Health and hygiene
- Humidity and thermal comfort
- Lighting
- Acoustics
- Functionality
- Maintainability
- Constructability or buildability
- Budgeted costs

Additional sustainability requirements include:

- Energy efficiency
- Water conservation
- Environmental responsiveness to the site by the building design, dynamically through the days and seasons
- Life cycle costing including material durability and low maintenance
- Reuse, repurpose, and continuous recyclability of materials and products
- Indoor environmental quality including use of low/no-VOC and no-HAP materials
- Sourcing of raw materials
- Views and natural sunlight
- Natural ventilation
- Sustainable return on investment

The owner's project requirements provide the starting point and foundation for the design team in the evaluation and selection of building materials, products, and systems. The design team's response to these requirements is captured in a document called the "basis of design."

## 4.1.2 Basis of Design

A basis of design (BoD) document records the assumptions made by the designers in response to the owner's project requirements. The basis of design document describes,

in a narrative format, the materials, products, and systems that are proposed by the design team to respond to the owner's project requirements. Typically, this document is created during the schematic design phase of the project and is in addition to the construction documents that are developed by the design team over the course of the project.

Basis of design documents include concepts, calculations, decisions, and material, product, and system selections made using the owner's program requirements. These documents usually contain both narrative descriptions and specific assumptions made by the design team. They also delineate the reasoning behind the assumptions made by the design team.

A BoD document typically describes the:

- Specific codes, standards, and guidelines that were taken into consideration during design.
- Information regarding environmental conditions that impact the design.
- Generic descriptions of materials, products, and systems.
- Fire suppression, mechanical, plumbing, electrical, communication, and security requirements.

### 4.1.3 Project Budget and Schedule

It is important to establish the construction budget and schedule for design and construction early in the project development process. As the project progresses from schematic design through construction documents and into bidding the budget will constantly be reassessed to take into account the additional product information that is incorporated.

Consideration of the type and availability of products, materials, and systems with attributes that help a project become sustainable can impact the budget and schedule. It is important to verify the availability and cost of these products and determine their impacts. Bidder reaction to the use of these products should be investigated. Bidders will often increase their bid if they encounter new or unfamiliar requirements in the project documents. Therefore, it is important to clearly and as simply as possible describe the products, materials, and building systems including special requirements. Percentages of recycled content, limitations for volatile organic compounds, percentage of products manufactured within the project's region, special certifications for wood or equipment, and other sustainable attributes are examples of special requirements. It is also important to clearly describe each required submittal, quality assurance, and installation requirement, as well as other items unique to the sustainable criteria. This clarity assists the bidder, and the ultimately successful contractor, to understand the additional requirements and helps avoid inflated bid amounts intended to cover uncertainty. Doing so should limit the impact of uncertainty on the schedule in either obtaining or installing products, materials, and systems, with the exception of unforeseen difficulties.

### 4.1.4 Federal Mandates

Sustainable design project initiatives are impacted by US federal policy mandates made by acts of Congress and Executive Orders (EOs) issued by the White House. EOs impacting sustainable design are as follows:

The **National Environmental Policy Act** of 1969 (NEPA) requires all branches of the US government to perform Environmental Assessments (EAs) and Environmental

Impact Statements (EISs) for proposed airports, buildings, military complexes, highways, parkland purchases, and other federal projects.

The **Clean Air Act** of 1970 (CAA) with the 1990 amendments set controls and standards on air quality. Besides setting vehicle emission standards the CAA also applies to utilities, manufacturers, processors, and refineries. It requires the installation of pollution control equipment to reduce emissions, and for polluting facilities to obtain operating permits.

The **Clean Water Act** of 1972 (CWA) as amended in 1977, implemented pollution control programs including industry wastewater standards, and set water quality standards for contaminants in surface waters. Discharging pollution into navigable waters requires obtaining a permit to control the release of recognized contaminants.

The **Endangered Species Act** of 1973 (ESA) bans construction or other actions, such as pesticide use, that could adversely affect habitats of the world's total 2,059 listed (as of May 9, 2013, endangered or threatened species and plants, 1,440 of which are known to be in the United States. ESA also initiated US involvement in following the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; www.cites.org/eng/disc/what.php). (See also Section 4.2.12.)

The **Safe Drinking Water Act** of 1974 (SDWA), reauthorized and amended in 1996, regulates over 170,000 public water systems (PWS), and water wells including the underground injection of fluids (i.e., liquids, gasses, or slurries) into porous rock formations. Maximum contaminant levels (MCLs) in potable water were set that defined the allowable amounts for different kinds of bacteria, protozoa, viruses, metals, pesticides, organic and inorganic chemicals, and radium. Specific notable rules of this Act include the *Lead and Copper Rule,* the *Arsenic Rule,* and the *Radionuclides Rule*.

The **Resource Conservation and Recovery Act** of 1976 (RCRA), as amended by **Hazardous and Solid Waste Amendments** of 1984 (HSWA), controls the generation, transportation, treatment, storage, and disposal of hazardous waste, and created a framework to manage nonhazardous waste. Hazardous waste found at abandoned or inactive sites is regulated separately under the **Comprehensive Environmental Response, Compensation, and Liability Act** (CERCLA) or **Superfund Act** of 1980. Most states and municipalities have additional solid and construction waste rules and regulations that should also be reviewed to determine the impact on the project design and the maintenance of the facility.

The **Toxic Substances Control Act** of 1976 (TSCA), amended in 1986, 1988, and 1992, regulates through the EPA the use of over 500 different hazardous organic and inorganic chemicals and elements. This affects the construction industry through the manufacture and use of building components containing hazardous materials, particularly vinyl chloride, lead, mercury, and radon. Asbestos and PCBs were also targeted and have since been eliminated from use in the United States.

The **Energy Policy Act** of 2005 (EPAct) mandated achieving a 30 percent reduction in energy consumption. This is applied to all federal building projects and is measured by cost under either the *International Energy Conservation Code* (IECC; www.iccsafe.org) or *ASHRAE Standard* requirements (www.ashrae.org). EPAct also mandates life cycle cost-effective water conservation technologies be used and sustainable design principles be applied to siting, design, and construction. All energy use is to be measured and monitored, with the data collected used to evaluate and optimize building performance. Entering collected data and lessons learned from each completed project are mandated. This information is added to the Federal High Performance Buildings Database (source: buildingdata.energy.gov/femp) and High Performance Buildings Database (source: buildingdata.energy.gov/hpbd).

In 2007 the Department of Energy (DOE) issued an interim final rule that commercial and high-rise residential building use ASHRAE/IESNA 90.1-2004, Appendix G, which includes specific exclusions for plug and process loads. Low-rise residential projects were required to comply with the IECC Section 404 requirements. Other building types are to conform to general EPAct requirements.

(Source: Illuminating Engineering Society of North America (IESNA); www.iesna.org)

The omnibus **Energy Independence and Security Act** (EISA) compilation was enacted in 2007. EISA affects projects by requiring energy efficient lamps and appliances with comparative labeling on federal projects. EISA also established the zero-energy commercial buildings initiative and published energy reduction goals for federal and other building types for new construction. Under Section 435, federal leases of nonfederal properties were required to be Energy Star–certified as of December 19, 2010.

(Source: www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf)

The **Lacey Act** of 1900 as amended in 1969, 1981, 1988, and particularly by the **Food, Conservation, and Energy Act** of 2008, influences the construction industry by defining and setting penalties for illegal logging and trafficking in illegally sourced plant products, both domestic and international. This includes lumber, furniture, and paper products fabricated in the United States or anywhere else in the world. There are set individual and corporate penalties for taking, harvesting, possessing, transporting, selling, or exporting illegal plants and plant products. One method of assuring compliance is to procure "certified" wood and wood products attested to by a third-party certifier, such as the Rainforest Alliance (www.rainforest-alliance.org/forestry/certification). The certifier attests that the wood or wood product meets established legal and sustainable principles, such as those established by the Forest Stewardship Council (FSC; www.fscus.org). (See also Section 4.2.12.)

**Executive Order (EO) 13423, Strengthening Federal Environmental, Energy, and Transportation Management**, was enacted in 2007 to improve energy efficiency and reduce greenhouse gas emissions. EO 13423 mandates new and renovated federal buildings to reduce their energy use by 3 percent per year, achieving a 30 percent total reduction by the end of 2015, as measured against the facility's 2003 baseline. Building water use is mandated for a 2 percent per year reduction, attaining a total 16 percent based on the 2007 level by the end of 2015. Use of toxic and hazardous chemicals and materials are required to be reduced. An increase in solid waste diversion from landfills is also required. And cost-effective waste prevention and recycling programs are to be maintained.

**Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance**, was signed in 2009 and expands on the earlier EO 13423, making the reduction of greenhouse gas emissions (GHG) a priority for federal agencies. Specific targets include reducing petroleum consumption, potable water intensity, and industrial, landscaping, and agricultural water intensity by 2 percent per year through fiscal year 2020. Nonhazardous solid waste, and construction and demolition materials and debris are required to meet a 50 percent or higher diversion rate by fiscal year 2015. A minimum of 15 percent of existing federal buildings and leases (>5,000 gross square feet) are to meet the Guiding Principles by fiscal year 2015, continuing progress until reaching 100 percent. And products and services for 95 percent of all new contracts including nonexempt contract modifications, are required to be energy-efficient, water-efficient, biobased, environmentally preferable, non-ozone-depleting, and they must contain recycled-content and use nontoxic or less-toxic alternatives.

Federal facilities are mandated to comply with **GSA Guiding Principles for Sustainable New Construction and Major Renovations**. Generally this includes using

integrated design principles, optimizing energy efficiency, protecting and conserving water, improving indoor environmental quality, and reducing the environmental impact of materials. It includes adherence to sustainable principles including integrated design, commissioning, energy efficiency, on-site renewable energy, measurement and verification, benchmarking, water efficiency, moisture control, daylighting, low-emitting materials, recycled and biobased content, environmentally preferable products (EPP), waste and materials management, and the elimination of ozone-depleting compounds.

(Sources: www.gsa.gov/graphics/pbs/12012008_Guiding_Principles_for_Sustainable_New_Constuction_and_Major_Renovations.pdf and www.wbdg.org/references/fhpsb_new.php)

**Federal Leadership in High Performance and Sustainable Buildings Memorandum of Understanding** (MOU as signed by 21 federal agencies in January 2006) **and Guidance** (as approved by the Office of Management and Budget (OMB) December 2008). The 21 MOU parties collaborated with the express purpose of helping federal agencies and organizations plan, acquire, site, design, build, operate, and maintain high performance and sustainable buildings. The common set of MOU sustainable Guiding Principles include:

- reducing the total ownership cost of facilities
- improving energy efficiency and water conservation
- providing safe, healthy, and productive built environments
- promoting sustainable environmental stewardship

In general the MOU addresses integrated design, energy performance, water conservation, indoor environmental quality, and material specifications.

(Source: www.epa.gov/oaintrnt/projects/buildings_mou.htm)

Federal construction work is regulated closely by these environmental and other safety-based acts and executive orders. Knowing what they are early in the design process of federal projects and closely adhering to them during design and construction is critical to a project's schedule and costs.

## 4.1.5 Funding Opportunities

Knowledge of applicable funding incentives is usually critical to the owner's decision making for the inclusion of sustainable features in a project. It is fiscally prudent to research applicable grants, loans, rebates, tax credits, and other incentives available from utilities, nonprofit organizations, and local, state, and federal governments. So, for example, if photovoltaics, or PVs, on the roof are being considered, then research the availability of grants and other financial support to offset the cost of adding this feature. Renewable energy and energy efficiency incentives are governed by design and construction standards. This includes building energy codes, contractor licensing, solar/wind access and permitting standards, net metering, appliance and equipment efficiency standards, public benefits funds, renewable portfolio standards (RPS), line-extension, interconnection standards, equipment certification, and the green power-generation and purchasing policies of the utilities. Applicable rules, regulations, policies, executive orders, statutes, enacted legislation, public utilities commission orders, and administrative rules govern these incentives. Knowledge of applicable funding incentives is best confirmed very early in the design process, if it is not already in place at the time of project conception.

The primary government website used to initially search for US renewable energy and energy efficiency incentives is the *Database of State Incentives for Renewables and Efficiency* (DSIRE; http://dsireusa.org/).

The *Directory of Energy Efficiency and Alternative Energy Programs in Canada* can be searched at: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm?attr=0.

Beginning research of US water efficiency rebates is best started with the EPA's WaterSense.

(Source: www.epa.gov/watersense/rebate_finder_saving_money_water.html)

### 4.1.6 Applicable Codes and Regulations

Codes, regulations, and their interpretation by authorities having jurisdiction (AHJ) can have a major impact on project design and construction.

Products that have recently entered the marketplace or are not of standard manufacture can sometimes conflict with the code and may require a variance from the AHJ code official before being installed. For example, the US Army Corps of Engineers does not allow the use of copper piping to drain waterless urinals (Figure 4.1). However, the City of Chicago Plumbing Code at one time mandated the use of copper piping to drain urinals, waterless or not. The fact that uric acid draining from waterless urinals is typically strong enough to corrode through copper pipe was not considered by these earlier codes. In Philadelphia, the Plumbers Union Local 690 reportedly initially blocked the installation of waterless urinals because there was substantially less piping work for plumbers. They were eventually allowed in the originally disputed project but only after the plumbers also installed water supply piping allowing for future conversion to flush urinals. It does not help that most municipalities assess waste treatment costs using water meters, and would therefore lose revenue using waterless urinals. In New York City, waterless urinals may be installed but only with prior approval and the likely opposition of the UA1 New York Plumber's Union. The Uniform Plumbing Code (UPC) was amended in 2009 to allow for waterless urinals but also added the requirement to pipe water to the urinal, capping it for the potential conversion to a flush urinal. The International Plumbing Code (IPC) accepted waterless urinals in 2006 and further updated the Code language in 2010.

California was the first state to implement a green building code when it enacted the 2008 California Green Building Standards Code, which is Part 11 of the 12-part California Code of Regulations, Title 24. Title 24 contains regulations for energy

**Figure 4.1** Waterless urinal
Wikipedia, Chris Goddard

efficiency, environmental quality, material conservation and resource efficiency, water efficiency and conservation, and other requirements.

Recent national development in the code community has resulted in the introduction of the International Green Construction Code™ (IgCC), which was unveiled in 2010 (Figure 4.2). When adopted by states or individual cities and communities, this code will lead to an increase in high-performance or green buildings. It is notable that the IgCC offers a jurisdictional compliance option to use the ANSI/ASHRAE/USGBC/IES Standard 189.1-2009, Standard for the Design of High-Performance Green Buildings. IgCC and this Standard both cover sustainable criteria that include materials and resource use, energy efficiency, indoor environmental quality, water use efficiency, and the building's impact on its community and site. As of the date of publication of this Practice Guide, the IgCC has been adopted by the states of Rhode Island, Maryland, Florida, North Carolina, Oregon, and the city jurisdictions of Boynton Beach, FL; Richland, WA; Kayenta Township, AZ; Keene, NH; Fort Collins, CO; and Phoenix and Scottsdale, AZ.

(Source: www.iccsafe.org/cs/IGCC/Pages/default.aspx)

As a result of the American Recovery and Reinvestment Act of 2009 (ARRA), the International Energy Conservation Code (IECC; see also Chapter 1, Section 1.2.1.2) and ANSI/ASHRAE/IESNA Standard 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings (see also Chapter 1, Section 1.3.4) were published in one book. This volume covers multiple design options for attaining energy efficiency applicable to all building types.

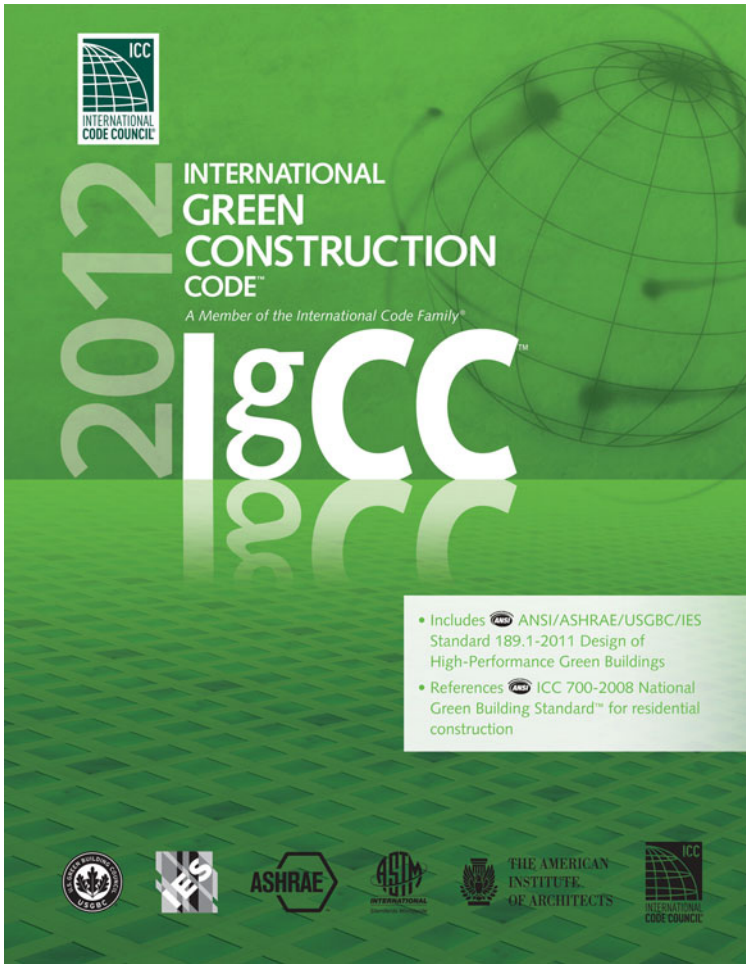


**Figure 4.2** International Green Construction Code™
International Code Council

Collecting and using graywater is regulated under the Uniform Plumbing Code (UPC), International Plumbing Code (IPC), and some states and municipalities. Rainwater harvesting is the capture and storage of rainwater for subsequent use. It has been illegal in the states of Utah, Washington, and Colorado, with the latter two states, or a few of those states' municipalities, allowing specific exemptions for residential use. Many states including Arizona, California, Florida, Georgia, Hawaii, Kentucky, New Mexico, North Carolina, Oregon, Texas, and Virginia, plus municipalities such as Atlanta, Austin, Seattle, and Tucson encourage rainwater harvesting and reuse. The American Society of Plumbing Engineers (ASPE) and the American Rainwater Catchment Systems Association are jointly developing a consensus standard for rainwater catchment systems.

(Source:www.greenbuildinglawblog.com/2010/02/articles/codes-1/stinky-situationsthe-corrosive-case-of-waterless-urinals/)

### 4.1.7 Sustainability and Historic Preservation

Reducing operating energy costs is a key driver for renovation projects of existing old and historic buildings. Note that there are rules and standards governing the alteration and restoration of historically registered buildings such as the Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings (see also Chapter 1, Section 1.1.9 and Chapter 3, Section 3.6). This federal historic preservation standard discusses energy efficiency as a special requirement with the admonition that "*particular care must be taken not to obscure, radically change, damage, or destroy character-defining features in the process of rehabilitation work.*" (Source: www.nps.gov/hps/tps/standguide/) It is important to address a number of historic issues in the planning stage of a project. It is also important to identify which project criteria will take priority (the Secretary's Standards or green standards) on any given project. There will be areas of overlap and areas of opposition between the criteria. It is important to start sorting these out early in the process. To assist teams working on historic properties that wish to follow green standards, the Secretary of Interior issued *Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings* in 2011. The stated purpose of this new publication is to "offer specific guidance on how to make historic buildings more sustainable in a manner that will preserve their historic character and that will meet *The Secretary of the Interior's Standards for Rehabilitation.*"

The principles are the same (or should be) for projects either seeking certification or not. The goal should be to maintain or reuse everything that is original and existing. In other words, what exists in the building when you start working on the project should be retained in the completed renovation. Existing paving materials may be able to be reused; flooring may be refinished even if it is used in a different location in the building; exterior windows may be able to be used for borrowed lights inside the building. Properly approached, an existing building should be a treasure trove of materials for the new use. Sometimes the need to honor existing elements and products will lead to innovative design solutions. Honor the building.

Modifying historically registered facilities (see Figure 4.3) to make them more sustainable follows a process that begins with identifying federal, state, and private grant and incentive programs in order to reduce capital costs. Renovating historic structures demonstrates our respect of our cultural and architectural history, but also uses the immense resource of embodied energy existent in all built structures. If the building is listed on the Historic Register or is in a historic district, the project may be eligible for a federal 20 percent tax incentive with many states offering other inducements. Projects are more likely to go forward when the owner is also the building occupant. When this is not the

**Figure 4.3** Historic building undergoing restoration

Hudson River Housing, 291 Mull Street project

case the owner and tenant typically split the energy-saving benefits, which can make it problematic to initiate a project. Another potential difficulty is coordination of capital and operational budgets within the owner's organization. If both budgets are not coordinated an artificial division may be present within the owner's organization where investing capital to reduce long-term operational costs does not gain priority.

Knowing how your building is performing over a few years' time is important to establish your energy baseline. The baseline, along with reports from investigative measures such as blower door testing and infrared thermography, gives the design professional and energy consultant the data needed to perform energy modeling and propose viable options. A key owner decision point is to trust the building performance data monitored, measured, and collected in order to verify actual energy savings. This is especially important when energy performance contract (EPC) financing instruments are used. EPC is a turnkey service where the savings generated from installed energy efficiency, and renewable energy and distributed generation projects are used as the basis for project financing.

(Source: www.energystar.gov/ia/partners/spp_res/Introduction_to_Performance_Contracting.pdf)

Owners usually evaluate options after reviewing the available capital financing to determine the acceptable annual sustainable return on investment (SROI). Acceptable options frequently include all of the minimally invasive cost-effective energy saving strategies, such as lighting retrofits and simple HVAC replacements. Deeper consideration is required for the more capital-intensive and invasive measures that have longer payback periods. These include renovating the:

- Exterior envelope to slow the rate of energy transference, except for allowing solar gain and natural ventilation when doing so is beneficial.
- Plumbing systems to reduce potable water use, reduce heat loss, eliminate condensation, reduce turbulence, and replace inefficient pumps and motors with higher efficiency models.

- HVAC systems to reduce heat loss, eliminate condensation, reduce turbulence, reduce friction, replace inefficient fans and motors with higher efficiency models, and reduce air pollution.
- Electrical systems to reduce transmission loss, exchange inefficient switchgear, transformers, and generators with highly efficient models and to provide energy generated from clean and renewable sources.
- Lighting systems to reduce electrical use and heat gain by exchanging inefficient incandescent lamps for long-life, high-efficiency LED lamps, to replace older fluorescent lamps with low-mercury more efficient lamps, and to implement daylighting strategies where practical and aesthetically sensitive.
- System controls with sensors to control lighting, window shades, and HVAC through a whole building energy management system.

Reducing the rate of energy transference through the exterior envelope is accomplished by performing weatherization measures that include:

- Reducing air leakage
- Adding insulation
- Judicious application of air and vapor barriers
- Retrofitting windows and doors with weather seals
- Adding storm windows
- Changing out single-paned glazing with double- or triple-insulated glazing units, which is to be considered only when the elevation is not historically registered
- Adding insulating shade systems

Examples of not meeting historic preservation standards include replacing windows in a historic elevation with insulated spandrel glass and replacing multi-paned window sashes with a single-paned glazing unit. Removing inherently energy efficient historic interior window shutters or transoms is also not recommended. Nor are removing trees, shrubs, or landscape features that perform passive solar energy functions. Care is advised when introducing insulation and air sealing in humid environments to avoid mold and bacterial growth. Insulation installation can alter features in a manner that negatively affects historic details. Maintaining porches and vestibules are encouraged since they help to retain heat, block direct sun, and promote natural ventilation.

When planning projects, carefully consider the reuse of existing structures placed near usable infrastructure including multiple transportation options before building new. Pragmatically examine if all or only certain parts of their embodied energy may be practically assimilated. Examine if the building deserves to be registered as a Federal or State Historical Landmark. Also consider salvaging renovation waste materials and reuse, repurpose, or recycle them into new products to install in the project. Examples are fabricating wood wall panels or wood flooring into countertops or furniture, or relocating wood flooring to another room. The object is to try to maintain or reuse everything in the building that is original and existing.

**RESOURCES**

*Deep Green Renovation: Broad Scale Strategies for Achieving Deep Energy Savings in Existing Buildings* by Catharine Killien, 2011

Better Bricks/Northwest Energy Efficiency Alliance (NEEA) Existing Building Renewal Initiative; www.betterbricks.com/design-construction/existing-building-renewal-initiative

New Buildings Institute (NBI); www.newbuildings.org/advanced-design/getting-50-beyond

Rocky Mountain Institute (RMI) Retrofit Depot; http://retrofitdepot.org/

National Trust for Historic Preservation–Preservation Green Lab (PGL); www.preservationnation.org/issues/sustainability/green-lab/

*Advanced Energy Retrofit Guide for Office Buildings* http://apps1.eere.energy.gov/buildings/commercial_initiative/resource_database/detail.cfm?p=5

Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings www.nps.gov/hps/tps/standguide/rehab/rehab_standards.htm

## 4.1.8 Green Building Rating Systems

Sustainable Design or Green Building Rating Systems can be defined as schemes that may be applied to a new or existing facility or community to measure applied environmental criteria, and evaluate the results against the organization's defined set of environmental principles. The score is then evaluated against set benchmarks and the scores of other similar facilities or communities. The scored facility or community is further given a comparison ranking measured against code minimums and similar groups of facilities or communities.

Green building rating programs have been developed by groups of one or more non-government organizations (NGO), private-industry associations and companies, and government agencies. Consensus-based green building rating systems include group decisions on the weighted application of the organization's established principles and scaled environmental criteria. It is required for the design and construction teams to fully understand the owner's personal environmental principles and criteria, and selected rating system before applying them to sustainably design and construct a project.

### 4.1.8.1 Various Green Building Rating Systems

There are dozens of domestic (USA and Canada) and international green building rating systems previously discussed in Chapter 1.

**4.1.8.1.1** The most prevalent holistic green building rating systems used in the United States and Canada are the USGBC LEED™ series of rating systems, followed by the ANSI accredited GBI Green Globes. A third holistic rating system, the Green Building Challenge (GBC) GBTools, is applied primarily in Canada and seven other countries, but not typically in the United States. A fourth holistic system, the ILFI Living Building Challenge, is a complementary rating system that may be applied as an additional set of more stringent environmental criteria to the USGBC LEED™, GBI Green Globes, GBC GBTools or any other holistic green building rating system.

**4.1.8.1.2** Most other domestic (USA and Canada) green building rating systems focus on the sustainability of specific building types. The Audubon Green Leaf™ eco-rating program spotlights the lodging industry, with the Collaborative For High Performance Schools, or CHPS program, concentrating on educational facilities, while the EPA/DOE Labs21® program emphasizes improving energy use in laboratory buildings.

**4.1.8.1.3** A third type of green building rating system looks solely at building systems. The ASHRAE Building Energy Quotient (bEQ) program focuses specifically on environmental principles and criteria as applied to heating, ventilation, and air conditioning (HVAC) systems.

**4.1.8.1.4** Of the international green building rating systems, a few have been seminal in pioneering efforts toward sustainable design and construction in other countries. The UK BREEM, France's High Environmental Quality/Haute Qualité Environmentale (HEQ / HQE®), and GBC GBTools are the three most influential where each has impacted the development of green building rating systems or been adopted in other countries.

**4.1.8.1.5** Switzerland's MINERGIE® standard applies to both new and renovated buildings and is based primarily on a facility's energy consumption and fossil fuel consumption. The MINERGIE-ECO® standard adds other environmental requirements such as recyclability, indoor air quality, and noise protection to the regular requirements.

### 4.1.8.2 Labeling and Certification

There are distinctive certification labels, certificates, plaques, or ratings that can be achieved under the different green building rating systems. USGBC LEED™, Singapore's BCA Green Mark, and GBI Malaysia uses "Platinum, Gold, Silver, and Certified," while HK-BEAM awards "Platinum, Gold, Silver, and Bronze," and Germany's DNGB assigns Gold, Silver, or Bronze certificates. GBI Green Globes uses one, two, three, or four "Globes" and is slightly different from GBI Malaysia. Australia's Green Star, New Zealand's Green Star NZ, and South Africa's Green Star SA offer "4-Star, 5-Star, and 6-Star Green Star" ratings, while India's Teri-Griha grants one to five "Stars," and China's Three Star program gives "One-Star, Two-Star or Three-Star" labels. The Living Building Challenge recognizes "Petals" achieved for certification, and the UAE Estidama awards one to five "Pearls." Finland's PromisE rating system is a five-stepped classification that labels buildings as an A, B, C, D, or E-class to indicate the achieved level of "environmental friendliness," while Portugal's LiderA assigns "Class A++, Class A+, Class A, Class B, Class C, and Class D." Japan's CASBEE® rating system awards Excellent (S), Very Good (A), Good (B+), Fairly Poor (B–), and Poor (C) ratings, and Korea's GBCS system offers a "Best" or "Excellent" certification. Switzerland's MINERGIE® handles it by awarding certification based on achieving a specific set of environmental criteria giving them the labels Minergie-P, Minergie-ECO, Minergie-P-ECO, Minergie-A, and Minergie-A-ECO.

# 4.2 Preferred Material and Product Attributes

## 4.2.1 Introduction

Preferable sustainable attributes for materials and products are measured by and evaluated according to their record of environmental, social, and economic impacts. This begins with obtaining the raw materials, processing and manufacturing or fabricating them into useful products, installing them for optimum use, removing them when they have reached their useful life, and reprocessing them for reuse, repurposing, recycling, or energy conversion. Each of these steps uses energy, water, and labor, and may create unintentional

hazardous waste byproducts, and other pollutants that have environmental and societal impacts. Each desirable material or product attribute can be linked to supporting the goal of sustainability by meeting one or more green building or sustainable objectives.

*Due care* means "that degree of care at which a reasonably prudent person would exercise under the same or similar circumstances. As a result, it is applied differently to different categories of persons with varying degrees of knowledge and responsibility" (Senate Report 97-123).

## 4.2.2 Life Cycle Analysis

Follow the standard requirements of ISO 14040 and 14044 to perform a life cycle analysis (LCA) (www.iso.org/iso/catalogue_detail?csnumber=37456, www.iso.org/iso/catalogue_detail?csnumber=38498). This includes first identifying raw materials used to make the final product and the location origin where those raw materials were initially mined, quarried, drilled, harvested, or otherwise extracted from the earth. Second, locate the raw material processing and manufacturing or fabricating plant or plants. Third, locate the project site and collect specific product material processing, byproduct, and other impact data including use of energy, water, and component materials, waste generated, biodiversity impacted, and air quality affected. Calculations may then be performed to determine environmental impact attributes from raw material extraction and processing to the installed product. The primary environmental attributes for LCA as defined by the European Standard prEN15804:2010 is as follows:

- *Global warming* based on a constant increase in the concentration of greenhouse gasses in the atmosphere including water vapor, carbon dioxide ($CO_2$), methane ($CH_4$), ozone ($O_2$), nitrous oxide ($N_2O$), and chlorofluorocarbons (CFCs).
- *Ozone depletion* in Earth's stratosphere due to the chemical action of manmade halocarbons (e.g., CFCs, freons, and halons).
- *Acidification* or the decrease in pH levels in lakes and oceans caused by the uptake of anthropogenic $CO_2$ from the atmosphere.
- *Eutrophication,* or the depletion of the oxygen in water caused by an unstable bloom of plant growth from excess nitrates and phosphates.
- *Photochemical ozone creation,* or smog, is a chemical reaction of sunlight, nitrogen oxides, and volatile organic compounds (VOCs).
- *Depletion of abiotic or nonliving resource elements* including deposits of sediments, clays, ores, and minerals (e.g., silicon (sand), gravel, granite, limestone, quartz crystal, zinc, titanium, copper, iron, and aluminum, all of which are elements that cannot be replenished or broken down by geologic forces over a 500-year period).
- *Depletion of abiotic or nonliving resource fossil fuels and primary energy* that includes crude oil, natural gas, coal, and peat, which are primarily combusted creating emissions of carbon dioxide, water, and heat energy.

  (Source: www.cen.eu/cen/products/en/pages/default.aspx)

## 4.2.3 Raw Material Attributes

A product's "embodied energy" is the total energy consumed. This refers to the energy used to mine, quarry, extract, shear, harvest, or synthesize the raw materials used to make

the product, plus the energy used to transport, and manufacture or fabricate and install the final product. This includes energy used in the forms of combusted fuel and electricity along with the worker labor expended to operate and maintain the machines for collecting, transporting, and processing. A product with low embodied energy is generally considered more desirable than one with high embodied energy.

Having a "low carbon footprint"' is premised on the total amount of carbon and carbon compounds resulting from processing raw materials into a finished and installed product including maintenance of the product throughout its useful life. The term is linked to the scientific concept of global warming, established by the measured steady increase of carbon dioxide and other greenhouse gasses in the Earth's atmosphere, and further linked to the measured steady increase in the Earth's overall temperature.

A sustainable raw material is one whose extraction and processing equates to a low environmental impact and that does not pollute or otherwise negatively affect the air, water, or earth including impacts to the health and well-being of people and communities. When some raw materials are processed, a particular substance is extracted from a conglomerate material resulting in mounds of tailings that contain toxic or otherwise hazardous minerals. Improperly stockpiled tailings pollute the land and watershed on which it is stored. For some materials, additional processing is done using acids, caustics, and other hazardous chemicals to react with and separate out specific material elements from the compounds. Residues of the chemicals used may be present in the tailings. There are some processes that consume hundreds of thousands or even millions of gallons of water to separate the useful substance from a conglomerate. The resulting contaminated water may be flushed untreated directly into a waterway or held in open retention ponds for years and even decades. These retention ponds can leak and historically have had catastrophic failures that released toxic slurries into a watershed, devastating the land, the downstream watershed, and eventually the deep-water aquifers.

Some raw materials require heat energy to transform them into a particularly useful material such as steel, cement, and masonry. Petroleum crude oil is usually separated through heating into gasoline, diesel, motor oil, and other oil derivatives, eventually making polymer-based plastics. When materials are heated they create combustion byproduct gasses and particulates that may be released into the atmosphere (see Figure 4.4). This typically impacts air quality including the creation of atmospheric and ground-based ozone, and greenhouse gasses. Ash particulates are also a combustion waste byproduct that often contains concentrated amounts of toxic elements. Care must be used in the storage, handling, and reuse or repurposing of the ash produced.

The objective of sustainable design is to design projects that fulfill programmatic needs by primarily using products made from renewable raw or recycled materials containing low embodied energy and also use little or no process water.

A general rule of thumb is that the lower a material's or product's embodied life cycle energy, the less negative impact there will be to the environment and economy.

### 4.2.4 Material and Energy Efficiency

Minimizing facility loads for all forms of energy use by the application of "energy efficient" design and construction practices is a desirable objective. It is very beneficial to slow or eliminate the use of nonrenewable resources and to minimize the owner's annual energy expenditures. Doing so will significantly reduce and may even eliminate the need to expend energy from nonrenewables to meet pre-set comfort range parameters of the

**Figure 4.4** Smokestacks
Wikimedia, Dori

building spaces. The objective of energy efficiency can be accomplished by implementing some or all of the following techniques:

- Minimizing heating and cooling load swings by providing a thermally efficient building envelope accomplished by making it airtight with vestibules at entrances, and optimizing a contiguous envelope of insulation.
- Minimizing heating and cooling load swings by applying the common elements of passive solar design including operable windows, thermal mass, and thermal chimneys.

**Figure 4.5** Typical PassivHaus super-insulated wall sections
Bonded Logic Inc.

- Minimizing heating loads by applying passive solar design to use the sun to heat thermal mass to reradiate the heat energy at a steady rate, and to heat water, reducing the amount of energy needed to bring the water up to temperature.
- Capturing heating or cooling energy from building ventilation and equipment exhaust, and transferring that energy to temper the fresh air supply, thereby reducing the additional energy needed to bring the fresh air to the preferred temperature.
- Reducing artificial lighting electrical energy use and resultant heat loads from lamps through daylighting design.
- Using high efficiency motors and other equipment to reduce energy loss inherent in operating code minimum lower efficiency equipment.
- Minimizing piping and ductwork distribution runs to reduce energy loss. A shorter run generates less internal friction and turbulence, and therefore needs smaller size pumps or fans that use less electricity to operate.
- Insulating piping and ductwork distribution runs to reduce energy loss and to eliminate condensation. Insulation material wraps slow the transference of heat or cold from inside the piping or ductwork into the spaces they transit.
- Conducting whole building commissioning to optimize all building systems ensures the best performance of all systems in place and in concert.

Product attributes that contribute to the objective of an airtight and thermally efficient envelope include:

- Air sealing and slowing thermal transference using spray-applied foam or cellulose insulation (Figure 4.6).
- Slowing thermal transference using rigid board insulation, which may also provide air sealing when joints are tongue-in-groove, or tape-sealed, or buttered with a mastic sealant.
- Air sealing using air barriers that include sprayed films, trowelled viscous fluids, thin flexible plastic sheets, and tapes.
- Air and vapor sealing using vapor barriers and retarders made with liquid penetrating sealers, sprayed films, trowelled viscous fluids, thin flexible plastic sheets, and tapes.
- Joint sealer treatments with air sealing properties including caulking, elastomeric sealants, precompressed foam sealers, and expansion foam sealers.
- Door and window hardware—closers, gaskets, and weather seals.
- Door vestibule airlocks and air screens.

Product attributes that contribute to the objective of optimizing the use of insulation include:

- Thermal insulation materials including spray-applied foams, foamed concrete, rigid insulation boards, cellulose, perlite, asbestos-free vermiculite, aerogel beads, spun fiberglass, and batts or blanket insulation made using materials of fiberglass, PET plastic fibers, mineral wool, cotton, or sheep's wool.
- Composite thermal insulation products including Structural Insulated Panels or SIPs, Insulating Concrete Forms or ICFs, insulated tilt-up concrete (Figure 4.7), insulated precast concrete, and insulated prestressed concrete.
- Heat energy reflective attributes of low-E soft- and hard-coat glazing, suspended low-E films, aluminum foil bonded to rigid board insulation, and metallic-coated window shade fabrics.

**Figure 4.6** SPF Sprayed polyurethane foam
Image courtesy of Wikipedia user Cdpweb161

The following products contribute to the passive solar design objective including natural ventilation, solar chimney effect, solar hot water, and trombe walls:

- Operable windows and skylights
- Operable screened louvers
- Moveable insulation
- Hot water heating systems
- Heat from trombe walls made using concrete, stone, brick, or block masonry, and dark metal surfaces (Figure 4.8)

**Figure 4.7** Insulating tilt-up wall panels
David Hall, Liteform

- Adjustable roller screen window treatment
- Vertical dark-surfaced metal panel systems with plenum spaces behind the exterior face that when exposed to sunlight heats the air in the enclosed plenum, which may be used to preheat the supply air.

Products that contribute to a daylighting design objective include:

- Light shelves made with a flat-surfaced material that have a light reflective surface including painted gypsum board, wood, wood composites, plastics, and metals.
- Light reflective coatings on light shelves and ceiling surfaces.

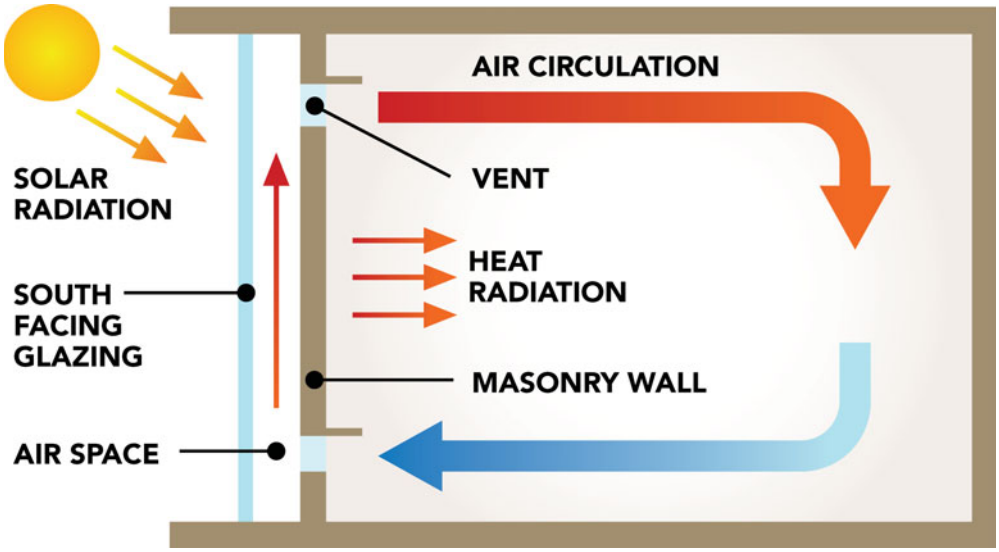


**Figure 4.8** Trombe wall concept diagram
Meadowlark Builders

- Clear and translucent glazed window units, clerestories, skylights, translucent wall panels, doors, sidelights, transoms, and interior borrowed lights.
- Solar tube skylights that reflect daylight deep into a building.
- Shade systems including interior blinds, and manual and electrically operated shades, along with exterior fixed and operable horizontal and vertical sunshades and screens.
- Operable shade controls with timer software presets, or those that are tied to a sensor-driven whole building energy management system.
- Artificial lighting control systems including light sensors, motion detectors, preset lighting selections, dimming controls, timer software, and computer software-based programming controls with ancillary manual remote unit controllers.
- Whole building energy management system.

## 4.2.5 Efficient Use of Water

A key sustainable objective is to *conserve potable water*, which is accomplished by eliminating or reducing water use, and through reuse. Products and processes attributed to supporting this include:

- Waterless urinals
- Composting toilets
- Water flow reduction regulators including point-of-use manual and sensor-type water cutoffs
- Rainwater capture and storage for nonpotable use (e.g., irrigation and toilet flush-water)
- Designed wetland and greenhouse living systems used to filter and treat:
  - Rainwater for potable water use
  - Graywater from sinks, showers, baths, and laundry washers for potable water use
  - Blackwater from toilet flush-water, and heavy-particulate graywater from kitchens or process water
- Methods of piping graywater for nonpotable use including irrigation and as toilet flush-water
- Drip irrigation
- Xeriscape planting design, which has the benefit of eliminating the need for irrigation

## 4.2.6 Waste Reduction or Elimination

Another sustainable objective is to eliminate or significantly reduce waste from construction and deconstruction or demolition operations, and from occupant use through reuse, repurposing, recycling, and energy conversion. Construction products that support this objective include:

- Durable long–life cycle products that delay a product's entrance into the waste stream. Materials or products with this attribute include:
  - Wood post and beam framing
  - Slate shingle roofing

- Copper metal roofing
- Quarried stone masonry walls, floor tiles, and cobbles
- Brick masonry walls and pavers
- Linoleum flooring
- Pivot door hardware
- Stainless steel finishes
- Glass
- Rock wool insulation
- Sheep wool insulation
- Cellulose insulation

- Using products and systems that facilitate an easy separation of dissimilar materials, making reuse or recycling easier include:
  - Ballasted and mechanically fastened roofing membrane systems
  - Uncoated metal products with textured, brushed, or polished finishes
  - Furniture systems that feature easily disassembled and replaceable components (Figure 4.9)
  - Carpet that is mechanically fastened to tack-strips
  - Lay-in ceiling panels in suspended metal frames
  - Water-soluble adhesives
- Using materials that are typically collected locally for recycling include:
  - Metals including aluminum, steel, copper, and zinc
  - Glass
  - Plastics, primarily #1 PETE or polyethylene terephthalate and #2 HDPE or high-density polyethylene. Other plastics such as:
    - #3 PVC or polyvinyl compounds are not typically recycled; usually there is less than 5 percent of PVC in the waste stream.

**Figure 4.9** Modular office furniture system
Global

  - #4 LDPE or low-density polyethylene is not typically recycled.
  - #5 PP or polypropylene is recycled by some curbside programs.
  - #6 PS or polystyrene is recycled by some curbside programs.
  - #7 Other or miscellaneous plastics are not typically recycled.

    (The list above is general and varies widely by area.)
- Incorporating recycled materials into primary products that are also recyclable is a highly desirable objective. An issue of concern is that plastics are likely to be contaminated by metals, paper, pigments, inks, and adhesives. Typically almost all recycled plastics become secondary "downcycled" products such as textiles, parking lot bumpers, or plastic lumber that are not further recyclable. Materials that may be recycled back into primary products are:
  - Paper
  - Glass
  - Metals
  - Polystyrene
- Specifying the use of materials that are more suitable to being reused or repurposed include:
  - Solid wood products (e.g., post and beam framing, door and window frames, flooring, and furniture)
  - Glass
  - Brick
  - Stone and stone composites
  - Metal concrete forms
- Using materials, products, and packaging that are leased or returnable to the manufacturer for recycling or repurposing such as:
  - Carpet
  - Furniture systems including demountable partitions, office cubicles and desk systems, and chairs
  - Wood pallets and crates
  - Windows
- Energy conversion is the next-to-last desired step in priority after downcycling and before landfilling. Downcycling is when a material is recycled into a new product that is not capable of being recycled further, and will most likely be buried in a landfill or combusted. Products that can be used for energy conversion are:
  - Solid wood and wood sawdust
  - #1 PETE, #2 HDPE, #4 LDPE, #5 PP, and the polyethylene/polypropylene mixed product known as polyolefin—all of which can be burned producing nontoxic combustion byproducts of carbon dioxide, water, and heat energy.
- Of note is an upstate New York–recycled plastic thermal-cracking facility that takes solid plastic waste and heats it until it transforms back into basic methane, ethane, butane, and propane hydrocarbon elements that may be converted into new polymer plastics or combusted. Landfilling of plastics will see significant reduction as more of these facilities are constructed. (Sources: www.gizmag.com/plastic2oil-converts-plastic-to-fuel/19108/ and www.plastic2oil.com/site/home)
- Construction and demolition methodologies and practices that support the desirable objective to eliminate or significantly reduce waste are:
  - Predemolition salvage
  - Deconstruction salvage
  - On-site source separation into dumpsters of recyclable construction waste

- Waste facility separation of mixed recyclable construction waste
- Mandating suppliers ship products using only returnable, reusable, or recyclable packaging, protection, supports, bracing, pallets, and cartons

Prolonging the useful life of existing buildings and adaptively salvaging underused buildings is a desirable objective. Doing so conserves resources, preserves cultural resources, reduces waste, respects local landmarks, and reduces environmental harm from the manufacture and transport of materials for new construction. Methodologies and practices that assist this endeavor include:

- Remediation of hazardous materials
- Partial deconstruction, salvage, repurposing, and reuse
- Historic preservation renovation
- Shoring and underpinning
- Whole building relocation
- Repointing masonry

### 4.2.7 Local/Regional Materials and Manufacturing

Materials and products that originate in the same locale or region as the project site are desirable in great part owing to positive environmental and economic impacts. Environmentally a local product's embodied energy would typically be less than a product shipped from 500 miles or more away due to a minimum of transportation energy expended. Products that are extracted, processed, manufactured, and installed within a locale or region create substantial regional economic value. Each processing step includes the use of a company's labor, machinery, and physical plant and paying these local workers and parts suppliers provide a financial impact. Payees who work and live in the same locale or region generally spend most of their earnings within their own community to purchase goods and services creating more economic value through the effect of turning over dollars multiple times within the community's local economy.

The U.S. Office of Management and Budget (OMB) officially describes a local economy as a Core Based Statistical Area (CBSA), which is a collective term for Metropolitan and Micropolitan Statistical Areas (www.census.gov/geo/reference/gtc/gtc_cbsa.html). Metropolitan and micropolitan statistical areas are defined in terms of whole counties or county equivalents. As of an August 31, 2010, update, there are 370 "metro" areas and 584 "micro" areas. CBSAs are composed of an economic center of 10,000 or more residents plus nearby areas with commuting ties and a high amount of social and economic interaction. Economic impact value is best quantified using these CBSAs to evaluate regional impact.

### 4.2.8 Recycled Content and Recyclability

Recycled content is defined in accordance with the International Organization of Standards document ISO 14021, Environmental Labels and Declarations–Self-Declared

Environmental Claims (Type II environmental labeling). The recycled content value of a material assembly is typically determined by weight. Two categories commonly used when discussing recycling are:

> ***Postconsumer*** material is defined as waste material generated by households by commercial, industrial, and institutional facilities in their role as the end users of the product, which can no longer be used for its intended purpose.
>
> ***Preconsumer*** (postindustrial) material is defined as material diverted from the waste stream during the manufacturing process. Reutilization of materials (i.e., rework, regrind, or scrap generated in a process and capable of being reclaimed within the same process that generated it) is excluded. Closed-loop product recycling programs are those product producers or manufacturers that accept either their own products or the products of other manufacturers. This is done to process materials at the end of their useful life, recycling them back into a similar product category.

Postconsumer recycled materials are the more highly valued recycling term since it is taking material with a historically longer life cycle than preconsumer materials and extending that life cycle further.

## 4.2.9 Materials Reuse

Reusing a salvaged material or product places the previously used item in a new location, and as a benefit captures the material's embodied energy. This also includes using raw material that would otherwise be discarded or combusted. Materials reuse is a concept integral to historic preservation. (See also Chapter 3, Section 3.6 and Section 4.1.7.)

Raw materials existing within a proposed building footprint, such as timber and stone, may be harvested or mined and processed for incorporation into the project. Timber can be sawn into lumber, which after drying out may be fabricated into wood siding and trim, strip or plank flooring, wood paneling, wood furniture, wood veneer, or woodchips and firewood. Stone collected from the site may be used for masonry rubble walls, site retaining walls, or driveway/walkway cobbles and landscape borders.

> ***Refurbished*** materials are used or salvaged goods that have been reworked and restored to an acceptable working order and reused in the same capacity.
>
> ***Reclaimed*** materials are considered to be materials that have been used before either in buildings, temporary works, or other uses and are reused as construction materials without reprocessing or refurbishing. Examples are barn wood and timbers, and old logs reclaimed from the bottom of the great lakes or rivers.
>
> ***Repurposed*** materials are used or salvaged goods that have been reworked but used in a different capacity, preferably within the same building.

## 4.2.10 Low-Emitting Materials

It is a highly important sustainable objective to eliminate or significantly reduce concentrations of chemical contaminants that are capable of damaging air, water, and soil quality, and human health and productivity. This includes eliminating the release of Persistent

Bioaccumulative and Toxic (PBT) chemicals associated with building materials Chemicals and elements of concern to avoid are:

- Listed by the US EPA under EPCRA Section 302, Extremely Hazardous Substances; CERCLA Hazardous Substances; EPCRA Section 313, Toxic Chemicals; and US Clean Air Act, or CAA 112(r) Regulated Chemicals For Accidental Release.
- Listed by CERCLA as hazardous metals, specifically antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, and zinc.
- Listed by CAA 112(r) as 77 toxic substances of specified concentrations including dioxins, dioxin-like compounds, mercury and mercury compounds, ammonium salts, diisocyanates (MDI and TDI), and polycyclic aromatic compounds (PACs).

Low-emitting materials are established by the amount of total volatile organic compounds, or TVOCs, in products and materials, and should not contain hazardous substances as listed in the State of California's *Proposition 65, Safe Drinking Water and Toxic Enforcement Act of 1986, Chemicals Known to the State to Cause Cancer or Reproductive Toxicity,* published May 20, 2011 (http://oehha.ca.gov/prop65/prop65_list/files/P65single052011.pdf).

Building products (excluding built-in cabinetry, architectural millwork, and furniture) can be tested and evaluated for compliance in accordance with California Department of Public Health (CDPH) Standard Method V1.1-2010 and the applicable exposure scenario. Manufacturers attesting to compliance with Proposition 65 are required to submit which range of TVOCs their product falls under after a period of 14 days (336 hours), measured according to the CDPH Standard Method v1.1, whether they are:

- Less than or equal to 0.5 $mg/m^3$
- Between 0.5 and 5.0 $mg/m^3$
- Greater than or equal to 5.0 $mg/m^3$

Composite wood used as an interior product or product component (e.g., countertops, cabinetry, wall paneling, ceiling panels, interlocking floor panels, or furniture) should be constructed with materials documented to have low formaldehyde emissions and is typically labeled as being manufactured with no added formaldehyde (NAF). Standard methods of meeting low formaldehyde emissions are:

- The California Air Resources Board Airborne Toxic Control Measures (ATCM) for formaldehyde requirements for Ultra-Low-Emitting Formaldehyde (ULEF) resins or No-Added Formaldehyde (NAF) based resins.
- Steady-state concentrations obtained by European Standard EN 717-1 can be used for showing compliance after multiplication with a correction factor of 1.63, as defined in a method comparison by the California Air Resources Board (CARB), see Appendix H, Section D at www.arb.ca.gov/regact/2007/compwood07/apph.pdf.

New furniture and furnishing items, in order to meet the Business and Institutional Furniture Manufacturers Association's (BIFMA) e3 sustainability standard, can be tested using ANSI/BIFMA Standard Method M7.1-2011, Furniture Emissions Method in accordance with the ANSI/BIFMA X7.1-2011, Furniture Emissions Standard.

All components of a furniture or medical furnishing assembly, including textiles, finishes, and dyes, should contain less than 100 parts per million (ppm) of at least four of the five following chemical groups:

- Urea formaldehyde
- Heavy metals including mercury, cadmium, lead, antimony
- Hexavalent chromium in plated finishes consistent with the Restriction of the Use of Certain Hazardous Substances of the European Union Directive (EU RoHS)
- Stain and nonstick treatments derived from perfluorinated compounds (PFCs) including perfluorooctanoic acid (PFOA)
- Added antimicrobial treatments

All site-applied adhesives and sealants should contain no carcinogenic or reproductive toxicant components present at more than 1 percent of total mass of the product as defined in the California Office of Environmental Health Hazard Assessment's (OEHHA) list entitled "Chemicals Known to the State to Cause Cancer" or the Reproductive Toxicity, Safe Drinking Water and Toxic Enforcement Act of 1986 (CA Proposition 65).

Adhesives, sealants, coatings, roofing, and waterproofing materials applied on-site should meet the VOC limits of California Air Resources Board (CARB) 2007 Suggested Control Measure (SCM) for Architectural Coatings and South Coast Air Quality Management District (SCAQMD) Rule 1168 effective July 1, 2005.

Batt insulation products should contain no added formaldehyde (NAF), which includes urea formaldehyde, phenol formaldehyde, and urea-extended phenol formaldehyde.

There are products that are inherently nonemitting sources of VOCs—specifically, stone and ceramics; powder-coated, plated or anodized metals; glass without integral organic-based surface coatings; binders, sealants, concrete without sealers or coatings; and clay brick.

## 4.2.11 Bio-Based Materials

Plant-based bio-based materials may meet the criteria of a desirable environmental objective since they actively sequester carbon dioxide as a growing rapidly renewable plant and product, and only release carbon when combusted or biodegraded.

Bio-based materials are those that originated from organic carbon derived from modern nonfossil carbon sources as identified by test method ASTM D6866 (Standard Test Methods for Determining the Bio-based Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis), and are harvested in a legal manner. Materials that meet a bio-based objective can be those made from soybeans, corn, kenaf, jatropha, flax, castor oil, lemon oil, algae, jute, linseed oil, pine rosin, cork and cork flour, bamboo, mushroom mycelia, wood flour, timbers such as Mulberry or *morus alba*, Palm, Aspen, Pine, or other planted and harvested crop types. Due consideration should be given as to whether the bio-based materials were unsustainably grown in large clear-cut or slash-burned rainforests or in other endangered habitat areas, or if the planted seeds were genetically modified using other unsustainable actions. Bio-based product types include:

- Linoleum sheet and tile
- Fiberglass batt insulation binder
- Spray-foamed insulation made using natural oil polyols (NOP)

- ICF, or insulated concrete forms, made using natural oil polyols (NOP)
- Wood and concrete sealers
- Oil-based wood stains
- Roof membrane coatings
- Plastic lumber composite panels
- Interior structural panels
- Interior wall panels
- Strip, tile, and panelized flooring
- Adhesives
- Packaging materials
- Multipurpose cleaners
- Dielectric insulating transformer fluid

Some bio-based materials include methylene diphenyl di-isocyanate (MDI), which is used in lieu of the more toxic toluene di-isocyanate (TDI) in making two-part polyurethanes. Both MDI and TDI are known aromatic dermal and inhalation sensitizers and a major cause of work-related asthma (Sources: www.epa.gov/oppt/existingchemicals/pubs/actionplans/mdi.pdf and http://nanotechindustriesinc.com/GPU-technical.php).

The Buy America Act Federal Acquisition Regulation Section 25.003 lists various acceptable bio-based materials that originate from other countries.

(Source: www.acquisition.gov/far/html/Subpart%2025_1.html)

Bio-based materials are documented in the US Department of Agriculture's Biopreferred database at www.biopreferred.gov.

## 4.2.12 Certified Wood

Certified wood is timber or wood product that has been planted, grown, harvested, milled, and fabricated or manufactured in a manner meeting established sustainable principles, and is documented throughout the process by a third-party certifier. A key applicable law is the US Lacey Act, as amended in 2008 (7 CFR 340.6(d)), which renders it illegal for US individuals and companies to trade in timber and other goods procured from illegal sources, both domestic US and internationally. Using certified wood is one method of satisfying the due diligence requirements of this law, which specifically prohibits anyone from procuring timber or products made from timbers that are illegally harvested:

- From habitat protected under the US Endangered Species Act.
- As listed under the Convention on International Trade in Endangered Species or CITES International Treaty.
- In violation of US traditional property and civil rights.

Good sustainable practices include avoiding the use of timber harvested from forests:

- Where high conservation values are threatened by management activities.
- Being converted to plantations or nonforest use.
- Where genetically modified trees are planted.

In 2004 the United Nations Forum on Forests (UN-FF) adopted the following seven themes of sustainable forest management:

1. Extent of forest resources
2. Biological diversity
3. Forest health and vitality
4. Productive functions of forest resources
5. Protective functions of forest resources
6. Socioeconomic functions
7. Legal, policy, and institutional framework

### 4.2.13 Sustainable Use of Site Timber

It is a sustainable objective to harvest timber on the project site for use in the project. Specifically the timber to be harvested and processed into construction products and other useful items are those within the proposed building footprint plus those necessary to maintain the health of the forest.

A significant limiting factor to using site timber is the time required to air-dry or kiln-dry lumber before it can be used. Air-drying stickered lumber to 15 percent moisture content takes from several months to a year or more, depending on conditions and timber species. Kiln-drying stickered lumber in a climate-controlled enclosure to 8 percent moisture content may be completed in less than one month, but a premium is paid in combusting the nonrenewable fuel resource to fire the kiln.

Products that may be fabricated from site-harvested timber include:

- Wood beams, columns, and stud framing
- Wood siding or board and batten
- Exterior and interior wood trim
- Wood plank floors, walls, and ceilings
- Interior wood paneling
- Furniture including countertops, chairs, bed frames, tables, and more

Timber processing wastage sawdust and woodchips may be used on trails and planting beds, or combusted for use as heat energy. Unsuitable timber may also be cut into firewood cords and left on-site to air dry.

## 4.3 Evaluating Sustainability Options

There are a great many sustainable design criteria to assess when executing the design process. One method of reducing the time and effort inherent in considering these criteria is to rely on reputable independent third-party organizations that certify the ratings of buildings, equipment, products, and materials according to recognized sustainable principles selected by the owner as a condition of the project requirements. Many certifiers provide an eco-label on their certified products.

## 4.3.1 Product Certifications

Credible verification of performance claims by product manufacturers is best accomplished through independent third-party testing and certification based on widely accepted sustainable principles verified using standardized test methods. Not providing a third-party certification can lead prospective product users to form incorrect or erroneous suppositions since sustainable claims may be perceived as either true statements or self-serving "greenwash." A performance claim verified and certified by an independent third party carries an inherent authenticity that a self-interested manufacturer statement does not. There are many third-party certification companies that focus on specific product groups such as FloorScore® for flooring or on sustainable principles such as Cradle-to-Cradle (C2C) and the Forest Stewardship Council (FSC). (See also Chapter 1, Section 1.4.) This section will attempt to describe those entities applicable to North America.

### 4.3.1.1 Cradle-to-Cradle Certification

The book *Cradle-to-Cradle / Remaking the Way We Make Things* was published in 2002 by architect William McDonough, FAIA, and his German colleague and chemist Michael Braungart. The book was a manifesto calling on the manufacturing industry to transform current unsustainable practice by encouraging companies to follow principles of "ecologically intelligent design," thus imbuing sustainable principles into a product's life cycle development. Doing so can create goods and services that generate ecological, social, and economic value. Cradle-to-Cradle or C2C incorporates a basic premise that products at the end of their useful lives should never be landfill waste, but be designed as components for new products to be continually recycled or refurbished.

McDonough Braungart Design Chemistry, or MBDC, is the exclusive third-party assessor and certifier of manufactured products wishing to use the proprietary Cradle to Cradle Certified$^{CM}$ eco-label program. Assessed products are evaluated against criteria that establish the product's safety to humans and the environment, and its design for future life cycles. Products meeting established criteria in five defined categories can achieve one of four eco-label certification levels that include Basic, Silver, Gold, or Platinum. The five criteria categories include Material Health, Material Reutilization, Renewable Energy Use, Water Stewardship, and Social Responsibility.

(Source: www.mbdc.com/cradle-to-cradle/cradle-to-cradlecertified-program/certification-overview/ and www.c2ccertified.org/)

### 4.3.1.2 Green Seal Certification Mark

**Figure 4.10** Green Seal certification mark logo
Green Seal

Green Seal is a nonprofit third-party testing agency and certifier of green products that include paint, stain, coatings, cleaners, windows, packaging, adhesives, floor care, soap, and other products made from paper, plus they certify green facilities for the lodging, public housing, restaurant, and the food and beverage service industries. Testing is based on rigorous, science-based published standards (e.g., ISO and ASTM), which are used to assure that certified products are better for human health and the environment. USGBC LEED™ 2009 IEQ Credit 4.1 specifically requires that "Aerosol Adhesives must comply with Green Seal Standard for Commercial Adhesives GS-36 requirements in effect on October 19, 2000." USGBC LEED™ 2009 IEQ Credit 4.2 requires that architectural paints and coatings meet GS-11 VOC requirements, and that anticorrosive and

antirust paints meet Green Seal VOC Standard GC-03. The proposed USGBC LEED™ Version 4.0 does not call out specific Green Seal standards.

(Source: http://www.greenseal.org/www.greenseal.org/Portals/0/Documents/Standards/GS-11%20Stn%20Dev/anti-corrosivepaints.pdf)

#### 4.3.1.3 Certified Wood Certification

There are two principal international bodies that certify wood based on a defined set of sustainability principles, the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). Two other familiar North American certified wood organizations are the Sustainable Forestry Initiative (SFI) and the Canadian Standards Association (CSA), both of which are member organizations of PEFC, although SFI's Chain-of-Custody requirements were not in compliance with PEFC standards as of publication. As of the printing of this Practice Guide, USGBC LEED™ recognizes only FSC as a certifying body for certified wood.

#### 4.3.1.4 Forest Stewardship Council

The ten FSC Principles for Forest Stewardship (FSC-STD-01-001 (Version 4-0) EN) are articulated by FSC as follows:

1. Compliance with laws and FSC Principles:

   Forest management shall respect all applicable laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria.
2. Tenure and use rights and responsibilities:

   Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented, and legally established.
3. Indigenous peoples' rights:

   The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognized and respected.
4. Community relations and worker's rights:

   Forest management operations shall maintain or enhance the long-term social and economic well being of forest workers and local communities.
5. Benefits from the forest:

   Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.
6. Environmental impact:

   Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and the integrity of the forest.
7. Management plan:

   A management plan—appropriate to the scale and intensity of the operations shall be written, implemented, and kept up to date. The long-term objectives of management, and the means of achieving them, shall be clearly stated.
8. Monitoring and assessment

   Monitoring shall be conducted, appropriate to the scale and intensity of forest management, to assess the condition of the forest, yields of forest

products, chain of custody, management activities and their social and environmental impacts.

9. Maintenance of high conservation value forests:

   Management activities in high conservation value forests shall maintain or enhance the attributes, which define such forests. Decisions regarding high conservation value forests shall always be considered in the context of a precautionary approach.

10. Plantations:

    Plantations shall be planned and managed in accordance with Principles and Criteria 1–9, and Principle 10 and its Criteria. While plantations can provide an array of social and economic benefits, and can contribute to satisfying the world's needs for forest products, they should complement the management of, reduce pressures on, and promote the restoration and conservation of natural forests.

FSC also has 56 criteria leading to 192 audit indicators necessary to certify sustainable wood. The FSC Chain-of-Custody requirements are detailed by document FSC-STD-40-004 V2-1 EN, approved October 1, 2011.

(Source: www.fsc.org/standards.html)

The difference between FSC and PEFC (including SFI and CSA) revolves around a few significant issues:

- Comprehensive socioeconomic criteria are required by FSC but are not fully or directly addressed by PEFC, SFI, and CSA.
- FSC has specific prescriptive and performance requirements, whereas PEFC, SFI, and CSA include unverified voluntary reporting actions.
- FSC requires certified verification of timber source legality for mixed sourcing, whereas PEFC, SFI, and CSA do not.
- The SFI standard does not have a specific numerical limit regarding conversion of forestlands to nonforest uses. FSC's limit is no greater than or equal to 2 percent over a rolling five-year period.
- FSC has a comprehensive ban on genetically modified organisms (GMOs) while SFI allows for GMO research under applicable laws.

A 2011 comparison between FSC and SFI can be accessed at www.dovetailinc.org/reportsview/2011/sustainable-forestry/pkathryn-fernholzp/differences-between-fsc-and-sfi-certification.

The complete FSC Principles and Criteria for Forest Stewardship document can be accessed at www.fsc.org.

**Figure 4.11** Programme for the Endorsement of Forest Certification logo

Programme for the Endorsement of Forest Certification

### 4.3.1.5 Programme for the Endorsement of Forest Certification

PEFC member organizations adhere to and certify timber operations according to PEFC standard forestry management principles and the six standard criteria requirements (PEFC ST 1003:2010), which are:

1. Maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycle.

2. Maintenance of forest ecosystem health and vitality.
3. Maintenance and encouragement of productive functions of forests (wood and non-wood).
4. Maintenance, conservations and appropriate enhancement of biological diversity in forest ecosystems.
5. Maintenance and appropriate enhancement of productive functions in forest management (notably soil and water).
6. Compliance with legal requirements.

   (Source: www.pefc.org/standards/technical-documentation/pefc-international-standards-2010/item/672)

#### 4.3.1.6 Sustainable Forestry Initiative

The SFI 2010-2014 STANDARD document enumerates 14 principles of sustainable forestry, up to 20 objectives, 38 performance measures, and a maximum 115 audit indicators. SFI principles include:

1. Sustainable Forestry
2. Forest Productivity and Health
3. Protection of Water Resources
4. Protection of Biological Diversity
5. Aesthetics and Recreation
6. Protection of Special Sites
7. Responsible Fiber Sourcing Practices in North America
8. Avoidance of Controversial Sources including Illegal Logging in Offshore Fiber Sourcing
9. Legal Compliance
10. Research
11. Training and Education
12. Public Involvement
13. Transparency
14. Continual Improvement

The SFI Chain-of-Custody certification requirements are covered under document *Section 3, SFI Chain-of-Custody Standard*. As of the publication of this Practice Guide SFI is in conflict with PEFC principles and may no longer be accredited by them.

(Source: www.sfiprogram.org/files/pdf/Section2_sfi_requirements_2010-2014.pdf)

#### 4.3.1.7 Canadian Standards Association

CSA published Canada's National Standard for Sustainable Forest Management, CAN/CSA Z809 in 1996, which defines elements necessary for certification. CSA calls out six sustainable forestry management performance requirement criteria as follows:

- Criterion 1—Conservation of Biological Diversity including Ecosystem Diversity, Species Diversity, Genetic Diversity, and Protected Areas and Sites of Special Biological Significance

- Criterion 2—Maintenance and Enhancement of Forest Ecosystem Condition and Productivity, which includes Forest Ecosystem Resilience and Forest Ecosystem Productivity
- Criterion 3—Conservation of Soil and Water Resources including Soil Quality and Quantity, and Water Quality and Quantity
- Criterion 4—Forest Ecosystem Contributions to Global Ecological Cycles that includes Carbon Uptake and Storage, and Forest Land Conversion
- Criterion 5—Multiple Benefits to Society including Timber and Non-Timber Benefits, Communities and Sustainability, and Fair Distribution of Benefits and Costs
- Criterion 6—Accepting Society's Responsibility for Sustainable Development, which covers Aboriginal and Treaty Rights, Respect for Aboriginal Forest Values, Knowledge, and Uses, Public Participation, and Information for Decision-Making CSA's Chain-of-Custody (CoC) criteria are described by document *CSA Plus 1163*.

  (Sources: http://certificationcanada.org/_documents/english/csa/Plus_1163.pdf and www.csa-international.org/%5Crepository%5Cgroup%5CZ809-02EN.pdf)

## 4.3.2 Labeling

Eco-labels are bestowed by environmental certification organizations and government agencies as a visual stamp of approval that the product meets or exceeds well-defined criteria based on a specific set of environmental principles. Certification labels vary based on what specific requirements are met such as the exact percentage of certified materials and VOC content. There are many eco-labels from which to select. Evaluating which label to pursue is based on the material or product type, the project location, and verification that the certifying agency is an independent third party.

Examples of eco-labels include: FSC, PEFC, SFI, and CSA labels for certified wood products; Green Seal to certify meeting VOC and human health hazard standards; and C2C eco-labels for meeting defined proprietary sustainability criteria. The following discussion covers additional North American eco-labels.

(Source: www.ecolabelindex.com/ecolabels)

### 4.3.2.1 Energy Star

Introduced jointly in 1992 by the US Environmental Protection Agency (EPA) and the US Department of Energy (DOE) as a voluntary labeling program, Energy Star is used to evaluate and rate energy efficient products and practices. The Energy Star label is applicable to major appliances, office equipment, lighting, home electronics, new homes, and commercial and industrial buildings. Energy Star is a government-backed symbol for energy efficiency used to influence consumer-buying habits toward purchasing a product that reduces energy demand and costs while also reducing greenhouse gas emissions.

USGBC LEED 2009 for Existing Buildings EA Prerequisite 2 calls for the building to have an Energy Star Portfolio Manager performance rating of 69. LEED 2009 EB Credit EA 1 awards a point for meeting an Energy Star Portfolio Manager rating of 71, plus more points up to a total of 18 for energy performance ratings from 73 to 95.

The proposed USGBC LEED Version 4.0 Existing Building: Operations and Maintenance Rating System, incorporates Energy Star programs for EA Prerequisite: Minimum Energy Performance (rating is 75), EA Credit: Optimize Energy Performance

(3–20 points for Energy Star ratings of 76 to 95), and MR Credit: Purchasing—Ongoing Consumption.

(Source: www.energystar.gov)

#### 4.3.2.2 GREENGUARD

Founded in 2001 by Dr. Marilyn Black, PhD, LEED-AP, the GREENGUARD Environmental Institute (GEI) is an ISO-IEC Guide 65:1996 accredited third-party organization that tests and certifies materials and products for low chemical emissions, and also provides open access to a searchable web-based database of their certified products. GEI was acquired by UL Environment in 2011. The different program certifications offered by GEI include:

- GREENGUARD Indoor Air Quality Certified® program tests and measures product chemical and particle emissions while simulating actual use.
- GREENGUARD Children & Schools Certified℠ is similar but products need to meet Chronic Reference Exposure Levels (CRELs) and low limits on phthalate emissions.
- GREENGUARD Select Certified℠ is a customized application for Commercial, Education, Healthcare, and Home products to meet GREENGUARD Children & Schools criteria plus the latest VOC content limits, lower formaldehyde emissions requirements (driven by California Air Resources Board (CARB) and California Department of Public Health's (CDPH) 2012 CA 01350 requirements), lead and phthalate content requirements (as defined by the US Consumer Product Safety Information Act), and BIFMA–defined commercial furniture testing protocols.
- GREENGUARD Synthetic Turf Certification tests and certifies synthetic turf specifically for lead content, heavy metal migration, and chemical emissions.
- GREENGUARD AgBB+ is an environmental claims validation (ECV) service that verifies product claims made about specific environmental aspects such as formaldehyde-free, recycled content, and low-VOC content.

GEI's certification process, once initiated, is stated to take from two to a little over five months to complete.

(Source: www.greenguard.org/en/index.aspx)

#### 4.3.2.3 Carpet and Rug Institute Green Label Plus

The Green Label program was launched by the Carpet and Rug Institute (CRI) in 1992 to test carpet, cushions, and adhesives to identify products with very-low VOC emissions. Carpets and adhesives are tested by an independent third-party certified laboratory, and must meet stringent criteria for low chemical emissions to earn the use of the Green Label Plus label. The ANSI-accredited green carpet program Green Label Plus meets testing procedures for the Collaborative for High Performance Schools (CHPS) (see Chapter 1, Section 1.4.1.3) and also meets State of California Section 01350 Version 1.1 requirements. CRI uses the third-party indoor laboratory, Air Quality Science of Atlanta, to perform testing.

CRI Green Label Plus–certified carpet products are approved as a compliance path for Option 1 of IEQ Credit 4.3: Low-Emitting Materials—Flooring Systems of the

USGBC 2009 for the New Construction and Major Renovations (NC), Commercial Interiors (CI), and Core & Shell (CS) green building rating systems.

(Source: www.carpet-rug.org/commercial-customers/green-building-and-the-environment/green-label-plus/)

#### 4.3.2.4 SCS FloorScore®

FloorScore is a program that certifies flooring products that meet the indoor air quality low-VOC emission requirements of California Section 01350. FloorScore was developed jointly by the Resilient Floor Covering Institute (RFCI) and Scientific Certification Systems (SCS) specifically for resilient flooring and wall base made from linoleum, rubber, vinyl, laminate, ceramic, and wood materials.

Section 01350 is also the base criteria adopted by the Collaborative for High Performance Schools (CHPS), and is also a requirement by the California Department of General Services for all contracted professional architectural and engineering services. SCS is an independent third-party certification firm that assesses and establishes whether products meet the requirements of the latest edition of SCS-EC-10 in order to qualify for the FloorScore® seal.

FloorScore-certified noncarpet products are approved as an alternative compliance path for Option 1 of IEQ Credit 4.3: Low-Emitting Materials—Flooring Systems of the USGBC 2009 for the New Construction and Major Renovations (NC), Commercial Interiors (CI), and Core & Shell (CS) green building rating systems. The proposed USGBC LEED Version 4.0 EQ Credit: Low-Emitting Materials criteria no longer specifically names FloorScore but requires that TVOCs meet criteria set by CDPH Standard Method v1.1 or the German AgBB Testing and Evaluation Scheme.

(Source: www.scscertified.com/gbc/floorscore.php)

### 4.3.3 Materials Evaluation Guidelines and Resources

There are other guidelines and resources that can be used to facilitate understanding and evaluation of the complex, interconnected environmental body of knowledge surrounding sustainability. The following is a listing of a few of these resources.

#### 4.3.3.1 Whole Building Design Guide

The Whole Building Design Guide (WBDG) is a program of the US National Institute of Building Sciences (NIBS) to create an internet-based gateway to comprehensive and current information about whole building design techniques and technologies (see Figure 4.12). The site is divided into the different tabbed areas of:

- Design Guidance
- Project Planning
- Management and Delivery
- Facilities Operations & Maintenance
- Documents & References
- Tools

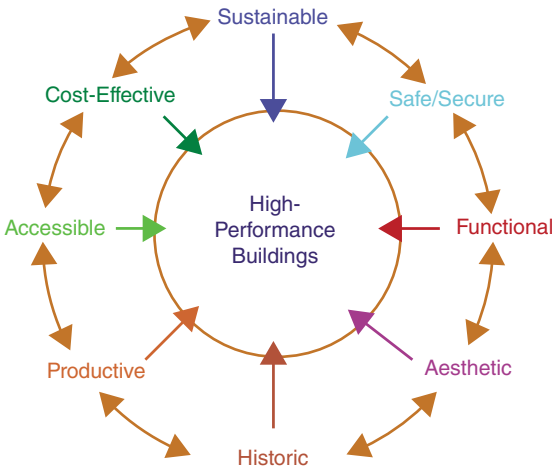


**Figure 4.12** Relationship between components of high-performance building
Whole Building Design Guide

- Continuing Education
- Building Information Modeling (BIM)
- Applied Research

(Source: www.wbdg.org)

**Figure 4.13** Cal Recycle logo
Cal Recycle

### 4.3.3.2 Green Building Materials

The California Department of Resources Recycling and Recovery (CalRecycle) (see Figure 4.13) created a website that defines sustainable (green) building and green building materials. It also describes how to proceed with evaluations of environmental attributes and cites original references. A Recycled Content Product Directory can be accessed at www.calrecycle.ca.gov/RCP/.

(Source: www.calrecycle.ca.gov/greenbuilding/materials/)

### 4.3.3.3 Green Building Pages

Green Building Pages' Benchmarking Sustainability (© copyright 2002) is a transparent and comprehensive set of 160 criteria to evaluate products and product certifications over the entire life cycle and environmental, economic, and social sustainability attributes. The major categories include:

- Production and Manufacture (including LCA and carbon footprint)
- Installation, Use and Maintenance
- End of Product Life
- Company Social Sustainability Profile
- Certifications (Type I, II, II)
- Testing
- Sustainable Achievements

This open web resource aligns with the ASTM E2129, Standard Practice for Data Collection for Sustainability Assessment of Building Products, the Global Reporting Initiative (GRI) Sustainability Reporting Guidelines, as well as other industry standards. The Green Building Pages' Benchmarking Sustainability product and certification evaluation

format is the result of more than 15 years of research and contributions by many building industry and product life cycle experts. It is a free online sustainable design decision-making tool.

(Source: www.greenbuildingpages.com/)

#### 4.3.3.4 BEES

Building for Environmental and Economic Sustainability (BEES) is environmental evaluation software developed by the National Institute of Science and Technology (NIST) for use by designers, builders, and product manufacturers. Products are analyzed based on the ISO 14040 series life cycle assessment approach, which covers environmental attributes from raw material acquisition to manufacture, transportation, installation, use, and recycling and waste management. The ASTM standard life cycle cost method is used to measure product economic performance. The ASTM Standard for Multi-Attribute Decision Analysis is further used to combine both product environmental attributes and economic performance.

(Source: www.nist.gov/el/economics/BEESSoftware.cfm)

#### 4.3.3.5 GreenSpec Directory

The independent company, BuildingGreen, Inc., headquartered in Brattleboro, Vermont, has compiled a subscription-based database of product information with a specific focus on independently researched environmental attributes and issues.

(Source: www.buildinggreen.com/)

#### 4.3.3.6 Pharos

The Healthy Building Network also offers another subscription-based evaluation tool, Pharos, that offers product comparisons of multiple, prioritized environmental attributes. Pharos may also be used to search out available products that meet specific environmental attributes.

(Source: www.pharosproject.com)

## 4.4 Impact of Choice

### 4.4.1 Life Cycle Analysis

Performing a Life Cycle Analysis (LCA) of a product or service means assessing the cumulative impacts of embodied energy, global warming potential, and water demand (see also Chapter 1, Section 1.1.10 and Section 4.2.2 of this chapter). These consist of inputs and outputs over a product's lifetime (cradle to grave) that begins with raw material extraction and continues through installation and maintenance until final disposal. It is a scientifically based method to measure the environmental performance of products and systems from raw material extraction to manufacturing, production and distribution, to transportation operations and maintenance, and to recycling and waste management. Aggregate inputs of energy and raw materials plus outputs of air emissions, water emissions, solid wastes, waterborne wastes, and other discharges are determined, inventoried, impacts assessed, and the data analyzed to recommend improvements. Energy is first

collected as quantities of electricity (kWh), natural gas (cu. ft.), diesel (gallon or liter), or coal (tons). The quantities are then converted into units of fuel energy as millions of British thermal units (Btu) or in metric gigajoules (GJ). Emissions use tons as units of measure to describe the material amounts released, which are finally converted into global warming potential (GWP) units. It is notable that reusing existing buildings, building components, and materials prolongs their life cycles and significantly reduces the total embodied energy and GWP used over time.

The USGBC supports reuse as proposed in the LEED Version 4.0 MR Credit: Building Life-Cycle Impact Reduction, OPTION 4. Whole-Building Life Cycle Assessment (3 points). European manufacturers have been assembling product LCA data for some time with US manufacturers beginning to compile their own LCA data. These are called Environmental Product Declarations (EPD) and were created for products or systems by applying an ISO 14025/TR standard and an LCA-based tool to attest to the environmental performance. LCA is the basis of environmental policy in the European Union, Japan, Australia, Costa Rica, South Africa, Thailand, and the US jurisdictions of California, Oregon, and King County (Seattle) in Washington State. EPDs for products and services, mandated by countries such as France and corporations such as Wal-Mart, are influencing other countries and the world market into adopting policies and enacting legislation to promote them. EPDs are also proposed as USGBC LEED Version 4.0 criteria.

Note that the lack of free access to a standardized LCA central inventory has prompted product manufacturers to measure, analyze, and calculate product LCA values, and individually declare their results. However, with the information coming from multiple self-interested parties, questions have been raised whether the data presented is comparable, statistically valid, of high quality, or is being updated to keep up with changes to manufacturing, fabrication, transportation, and to the product model. The National Renewable Energy Laboratory (NREL) at the Department of Energy (DOE) appears to have initiated a US Life Cycle Inventory (LCI) Database, which can be found at www.nrel.gov/lci. Other LCA tools and resources can be found at:

http://apps1.eere.energy.gov/buildings/tools_directory/
www.wbdg.org/tools/tools_cat.php?c=3
www.epa.gov/nrmrl/lcaccess/resources.html
www.epa.gov/nrmrl/lcaccess/pdfs/600r06060.pdf
www.lcacenter.org/pdf/Roadmap-to-EPDs-in-the-USA.pdf

## 4.4.2 Evidence-Based Design

> "Evidence-Based Design (EBD) is the process of basing decisions about the built environment on credible research to achieve the best possible outcomes."
>
> The Center for Health Design
> (Source: www.healthdesign.org/edac/about)

EBD has primarily been used to influence the design of healthcare facilities by applying environmental psychology, neuroscience, and behavioral economics to architecture. (Source: http://encyclopedia.thefreedictionary.com/Evidence-Based + Design)

This approach can be applied to facilities with specific uses, and with a focus on sustainable attributes. Peer-reviewed studies proving the environmental benefits and

negative impacts of materials, products, and systems form credible guidelines to influence design decisions.

One such study concluded that higher sales are likely when merchandize is located immediately under daylit areas. This study occurred in Wal-mart stores under where skylights were installed. Many other studies have proved that green buildings with the best indoor air quality and daylighting have occupant workers with higher productivity and lower sick-day use. Conversely studies of known "sick" buildings with poor indoor air quality proved a higher use of sick leave and lower productivity. Knowing why it was a sick building helps the design team with how to design a facility with better IAQ and daylight views.

### 4.4.3 Sustainable Return on Investment

Sustainable Return on Investment (SROI) is a methodology to identify viable sustainable initiatives that best accomplish the owner's goal of optimizing the total value of a project and positioning it with the best possible case for approval or funding.

SROI determines the full value of a project by assigning monetary values to all costs and benefits—economic, social, and environmental. The process provides decision-making support to increase the likelihood of a project's going forward by prioritizing the benefits of sustainable initiatives. SROI will help communicate the full value of your sustainable initiative including direct, indirect/noncash costs and benefits as well as the values of externalities that are generally overlooked in economic assessment and not typically revealed to stakeholders.

(Source: www.hdrinc.com/about-hdr/sustainability/sustainable-return-on-investment)

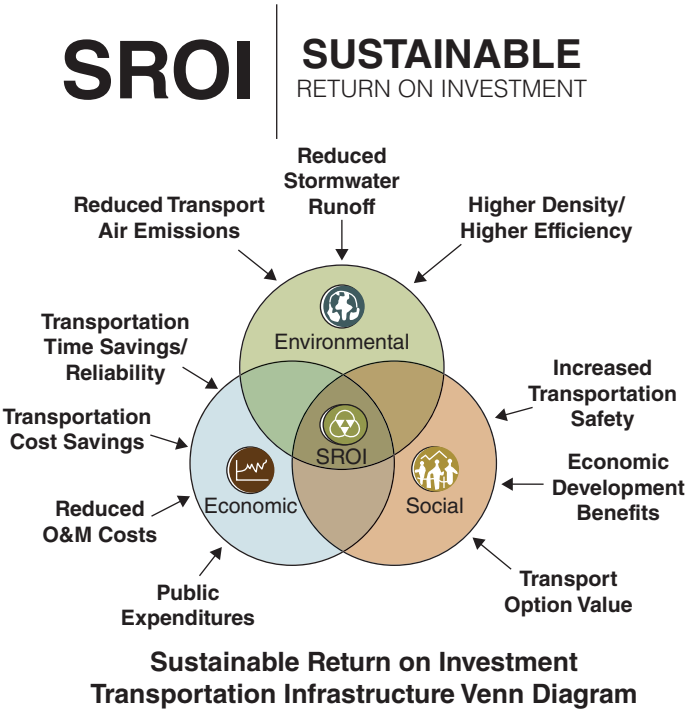


**Figure 4.14** Components that go into SROI
HDR Decision Economics

### 4.4.4 Operations and Maintenance

Operations and Maintenance (O&M) is a key sustainable design factor that is an important part of LCA, but often overlooked by designers and owners during the design process. O&M considers the cost of labor and parts necessary for optimum operations, the recommended maintenance of finish materials, systems, and equipment, and their eventual replacement. The environmental impact of operations and maintenance is a third significant criterion to add to the labor and parts required for each material, system, or piece of equipment installed.

For example, when choosing to install resilient flooring it is prudent to evaluate the durability of the product including the topcoat finish, and the recommended frequency of refinishing. If the material requires waxing and polishing once a week then significant time, labor, and new material is expended. Old wax must first be removed and rinsed with potable water, a new wax coating spread and later buffed to the desired shine. This effort takes at minimum many hours and could take days, depending on the total resilient flooring square footage to be waxed. This is not a sustainable action for a number of reasons. Significant potable water is spent, new wax materials are continually applied, and water vapor, possibly containing toxics or irritants, is expelled into the room. Common floor waxes can contain toxic cresol, carcinogenic formaldehyde, or other hazardous chemicals including toluene, xylene, phenol, nitrobenzene, and perchloroethylene. Even though nontoxic floor waxes are available, the labor and material investment for a regular waxing routine is substantial, and unnecessary when another choice such as a more durable cross-linked polyurethane factory finish is available. A cross-linked polyurethane finish requires regular sweeping, dust mopping, or vacuuming to remove loose dirt and grit, and a light damp mopping with a well-rung mop when needed. It is years before the finish would need to be replaced due to normal wear.

A second example is the application of a whole building control system used to manage energy consumption. Sensors report real-time data to a central computer system that is set to react to data that moves outside of preprogramed parameters. That reaction can be to switch on a motor to adjust a roller shade to block direct sunlight, which reduces glare and the heat energy being introduced into a room. At the same time a signal is sent to cool the room by turning on a ventilation fan that blows air across chilled water coils before it is placed into that same room. Another sensor notices that the room is empty and turns off the artificial lights and power to the room, except for powered items identified as essential. A temperature rise in the chilled water sends a signal to operate the pumps to move the chilled water from the cooling tower. This automated preprogrammed system is capable of being securely monitored and the parameters adjusted anywhere there is a phone line, cable, or Wi-Fi Internet connection. Monitoring can be done using multiple Internet-capable devices including smartphones and computer pads, laptops, and workstations. When data moves beyond predetermined setpoints in a monitored room an electronic alert can be sent to the responsible agent who has the opportunity to override the automated response. Maintaining a close control of the energy introduced and consumed within a facility helps achieve the sustainable goal of energy efficiency and as a result minimizes expending owner resources. This can, however, only be accomplished within the building's design capabilities. A facility designed and constructed to be high performance will achieve superior results as opposed to one designed and constructed to minimum base code requirements. And a base code facility with a whole building control system will outperform a similar base code building without one.

Sustainable operations and maintenance require an assessment of the impacts that material and system selection have during the design process. This includes close

follow-up monitoring of the labor, material, and energy resources depleted by the built operating facility necessary to verify conformance to the facility's design parameters.

### 4.4.5 Indoor Environmental Quality and Occupant Health

Studies have proven that healthy indoor environmental quality (IEQ) leads to enhanced occupant health and comfort, which typically leads to increased productivity. Productivity may be significantly improved due to the reduced incidence of headaches, colds, flu, allergic reactions, and other health-related discomforts that lead to absenteeism and the use of paid sick leave. Irritants, allergens, exposure to hazardous chemicals and other life-threatening substances, for instance, radon, carbon monoxide, and pathogens, such as *Legionella bacillus,* directly affect the health of building residents and transients. Irritants and allergens include dust mites, odors, pollen, cat dander, mold, and bacteria. Exposures to hazardous chemicals include: curing paint, stain, sealants, and adhesives; floor and furniture finishes; interior applied pesticides and rodenticides; and caustic or acidic fumes from cleaning supplies. Reducing occupant exposure to these materials should always be a basic goal of the sustainable design process. To achieve healthy indoor environmental quality, ensure that:

- Building materials incorporated are not wet or otherwise contaminated.
- Building materials incorporated do not off-gas chemical irritants or toxins.
- Building humidity is maintained between 25 and 60 percent according to parameters acceptable to the region.
- The exterior envelope significantly reduces heat energy transfer including uncontrolled air infiltration.
- The exterior envelope is waterproof and vapor retardant, and if water does penetrate it has a planned path of egress.
- The exterior envelope and interior plumbing are design detailed and constructed to prevent the possibility of condensation formation.
- Mechanical ventilation includes fresh filtered, humidity controlled, and tempered air provided directly to occupants during the heating and cooling seasons.
- Operable windows are provided for natural ventilation use during temperate seasons, and for periods when the mechanical system is inoperable.
- All sources of combustion, odors, and water vapor are exhausted to the exterior.
- Exhaust louver openings and combustion stacks are downwind and located away from fresh-air intakes.
- Areas plumbed with water, such as faucets and shower heads, be drained and have a maintained plumbing trap.
- Perimeter foundation grades all slope away from the building or to a maintained area drain.
- Concrete slab-on-grades are contiguously sealed and tied into the exterior foundation walls in areas of known radon.
- Sump pump pits in slabs-on-grade are capped and sealed against radon and other contaminants.
- Concrete slabs and walls do not exceed 75 percent relative humidity using in situ probes in accordance with ASTM F2170.

Almost all of the above listed actions emphasize achieving significant reduction of airborne contaminants, or to control water, condensation, and water vapor. Controlling both airborne contaminants and water in its various forms is fundamental to maintaining human health and well-being.

(Source: www.epa.gov/iaq/pubs)

## 4.4.6 Impact of Choice

The impact of choosing construction materials, products, equipment, and building systems for a project is that the selection eventually affects occupant health and therefore productivity, which in turn affects a company's bottom line. Incorporating materials, products, and building systems with the least negative life cycle impact is achievable for little or no added construction cost. Doing so is a smart long-term decision with a measurably positive socioeconomic and sustainable return on investment.

Smart investment considers the constructed building as an asset under use over its lifetime. Initial construction costs are actually not as great as the funds expended for long-term operational maintenance and renovation. But understand that these hard costs are usually only a fraction of the human resource expenditures of an operating facility. This is where revenue from an increase in worker productivity and a decrease in sick-leave use has a correspondingly larger financial impact over time for building owners who occupy their facility. And owners who lease their facility can expect to charge a higher per-square-foot rent than facilities built to just meet code.

Expending capital to achieve sustainable initiatives does not only receive a measurable economic return but also other beneficial results. These beneficial sustainable achievements can include:

- living lightly on the Earth
- a low carbon footprint, carbon neutrality, or a net-zero carbon footprint
- reducing greenhouse gasses
- energy efficiency
- water conservation
- using renewable and in particular rapidly renewable resources
- salvaging materials for reuse, repurpose, or recycling
- using low-VOC and non-HAP (hazardous air pollutant) materials to achieve good indoor air quality or indoor environmental quality
- to "do no harm" to facility occupants and the environment

Each of these sustainable achievements is not only personally beneficial but also positively impacts society and the environment.

(Sources: www.davislangdon.com/USA/Research/ResearchFinder/2007-The-Cost-of-Green-Revisited and www.wbdg.org/resources/lcca.php)

# Chapter 5
# Sustainable Design and Project Delivery

All projects, from the simplest buildings to the most complex infrastructure work, require a number of specialized individuals, firms, and companies that participate in a vast array of complex activities to design and construct a facility. The size of this group may be large or small, depending on the project type, size, and complexity.

Project delivery has been defined a number of ways by different organizations. The two following represent the most common, as defined by recognized "experts" in the design and construction industry:

> **American Institute of Architects (AIA):** Project delivery is " . . . the method selected to allocate roles, responsibilities, risks, and rewards among the parties accomplishing the design, preparation of construction documents, construction, and management of a construction project."
>
> (Source: *The Architect's Handbook of Professional Practice*, 14th edition, John Wiley & Sons, 2008; p. 1000)
>
> **Associated General Contractors of America (AGC):** Project delivery is ". . . the comprehensive process of assigning the contractual responsibilities for designing and constructing a project. . ." and ". . . is fundamentally a people method. . ." because the ". . . success or failure of any delivery method depends upon the performance, trust, and cooperation among the parties."
>
> (Source: *Project Delivery Systems for Construction*, Associated General Contractors of America, 2004; p. 3)

Project delivery is fundamentally focused on the achievement of a defined set of desired results through the design and construction process. The owner will generally be the party that sets the fundamental goals and objectives for the project, which may include sustainable design criteria. The design team will then expand on those fundamental goals and objectives, with considerable assistance from product manufacturers, design consultants, and the construction team in certain project delivery methods to develop comprehensive documentation which describes the desired results for the facility. If the selected project delivery method works properly, with the active and committed participation of all of the parties, and barring unforeseen difficulties, the success of the project is virtually assured.

The project delivery methods that are briefly discussed in this ***Sustainable Design and Construction Practice Guide*** are discussed in much greater detail in The Construction Specifications Institute's ***Project Delivery Practice Guide*** (John Wiley & Sons, Inc., 2010).

## 5.1 Project Delivery

Project delivery encompasses the contractual relationships necessary to establish a sequential process of design and construction activities that converts a conceptual idea into a completed and occupied facility. Project delivery encompassing sustainable design practices can be accomplished using any of the following methods:

- Design-Bid-Build (D-B-B)
- Design-Negotiate-Build (D-N-B)
- Design-Build (D-B)
- Construction Management (CM)
- Owner-Build (O-B)
- Integrated Project Delivery (IPD)

Competitive market forces frequently compel owners to select a project delivery method that will achieve balance between scope, budget, and schedule. On a sustainable design project, a fourth key factor is included in the balance equation: facility life cycle (Figure 5.1). This factor focuses on optimizing direct and indirect building life cycle costs relating to energy use, maintenance, waste disposal, and occupant health and productivity. Environmental impacts are thereby minimized throughout the building life cycle, including product manufacturing, construction, use or occupancy, and demolition or renovation and reuse.

These four key factors comprise the essence of each of the contractual arrangements for project delivery. How these factors are defined by the project priorities, and the owner's capacities to fulfill those factors are necessary for the owner to make an informed decision about which project delivery method to select. Selection of the project delivery method will also directly influence the nature and extent of work required for the design and construction of the project, including the contracts among the participants.

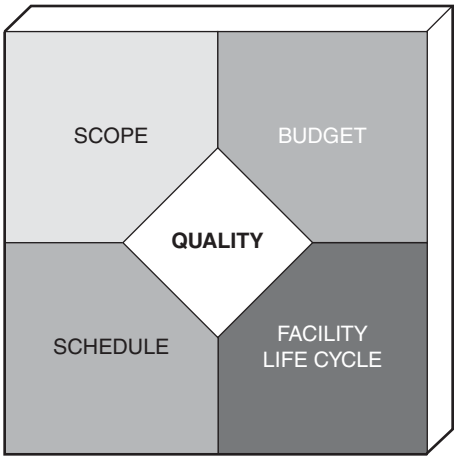


**Figure 5.1** Quality balance equation

The following discussions of each major project delivery method include a brief description of each method, a listing of advantages and disadvantages of each, and a discussion of potential sustainable design and construction practices that can be included in each phase of the project delivery method.

## 5.1.1 Design-Bid-Build

Design-Bid-Build (D-B-B) is the "traditional" method of moving a project from its conception to its completion, and has the longest history of use in the design and construction industry. D-B-B is a linear sequence of activities generally progressing from project conception through design, documentation, bidding, and construction (Figure 5.2). The basis of D-B-B is twofold:

- Design and construction documents are completed prior to bidding and construction.
- The contractor is selected by a competitive, price-based selection process.

### 5.1.1.1 Advantages

Advantages of the D-B-B project delivery method include:

- Sustainability Advantages:
  - Owner and design team have good control of sustainable design strategy development during the design and documentation phases.
- This method is the most familiar to all participants in the design and construction industry. Therefore, roles and responsibilities are well understood, and general conditions of contracts are similar from project to project.
- Schedules are generally linear in nature, and are therefore easier to establish and implement.
- Owners who do not have experienced construction staff and owners with boards of directors may consider this method most advantageous.

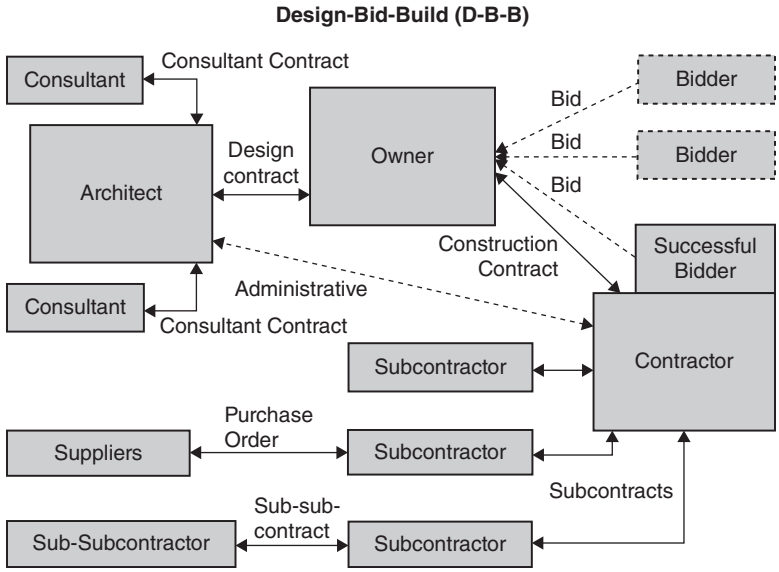


Figure 5.2 D-B-B project delivery method

- Public entities such as federal, state, and municipal governments usually require this delivery method to help ensure that taxpayers are paying a competitive price for public facilities.

#### 5.1.1.2 Disadvantages

Disadvantages of the D-B-B project delivery method include:

- Sustainability Disadvantages
  - The owner relies on the low bidder to implement sustainable design requirements, which may not be fully incorporated into the successful bid along with other aspects of the project's requirements.
  - The design team has marginal control of the effective implementation of sustainable design requirements in the context of a low-bid environment.
  - The actual cost impact of certain sustainable design requirements is not known until the bid opening, and may never be fully known at the end of the construction phase.
  - The contractor may find that the cost of certain sustainable design requirements is more than anticipated (waste management, indoor air quality), and may be subject to fulfilling those requirements in the framework of an inadequate bid amount.
- Bid-day surprises when bids exceed the budget. This can result in significant time delays due to the need to redesign and re-bid the project.
- D-B-B tends to create adversarial relationships, by its very nature, since the contractor's goals and objectives for the project often conflict with the owner and the design team's goals and objectives.
- Successful bidders cannot rely on the owner to carry appropriate design and construction contingencies.
- The design professional is usually established as the "impartial" administrator of the contract, but has an inherent and substantial conflict of interest by virtue of its contract with the owner.
- The owner has little or no control of selection of subcontractors, or of the actual buy-out of the project; the contractor may have the ability to "bid shop" if proper limitations are not included as part of the bidding requirements.

### 5.1.2 Design-Negotiate-Build

Design-Negotiate-Build (D-N-B) is closely related to the D-B-B project delivery method, and also has the long history of use in the design and construction industry. D-N-B allows for the possibility of a more integrated sequence of activities which also generally progresses from project conception through design, documentation, subcontractor bidding, and construction (Figure 5.3). The fundamental characteristics of D-N-B include:

- Design and construction documents do not necessarily need to be completed before the project cost is negotiated between the owner and the contractor.
- A specific set of bidding requirements and instructions for preparing and submitting general contract bids is not necessary; subcontracts may still be competitively bid.
- The contractor is selected by a process determined by the owner, often with advice from the design team. This process may involve a qualifications-based selection,

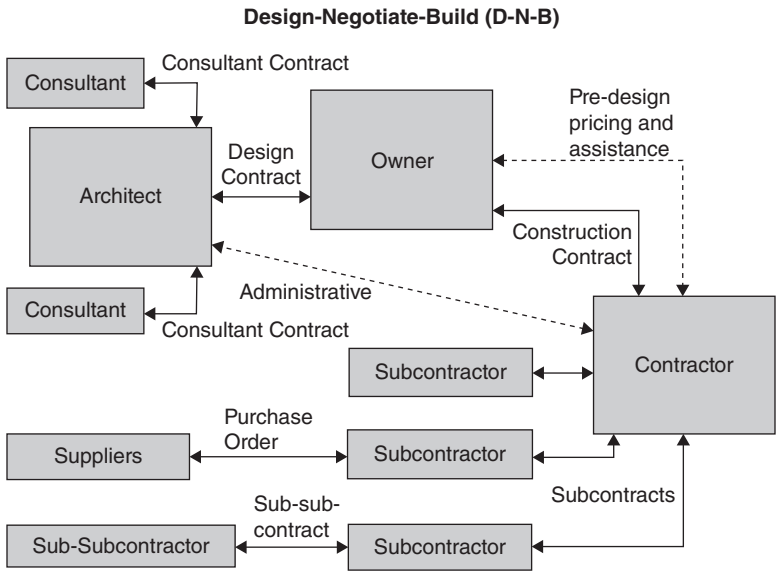


**Figure 5.3** D-N-B project delivery method

competitive fee-based selection, a combination of both of these, and a number of other possible methods.

### 5.1.2.1 Advantages

Advantages of the D-N-B project delivery method include:

- Sustainability Advantages
  - Owner and design team can collaborate with the contractor on the development of sustainable design and construction strategies, and incorporate the cost of those strategies into the negotiated contract sum.
  - If the contractor is on the team early in the design phase, the contractor can inform and influence the design of the building to optimize the implementation of sustainable design strategies within the context of overall project quality and cost.
- Negotiating with a D-N-B contractor is less formal than the D-B-B competitive bidding process.
- Negotiating the scope of work to fit the budget results in a more efficient design phase and a less adversarial construction phase.
- The owner has the opportunity to be more involved in the selection of subcontractors and suppliers.
- Cost can be managed to some degree prior to completion of the construction documents as the contractor maintains current estimates of the construction cost based on evolving information provided by the design team.

### 5.1.2.2 Disadvantages

Disadvantages of the D-N-B project delivery method include:

- Sustainability Disadvantages
  - No substantial disadvantages.

- Lowest possible cost of the project at the outset of construction is not likely, since the contractor is not usually selected by competitive, price-based selection process.
- Since the cost of the work is usually estimated prior to completion of the construction documents, the cost is not necessarily "guaranteed" until such time as the construction documents are complete.
- Design contingency allowances are usually necessary to be "carried" by the owner during the final development of the construction documents to cover "scope creep" that can occur as the contractor receives more detailed information from the design team.
- Owners may be prone to assuming that the contractor's early estimates are to be considered "not-to-exceed" amounts, which can result in misunderstandings and unfulfilled expectations as the design and construction documentation evolves.
- By committing to negotiation, the owner becomes committed to the project before the final construction cost is known.

## 5.1.3 Design-Build

Design-Build (D-B) may be preferred when the owner requires a single point of accountability and needs a more simplified contract arrangement. D-B allows the owner to contract with a single entity to provide all design and construction services for the project (Figure 5.4). D-B is also a linear sequence of activities generally progressing from project conception through design, documentation, and construction. The fundamental characteristics of D-B include:

- Design and construction services are integrated into a single contract for project delivery.
- The D-B contractor can be selected by a competitive, price-based selection process or on a qualifications-based process as determined by the owner.

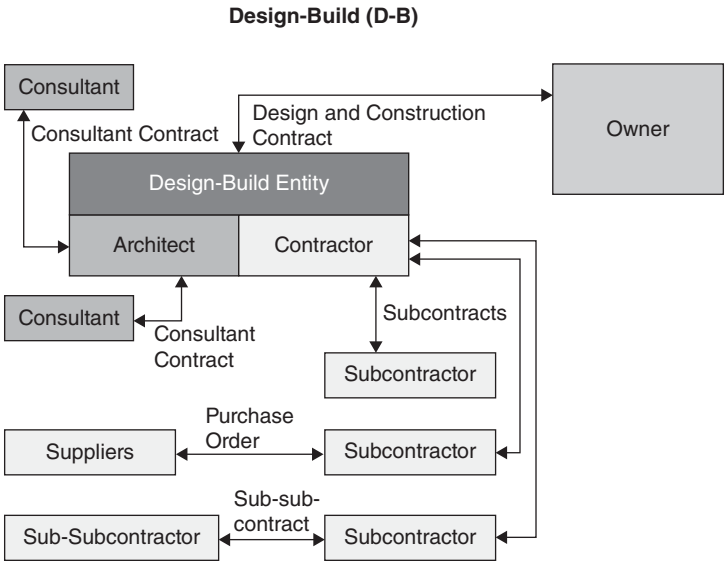


Figure 5.4 D-B project delivery method

#### 5.1.3.1 Advantages

Advantages of the D-B project delivery method include:

- Sustainability Advantages
  - The owner can specify sustainable design and construction requirements either according to performance (i.e., "achieve LEED Platinum Certification"), or by prescriptive or other methods to achieve desired sustainability goals and objectives for the project.
  - The design/construction team, as a single entity, has virtually unilateral control of the implementation of sustainable design and construction strategies, except specific prescriptive sustainability requirements.
  - The owner can mandate selection criteria of the D-B team to include broad experience in implementing sustainability requirements.
- A single entity is responsible for design and construction.
- Project delivery can usually be implemented in a more timely and cost-effective manner by using fast-track scheduling in both the design and construction phases.
- D-B firms usually specialize in certain types of facilities, which will tend to shorten the time and effort required to develop effective design solutions for certain types of projects.
- Since the design team and the construction team are integrated, product evaluation, selection, and buy-out can be accomplished more efficiently based on cost, availability, and performance.

#### 5.1.3.2 Disadvantages

Disadvantages of the D-B project delivery method include:

- Sustainability Disadvantages
  - The owner loses control of the implementation of certain sustainable design strategies, unless they are specified clearly and accurately in the request for proposal documents.
  - Owner does not know the actual cost impact of certain sustainable design requirements until the bid opening, and may never be fully known at the end of the construction phase.
- The owner loses the design professional as the "traditional" advocate during the design and construction phases of project delivery. This may require the owner to retain the services of a professional representative who is experienced in design and construction project management, to manage the owner's interests in the project.
- The owner must prepare a detailed project description or performance specification so that the D-B contractor has clear and definitive requirements on which to base the design and associated costs of the project. This usually requires that the owner retain the services of a design professional to develop the project description, performance specifications, and often concept drawings for this purpose.
- The owner may lose considerable control of the end product if the project description, performance specifications, and supporting drawings are not complete and explicitly clear in terms of desired results.

- Dispute resolution may require more owner time and expense since the design professional as "advocate" is not a part of the process independent of the D-B entity.
- The D-B entity may have more risk and potential liability due to expanded roles in design and construction. The D-B entity is usually required to carry both professional liability insurance and construction risk insurance, which can increase the overall cost of the project.

## 5.1.4 Construction Management

Construction management (CM) is the process of applying professional management expertise to a construction project for the purpose of effectively managing scope, cost, and time simultaneously. It is most often implemented on projects with complex or aggressive schedules or budgets, those that require extensive coordination between design disciplines, and those where the owner has limited expertise or staff availability with regard to design and construction. Used appropriately, the additional fees paid to a construction manager are offset by removing the burden of exhaustive project oversight from the owner or owner's staff. The CM can either be an agent or advisor (CMa) (Figure 5.5) or the contractor (CMc) (Figure 5.6). CM has many of the characteristics of the D-N-B delivery process, allowing for the possibility of a more integrated sequence of activities which generally progresses from project conception through design, documentation, contractor and/or subcontractor bidding, and construction. The fundamental characteristics of CM include:

- The CMa advises the owner on management of the design and construction of the project, and may also have the authority to represent and act on behalf of the owner.
- The CMc consults with both the design team and the owner, prepares the project schedule, makes recommendations for implementation and overall project delivery, prepares project cost estimates and assists in the cost management of the project, and finally executes the construction as the general contractor.

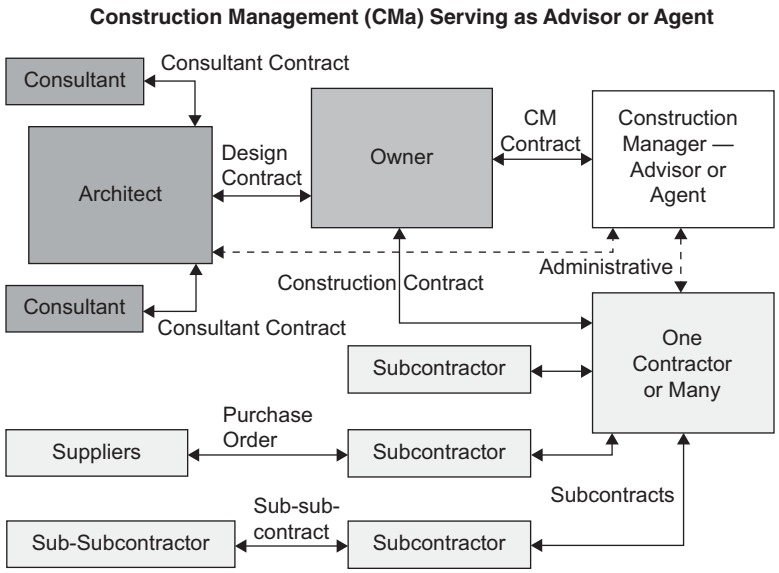


Figure 5.5 CMa project delivery method

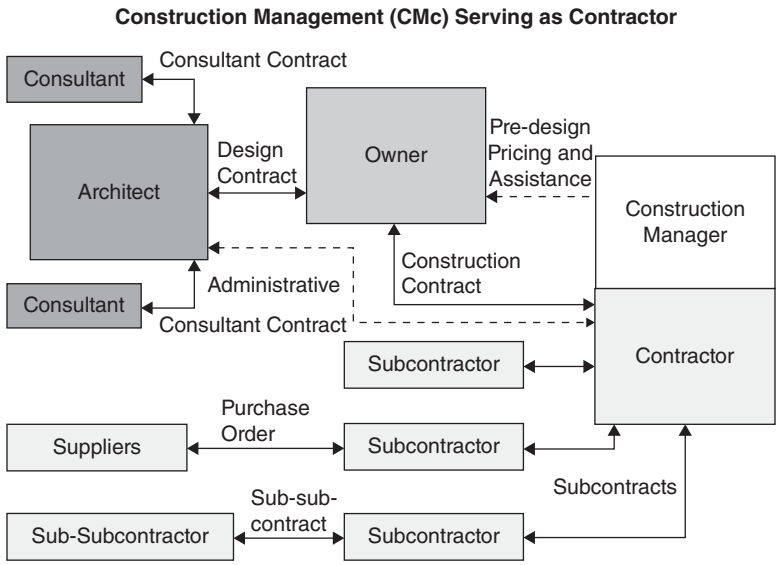


Figure 5.6 CMc project delivery method

### 5.1.4.1 Advantages

Advantages of the CM project delivery method include:

- Sustainability Advantages
  - The owner can rely on the CMa or CMc to ensure the proper implementation of the sustainable design and construction requirements for the project by the contractor.
  - If the CMa or CMc is a qualified sustainability consultant, the CM can play a valuable role in the successful implementation of the sustainability goals and objectives of the project.
  - The cost of sustainability may be effectively managed by the CM during the course of the project delivery process.
- The owner maintains direct contractual relationships with the design professionals and either a single prime contractor or multiple prime contractors, depending on project structure.
- The CMa does not bear financial risk for design and construction.
- The CMc will likely offset additional design professional fees and costs associated with fast-track project delivery or multiple bid packages.
- Use of a CMa or CMc can help facilitate the efforts of all members of the design and construction team, which can reduce overall effort and cost through proactive management of the project delivery process.
- The CMc can provide valuable cost management services to the design team and the owner by assisting with product and system selection, value engineering, cost/benefit and life cycle cost analysis.
- CM's flexibility allows application of selected services required to supplement those already available to the owner through in-house staff.

### 5.1.4.2 Disadvantages

Disadvantages of the CM project delivery method include:

- Sustainability Disadvantages
  - No substantial disadvantages, unless the CM is not experienced in sustainability.
- CM is not generally suited to small projects of limited scope and complexity, and projects that have little or no time constraints.
- The owner often pays a greater total amount for professional fees to the CM than for a more "traditional" project delivery method.
- Use of CM requires additional layers of reporting and communications within the design and construction team, and between those entities and the owner.
- CMc can result in potential conflicts of interest in cases where advice to the owner may affect the cost of the project and any associated profit accruing to the CMc.

## 5.1.5 Owner-Build

Owner-Build (O-B) is the process whereby a sophisticated and experienced owner entity, such as a real estate developer or corporate entity that is regularly engaged in facility development, manages the design and construction process directly. These owner entities invariably have in-house professional staff which are experienced in design and construction, and have considerable capabilities to manage those processes. O-B may employ any sequence of design and construction activities that best suit the owner, but will generally progress from project conception through design, documentation, bidding, and construction (Figure 5.7). The fundamental characteristics of O-B include:

- O-B usually employs direct contracts between the ownership entity and each design professional, contractor, and often subcontractors.

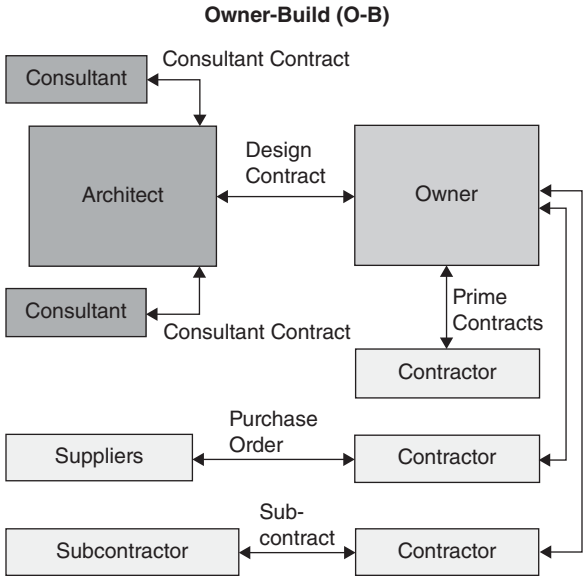


Figure 5.7 O-B project delivery method

- Similar to CMc, the owner entity does not usually retain another entity to provide construction services.

#### 5.1.5.1 Advantages

Advantages of the O-B project delivery method include:

- Sustainability Advantages
  - The owner has absolute control of the development of sustainable design and construction goals and objectives for the project, and the implementation of those goals and objectives as the "builder."
- The owner can achieve cost savings by performing the duties that a separate general contractor would perform under other project delivery methods.
- The owner has direct control of all phases and aspects of the project delivery process, particularly during the construction phase.
- Contract modifications can be implemented immediately and at any time, since the owner functions as both contractor and owner.

#### 5.1.5.2 Disadvantages

Disadvantages of the O-B project delivery method include:

- Sustainability Disadvantages
  - Unless the owner has someone in-house, the owner must still rely on a design professional or sustainability consultant to develop the implementation requirements for desired sustainability goals and objectives for the project.
  - The owner must manage each of the subcontractors very carefully in order to achieve effective implementation of the sustainable design requirements of the project.
- The owner assumes significantly more responsibility and risk associated with construction, project completion, and quality.
- If the owner performs design services in-house, the owner essentially assumes all project risks.
- Owners don't usually have the ability to provide direct labor to the project as do general contractors. This requires that each separate contractor must accomplish all of the work on the project, including mobilization/demobilization, provision of all tools and equipment necessary to complete the work, and other administrative, procedural, and temporary facilities requirements that are usually provided by a general contractor.

### 5.1.6 Integrated Project Delivery

Integrated Project Delivery (IPD) is anticipated by many as the delivery method that will transform the way future projects are conceived, designed, documented, constructed, and managed (operated and maintained) through the facility life cycle. One of the first working definitions of IPD was proposed by the AIA California Council:

> "Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the

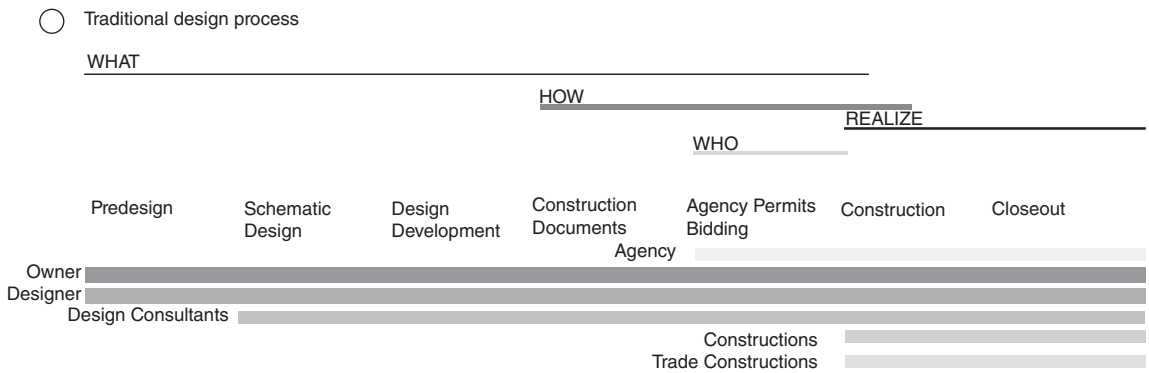


**Figure 5.8** Traditional design process

talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction."

(Source: Integrated Project Delivery – A Working Definition, Version 2, June 13, 2007, McGraw-Hill Construction)

In a very real and tangible sense, this approach to project delivery can be considered a sustainable approach to design and construction at a fundamental level. When all participants in this process are committed both to the success of each other and to the project in all respects, the results will properly incorporate functional, budgetary, schedule, and environmental considerations in an intelligent, integrated, and effective manner.

The flow of an IPD project from conceptualization through implementation to occupancy differs from other project delivery methods. Figure 5.8 illustrates the "traditional" project delivery process which is most commonly used in D-B-B, D-N-B, D-B, and O-B.

Figure 5.9 illustrates the essence of IPD in terms of the timeliness of involvement and participation of the primary participants in IPD. All participants are "on-board" much earlier in the process, and they are participating actively in the decision-making

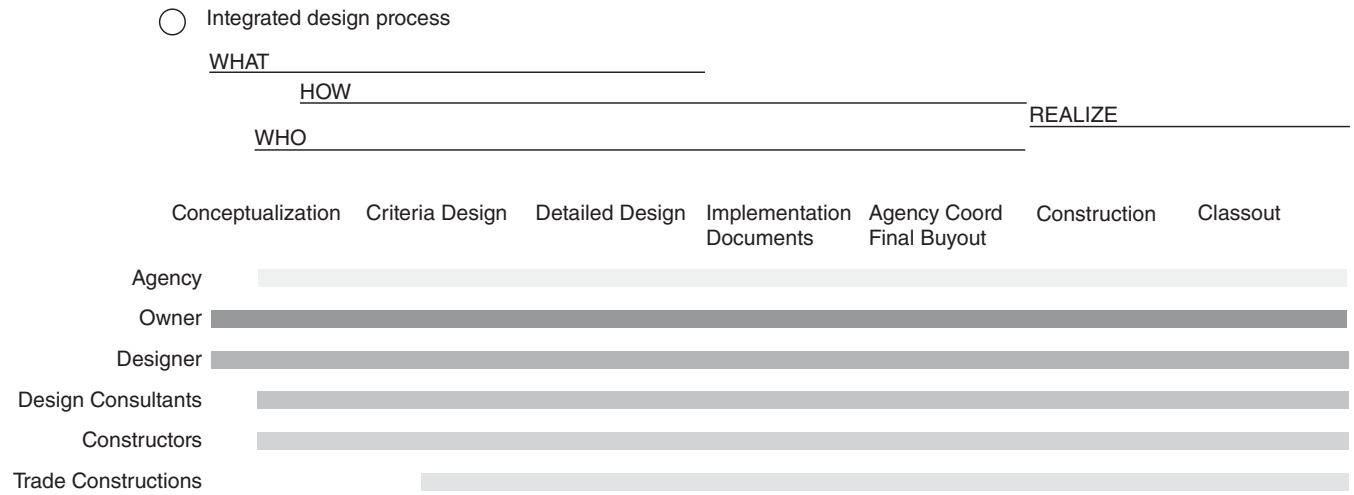


**Figure 5.9** Integrated project delivery and design process

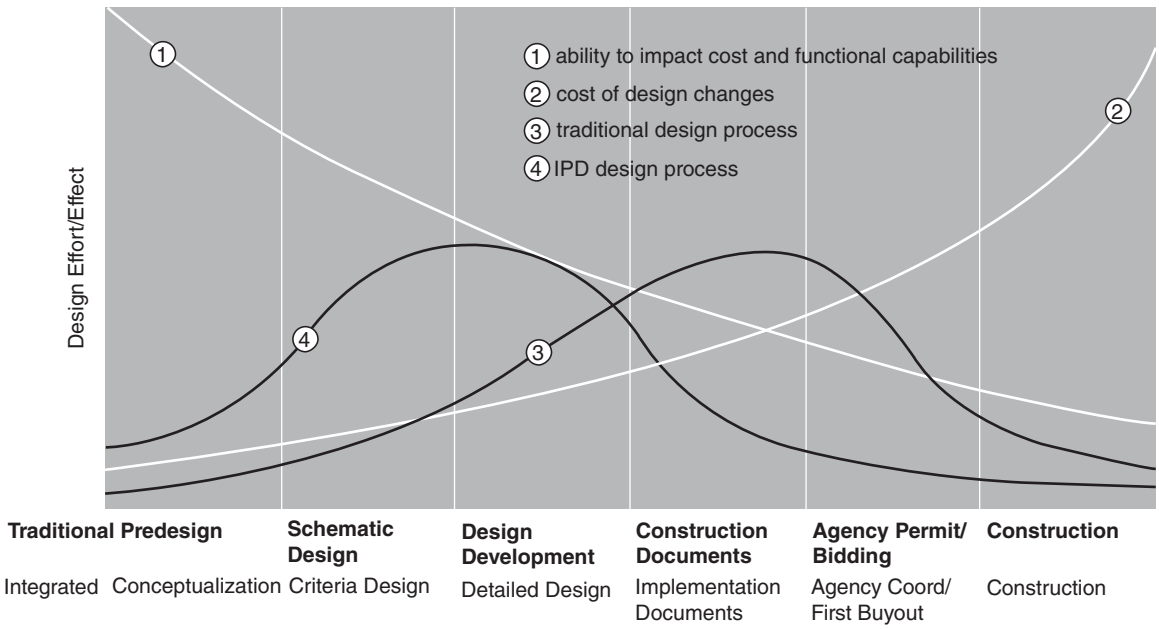


**Figure 5.10** MacLeamy Curve

process in an integrated and collaborative manner. This early and active involvement invariably produces much more cost-effective and timely results in the completed facility.

The IPD process is based on the premise of moving design decisions forward in the timeline as much as possible, as was proposed in 2004 by HOK CEO Patrick MacLeamy. This idea is graphically illustrated in the MacLeamy Curve, illustrated in Figure 5.10, which was introduced in the Construction Users Roundtable's *Collaboration, Integrated Information, and the Project Lifecycle in Building Design, Construction and Operation* (CURT WP-1202, August 2004). The fundamental concept of this illustration is that the cost of decisions in the project delivery process tends to be higher the later in the process that those decisions occur.

One of the core elements around which IPD is structured is the technological development of Building Information Modeling (BIM), which is the basis of how design and construction documents should be prepared and used under IPD. BIM is discussed in much greater detail in a number of other publications available in the construction industry, and is not addressed specifically in the *Sustainable Design and Construction Practice Guide*. However, when effectively used as a design, construction, and facility management tool in the context of IPD, BIM can also be considered a fundamental sustainable design and construction tool.

### 5.1.6.1 Advantages

Advantages of the IPD project delivery method include:

- Sustainability Advantages
  - The IPD team collaborates to develop sustainable design and construction strategies, and works together throughout the course of project delivery to effectively implement the sustainable design and construction strategies for the benefit of the environment, not just the owner.

- Higher-quality decision making regarding project cost, physical performance, implementation schedule, and life cycle performance.
- Better understanding of the facility design with greater evaluation of design options.
- Earlier detailed visualization of the facility during the design phases.
- Enhanced detection and resolution of conflicts between building components.
- Increased coordination of construction documentation.
- Greater component prefabrication opportunities.
- Optimized site utilization through more effective implementation planning.
- Efficient delivery of products, materials, and equipment to the site.
- Reduction of construction waste.
- Embedding and linking of important building information for use in facility management over the facility's life cycle.

#### 5.1.6.2 Disadvantages

Disadvantages of the IPD project delivery method include:

- Sustainability Disadvantages
  - No substantial disadvantages.
- From the owner's perspective, cost savings as the result of this delivery method may not be fully realized.
- From the perspective of each of the participants, the distribution of liability and responsibility may not be "comfortable" or fully understood in the absence of full and complete trust on the part of all participants.

# Chapter 6
# Construction Documentation Practices

In order to achieve the intended results of a sustainably designed project, it is fundamentally important that the procurement and construction documentation be complete, concise, correct, and constructible. This chapter will address construction documentation practices that are recommended by the Construction Specifications Institute (CSI) as they apply to documenting and specifying sustainable design requirements for a construction project.

These recommended practices, while consistent with CSI principles, standards, and formats, are to be applied in a variety of different ways in actual practice by the design and construction industry. However, when applied consistently, these recommended practices will help the design professional produce documentation that can be used by other participants in the design and construction process to achieve the intended result—a sustainable facility that will perform efficiently and effectively over its life cycle. These recommended practices can be applied to projects, whether or not a specific sustainable design or green building rating system is being used to measure and evaluate the sustainable attributes and overall performance of the completed facility.

## 6.1 Contract Issues

### 6.1.1 Owner-Design Professional Agreements

There are a significant number of organizations in the construction industry that publish standard forms of agreement (contract forms) for use by design professionals. This *Practice Guide* does not endorse or recommend any specific group of standard forms, nor does it attempt to address all of the various groups of standard forms which are available. The organizations that publish standard forms of agreement which are addressed in this *Practice Guide* include:

The American Institute of Architects (AIA)
National Society of Professional Engineers (NSPE)

ConsensusDOCS LLC
Design-Build Institute of America (DBIA)

The following is a discussion of the content of certain standard forms of agreement published by each of these organizations which specifically address sustainable design and construction issues. These discussions are not intended to be comprehensive in nature, and are not intended to represent legal advice or counsel. The topics covered here provide a basic awareness of these contractual provisions within each of the groups of standard forms, and establish a working knowledge of that content in basic terms.

#### 6.1.1.1 American Institute of Architects

The AIA publishes a wide variety of different standard forms of agreement for use between owners and architects, owners and contractors, design-build forms, integrated project delivery forms, and others. The essential forms of agreement that are discussed in this *Practice Guide* include:

- AIA Document B101–2007, Standard Form of Agreement Between Owner and Architect
- AIA Document B205–2007, Standard Form of Architect's Services: Historic Preservation
- AIA Document B211–2007, Standard Form of Architect's Services: Commissioning
- AIA Document B214–2012, Standard Form of Architect's Services: LEED® Certification

***AIA Document B101–2007, Standard Form of Agreement Between Owner and Architect:*** This standard form makes some broad and general references to sustainable design as a requirement of the architect's basic services. These references include the following Articles, paragraphs, and subparagraphs (Source: AIA Document B101™-2007) (emphases added):

**ARTICLE 3 SCOPE OF ARCHITECT'S BASIC SERVICES**

3.2.3 The Architect shall present its preliminary evaluation to the Owner and shall discuss with the Owner alternative approaches to design and construction of the Project, including the feasibility of incorporating **environmentally responsible design** approaches. The Architect shall reach an understanding with the Owner regarding the requirements of the Project.

3.2.5.1 The Architect shall consider **environmentally responsible design** alternatives, such as material choices and building orientation, together with other considerations based on program and aesthetics, in developing a design that is consistent with the Owner's program, schedule and budget for the Cost of the Work. The Owner may obtain other environmentally responsible design services under Article 4.

**ARTICLE 4 ADDITIONAL SERVICES**

The table in this Article lists optional additional services which the Owner may choose to incorporate into the Agreement, including:

- 4.1.22 Commissioning (B211™-2007)
- 4.1.23 Extensive environmentally responsible design

- 4.1.24 LEED® Certification (B214™-2012)
- 4.1.26 Historic Preservation (B205™-2007)

Three of these references require that a supplemental document be incorporated into the basic Agreement, which is discussed below. The description of additional services in subparagraph 4.1.23 (extensive environmentally responsible design) requires further definition and should be considered carefully in the context of the overall Agreement.

***AIA Document B205–2007, Standard Form of Architect's Services: Historic Preservation:*** This standard form supplement to the basic services agreement does not contain any explicit provisions that address sustainable design and construction. Historic preservation is, however, inherently a sustainable practice, and is addressed in more detail in other sections of this *Practice Guide.*

***AIA Document B211–2007, Standard Form of Architect's Services: Commissioning:*** This standard form supplement to the basic services agreement contains only one specific provision that addresses sustainable design and construction. Commissioning is, however, inherently a sustainable practice, but is not necessarily only associated with sustainable design and construction projects. Commissioning is addressed in more detail in other sections of this *Practice Guide.*

**ARTICLE 3 ADDITIONAL SERVICES**

3.1.8 LEED® Certification (B201™-2007)

***AIA Document B214–2012, Standard Form of Architect's Services: LEED® Certification:*** This standard form supplement to the basic services agreement is by definition a fundamentally important document on a sustainable design project. The entire document is dedicated to defining the scope of services associated with a project that is intended to achieve a specified level of LEED® Certification. This document addresses many important topics as part of these expanded additional services, including:

- Predesign workshops
- LEED Certification plan
- LEED Certification documentation
- LEED Certification specifications
- LEED Certification services during bidding
- LEED Certification services during contract administration
- Final LEED Certification report
- Owner's responsibilities regarding LEED Certification
- Architect's compensation for these services
- Special terms and conditions to be defined to suit project circumstances

### 6.1.1.2 National Society of Professional Engineers

The National Society of Professional Engineers (NSPE) publishes a variety of different standard forms of agreement for use between owners and engineers, owners and contractors, among others. These forms are issued and published jointly by the American Council of Engineering Companies (ACEC), the Associated General Contractors of America (AGC of America), American Society of Civil Engineers (ASCE), and Professional Engineers in Private Practice, a Practice Division of NSPE. These organizations are collectively

identified as the Engineers Joint Contract Documents Committee (EJCDC). It is the EJCDC that has prepared the essential forms of agreement that will be discussed in this *Practice Guide*, which is EJCDC E-500 (2008).

> ***EJCDC E-500 (2008), Agreement Between Owner and Engineer for Professional Services:*** This standard form of agreement makes no references to sustainable design as a requirement of the engineer's basic services.

#### 6.1.1.3 ConsensusDOCS LLC

ConsensusDOCS LLC (ConsensusDOCS) is an independent organization that publishes a variety of different standard forms of agreement for use between owners and design professionals, owners and contractors, and others. These standard forms are endorsed by a significant number of trade organizations and industry associations across the spectrum of the construction industry. The essential ConsensusDOCS forms of agreement that will be discussed in this *Practice Guide* are ConsensusDOCS 240 (2007, Rev 2009) and ConsensusDOCS 310 (2009, Rev 2011).

***ConsensusDOCS 240 (2007, Rev 2009), Standard Agreement Between Owner and Design Professional:*** This standard form of agreement makes no references to sustainable design as a requirement of the architect/engineer's basic services. ConsensusDOCS uses a Green Building Addendum as a supplement to the basic services agreement incorporating requirements for sustainable design.

***ConsensusDOCS 310 (2009, Rev 2011), Green Building Addendum:*** This standard form supplement to the basic services agreement is, by definition, a fundamentally important document on a sustainable design project. The entire document is dedicated to defining the roles and responsibilities of the primary "project participants," associated with a project that is intended to incorporate a defined set of "Green Measures." This standard form makes no specific reference to LEED® Certification or any other green building rating system or program.

This document states its purpose in the initial Article:

> "The Project Participants acknowledge that the incorporation of Green Measures into the Project affects the roles and responsibilities of the Project Participants and the procedures that each Project Participant is to follow in connection with the Project. The purpose of this Addendum is to set forth such roles, responsibilities and procedures and provide for other appropriate modifications to the Governing Contract and Affiliated Contracts as applicable."
>
> (Source: ConsensusDOCS 310 (2009, Rev 2011), Green Building Addendum)

This document addresses many important topics as part of these expanded additional services, including:

- Comprehensive set of definitions (see Chapter 1, Section 1.1 of this *Practice Guide*)
- Definition of "Elected Green Status" (i.e., "certification" or other compliance criteria)
- Designation of the "Green Building Facilitator" (entity who manages and coordinates the Green Measures implementation process)
- Requirements for plans and specifications
- Risk allocation

This document contains several unique provisions in Article 8, RISK ALLOCATION that should be considered carefully by the design professional. These include:

> 8.2 Liability of the Project Participants under this Addendum, including but not limited to the GBF [Green Building Facilitator], Design Professional and Constructor, shall be subject to any limitation or specific assumption of liability in their respective Governing Contract. Owner's loss of income or profit or inability to realize potential reductions in operating, maintenance or other related costs, tax or other similar benefits or credits, marketing opportunities and other similar opportunities or benefits, resulting from a **failure to attain the Elected Green Status or intended benefits to the environment, shall be deemed consequential damages** subject to any applicable waiver of consequential damages in a Governing Contract unless specifically excluded from such a waiver in the Governing Contract. [Final sentence omitted]
>
> 8.3 Unless otherwise expressly provided in a Governing Contract, no Project Participant other than GBF [Green Building Facilitator] **shall be liable or responsible for the failure of the Elected Green Measures to achieve the Elected Green Status or intended benefits to the environment or natural resources.** [Final sentence omitted]
>
> 8.5 Except to the extent applicable to the Design Professional or Constructor having assumed the role of GBF [Green Building Facilitator] as provided in this Addendum, nothing herein is intended to impose upon Constructor or Design Professional any liability or responsibility if the Elected Green Measures do not achieve the Elected Green Status, provided however that the **foregoing is not intended to relieve Design Professional of liability or responsibility for any defect or deficiency in any of the Elected Green Measures incorporated into the Plans and Specifications.**
>
> 8.6 Nothing herein is intended to impose upon Design Professional or GBF [Green Building Facilitator] liability or responsibility for the Constructor's means or methods of performing the Work, **except for any means or methods included in the Elected Green Measures and incorporated into the Plans and Specifications.**
>
> (Source: ConsensusDOCS 310 (2009, Rev 2011), Green Building Addendum; emphases and [clarifications] added, but such emphases and clarifications are not intended to be included in contract documents)

#### 6.1.1.4 Design-Build Institute of America

The Design-Build Institute of America (DBIA) does not publish a specific standard form of agreement for use exclusively by design professionals. Refer to Owner-Contractor Agreements below.

## 6.1.2 Owner-Contractor and Integrated Project Delivery Agreements

There are a significant number of organizations in the construction industry that publish standard forms of agreement between owner and contractor (contract forms) for

use in construction contracts. This *Practice Guide* does not endorse or recommend any specific group of standard forms, nor does it attempt to address all of the various groups of standard forms which are available. The organizations that publish standard forms of agreement which are addressed in this *Practice Guide* include:

The American Institute of Architects (AIA)
National Society of Professional Engineers (NSPE)
ConsensusDOCS LLC
Design-Build Institute of America (DBIA)

The following is a discussion of the content of certain standard forms of agreement published by each of these organizations which address sustainable design and construction issues. These discussions are not intended to be comprehensive in nature, and do not in any way represent legal advice or counsel. The topics covered are intended to provide a basic awareness of these contractual provisions within each of the groups of standard forms, and to establish a working knowledge of that content in basic terms.

### 6.1.2.1 American Institute of Architects

The AIA publishes a wide variety of different standard forms of agreement for use between owners and contractors, integrated project delivery forms, and others too numerous to list here. The essential forms of agreement that will be discussed in this *Practice Guide* are AIA Document A101–2007 and AIA Document C191–2009:

- AIA Document A101–2007, Standard Form of Agreement Between Owner and Contractor (Stipulated Sum)
- AIA Document C191–2009, Standard Form Multi-Party Agreement for Integrated Project Delivery

***AIA Document A101–2007, Standard Form of Agreement Between Owner and Contractor:*** This standard form of Agreement makes no references to implementation of sustainable design or sustainable construction practices as a requirement of the Contract. The construction documents (drawings and specifications) prepared by the Owner's design team would include specific requirements for the implementation of sustainable design on the project. The Owner may also stipulate sustainable construction practices within this Agreement, but those requirements would need to be determined by the Owner and written into this Agreement, likely in Article 8 MISCELLANEOUS PROVISIONS.

***AIA Document C191–2009, Standard Form Multi-Party Agreement for Integrated Project Delivery:*** This standard form of Agreement makes no references to implementation of sustainable design or sustainable construction practices as a requirement of this integrated, multi-party Contract. The requirement to meet a defined sustainable design or construction "target criteria" would need to be delineated within this Agreement, and the Parties to this Agreement would then be bound to meet the defined target criteria as a condition of the contract.

### 6.1.2.2 National Society of Professional Engineers

The NSPE publishes a limited set of standard forms of agreement for use between owners and contractors. These forms are issued and published jointly by the American

Council of Engineering Companies (ACEC), the Associated General Contractors of America (AGC of America), American Society of Civil Engineers (ASCE), and Professional Engineers in Private Practice, a Practice Division of NSPE. These organizations are collectively identified as the Engineers Joint Contract Documents Committee (EJCDC). It is the EJCDC that has prepared the essential forms of agreement that will be discussed in this *Practice Guide* including EJCDC C-520 (2007) and EJCDC C-525 (2007).

***EJCDC C-520 (2007), Suggested Form of Agreement Between Owner and Contractor, Stipulated Price:*** This standard form of Agreement makes no references to sustainable design as a requirement of the Engineer's basic services.

***EJCDC C-525 (2007), Suggested Form of Agreement Between Owner and Contractor, Cost-Plus:*** This standard form of Agreement makes no references to sustainable design as a requirement of the Engineer's basic services.

#### 6.1.2.3 ConsensusDOCS LLC

ConsensusDOCS is an independent organization which publishes a variety of different standard forms of agreement for use between owners and contractors. These standard forms are endorsed by a significant number of trade organizations and industry associations across the spectrum of the construction industry. The essential ConsensusDOCS forms of agreement that will be discussed in this *Practice Guide* are ConsensusDOCS 200 (2011) and ConsensusDOCS 410 (2007, Rev 2009).

***ConsensusDOCS 200 (2011), Standard Agreement and General Conditions Between Owner and Constructor:*** This standard form of Agreement makes no references to implementation of sustainable design or sustainable construction practices as a requirement of the Contract. The construction documents (plans and specifications as specifically referenced in these documents) prepared by the Owner's design team would include specific requirements for the implementation of sustainable design on the project. Also, the incorporation of ConsensusDOCS 310 Green Building Addendum (discussed under Owner-Design Professional Agreements) would amend this standard form of Agreement to activate sustainable design and construction requirements for such a project.

***ConsensusDOCS 410 (2007, Rev 2009), Standard Design-Build Agreement and General Conditions Between Owner and Design-Builder:*** This standard form of Agreement makes no references to implementation of sustainable design or sustainable construction practices as a requirement of the Contract. The construction documents (drawings and specifications) prepared by the Owner's design team would include specific requirements for the implementation of sustainable design on the project. Also, the incorporation of ConsensusDOCS 310 Green Building Addendum (discussed under Owner-Design Professional Agreements) would amend this standard form of Agreement to activate sustainable design and construction requirements for such a project.

#### 6.1.2.4 Design-Build Institute of America

The DBIA is an independent organization dedicated to design-build project delivery. It publishes a series of standard forms of agreement for use between owners and design-build entities exclusively. The relevant DBIA form of agreement that will be discussed in this *Practice Guide* is Document No. 525 (Second Edition, 2010).

***Document No. 525 (Second Edition, 2010), Standard Form of Agreement Between Owner and Design-Builder, Lump Sum:*** This standard form of Agreement makes no reference to implementation of sustainable design or sustainable construction practices as a requirement of the Contract. The construction documents (drawings and specifications) prepared by the Owner's design team should include specific facility performance requirements for the implementation of sustainable design on the project. These facility performance requirements, including sustainable design and performance criteria for a design-build project, should be specified in the 01 80 00 series Sections in Division 01 of the specifications. A more complete discussion of construction specifications for sustainable design and construction requirements is included in Section 6.3 of this *Practice Guide.*

## 6.1.3 Contractual Responsibilities

Each member of the design and construction team has certain responsibilities, and may assume significant risks and potential liabilities as the result of participation in this process. The owner also has certain responsibilities and may assume certain risks and potential liabilities as well. These issues must be specifically addressed in the preparation and execution of the agreements between the various participants. This *Practice Guide* does not intend to address legal issues directly, but it is important to acknowledge certain key features that the various agreements should consider, among many that cannot be comprehensively listed in this *Practice Guide.*

### 6.1.3.1 Owner-A/E Agreements

These agreements should carefully address the following issues in the context of the integrated agreement. The agreement should:

Ensure that additional services regarding sustainable design are clearly and specifically described. This may include the incorporation of supplemental agreement forms or detailed narratives which amend the agreement.

Accurately define or identify the commissioning authority/agent (CxA), which entity it is contracted to (usually the owner), and how the CxA is to be compensated.

Ensure additional compensation is included for these additional services, including special materials research and specifications enhancements, preparation of special documentation (LEED online reporting, compliance reports), energy modeling, fees paid to certifying organizations (GBCI), fees for an independent sustainable design consultant (LEED manager/coordinator). Typically the CxA is an independent third party entity whose services are contracted separately from the Owner-A/E agreement.

Not stipulate a warranty or guarantee on the part of the design professional or its consultants that a specific level of certification will be achieved; that the overall facility will perform to a certain level of energy efficiency, that sustainable construction material will have durability or life cycle performance that is beyond the control of the design professional; that the facility will not affect the environment in an adverse way.

#### 6.1.3.2 Architect/Engineer-Consultant Agreements

These agreements should also carefully address the following issues in the context of the primary owner-A/E agreement. The agreement should:

- Ensure that all applicable requirements of the owner-A/E agreement are incorporated into these agreements, including special materials and systems research, required specifications enhancements, preparation of special documentation (LEED online reporting and compliance reports), energy modeling, and special submittal reviews.
- Carefully coordinate with the role and specific responsibilities of the commissioning authority/agent (CxA), to avoid potential conflicts or mutual omissions regarding commissioning activities.

#### 6.1.3.3 Owner-Contractor Agreements

These agreements should carefully address the following issues in the context of the primary owner-A/E agreement. The agreement should:

- Include a carefully crafted risk-management strategy to consider appropriate allocation of responsibilities and risks.
- Anticipate and address the risks associated with green building.
- Include flow-down clauses in subcontracts.
- Address responsibility if the project does not achieve the required level of sustainability, certification, or energy performance.
- Address which party or parties are responsible for preparing, collecting, and reporting sustainable design and construction documentation.
- Address potential liability if a green product or technology fails.
- Include payment provisions that avoid unintended payment delay, such as tying the achievement of a green certification to substantial completion or to final payment.

## 6.2 Integration of Sustainable Design Requirements

### 6.2.1 Sustainable Design Rating System Influences

Section 1.4 of this *Practice Guide* lists and describes a significant number of green building rating systems and programs. Each of these systems and programs establishes specific sustainable design strategies and requirements that have corresponding compliance criteria. When specifying requirements for sustainable design and construction, it is fundamentally important to understand the compliance criteria, and how to most effectively specify and document those requirements so that the construction team can accurately price and precisely execute those requirements in the completed facility.

If a particular sustainable design rating system or program is being used, the procurement documents and specifications should include specific references to design credits or rating system points that are unique to that rating system or program. If the project is being designed to meet an independently established set of best practices criteria, the procurement documents and specifications should simply specify the intended requirements and corresponding compliance criteria. In either case, specific project-wide compliance requirements, design credits, or rating system points should be clearly and concisely specified within the document package for ease of reference and access to this fundamentally important information by all participants in the design and construction process.

The fundamental approach is to "consolidate" project-wide requirements in a single location, so that all participants in the design and construction process have immediate and recognizable access to this information, and so that it can be disseminated to subcontractors and suppliers as a common body of information for the entire project. This is known as the "Division 01 concept."

## 6.2.2 Division 01 Concept

The sections in Division 01, which are collectively referred to as the General Requirements, specify administrative, procedural, facility performance, and life cycle requirements, and temporary facilities and controls. Administrative and procedural requirements are those relating to the process of construction contract administration, the assignment of contractual responsibilities, and the methods of communicating, controlling, and assuring quality. Facility performance requirements are related to facility and system performance, and are more commonly used in the specifications in conjunction with a Design-Build project to establish design criteria for a project, or a specific aspect of a project such as HVAC systems. Life cycle operational requirements include commissioning, facility maintenance, and facility decommissioning. Temporary facilities and controls are those put into place for use only during the period of construction, and are removed when no longer required.

Division 01 sections expand upon the administrative and procedural provisions in the General Conditions of the contract, and apply broadly to the corresponding requirements of all other work results (product) sections of the specifications. Administrative and procedural requirements that are unique to a particular section of the specifications should be covered in the affected section and only make a general reference to the Division 01 requirements if appropriate in certain instances. Division 01 sections specify general requirements for execution of the work, and should be written in language broad enough to apply to all sections in Divisions 02 through 49.

Without Division 01, these general requirements would need to be repeated to a large extent in each section of the specifications. This would result in the increased possibility of conflicts, omissions, and other critical errors within the specifications. This Division 01 concept adheres to the CSI principle of stating information only once and in the right place within the procurement construction documents packages.

Figure 6.1 illustrates the relationships between Division 01 General Requirements and each of the other construction documents, with a highlighted emphasis on the relationship between Division 01 and individual specification sections. It is this highlighted emphasis that will be addressed in detail in Section 6.3 of this chapter.

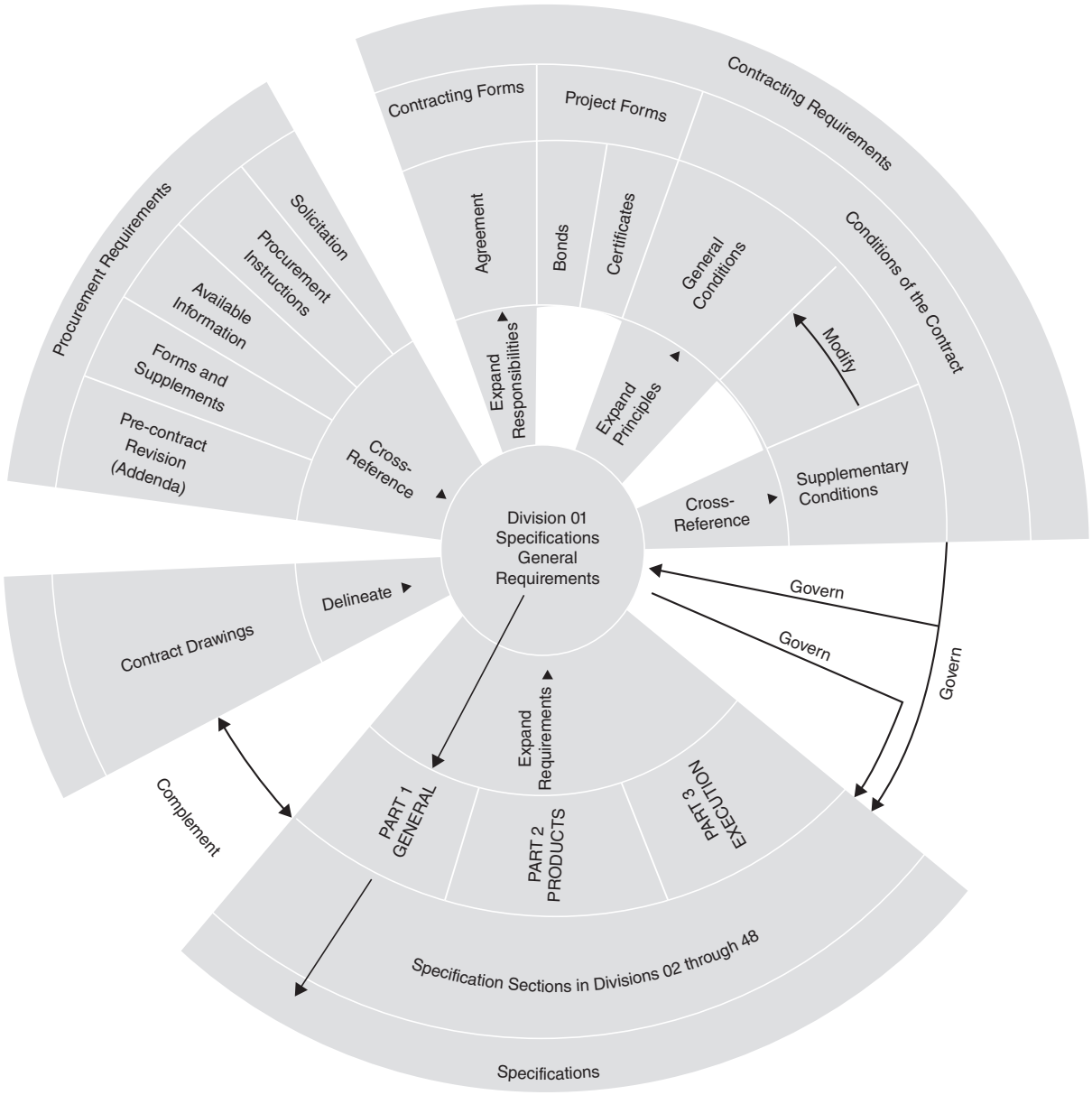


Figure 6.1 Division 01 relationship to specifications

# 6.3 Construction Specifications

## 6.3.1 Role of Specifications

The specifications are a fundamentally important component of all construction document packages. The specifications complement the drawings and other contract documents, and the various components of the contract documents must work together in a seamless way to communicate the requirements for the construction of a facility.

MasterFormat®, produced jointly by the Construction Specifications Institute (CSI) and Construction Specifications Canada (CSC), is a master list of numbers and titles classified by work results or construction practices, primarily used to organize project manuals within which the specifications are located and to relate drawing notations to specifications.

Nearly every section in the specifications can contain construction requirements that are specific to sustainable design. However, it should be the objective of the design professional/specifier to locate such information within the specifications in such a way that the information is communicated in a clear, concise, and correct manner so that all members of the construction team can find the information and use it effectively in the project's implementation. According to the Division 01 concept presented in Section 6.2.2 of this *Practice Guide*, this involves locating project-wide requirements that govern all sections of the specifications in various Division 01 specification sections. This approach allows this critical information to be stated once, in the correct locations within Division 01, and in such a way that if modifications are required at any time during the design or construction phases, this information need only be modified once and not in multiple locations throughout the document package.

It is important to recognize that many sustainable design characteristics and features are inherent in the design of various facility systems and components. In these cases, the specifications and drawings for these aspects of the design do not typically contain identifiable specification language or drawing information that identifies these characteristics; they are simply a result of the design itself. Examples of these specification sections are discussed in this section of this *Practice Guide.* Examples of drawings that indicate inherent sustainable design features of a facility are discussed in Section 6.4 of this *Practice Guide.*

The following is a discussion of the content of certain document and specification sections that specifically address sustainable design and construction requirements. These discussions are not intended to be comprehensive in nature, and do not in any way represent all of the possible content that a specifier may choose to include in the specifications for a sustainable design project. These discussions are intended to illustrate a basic approach to these provisions within each of these documents and specifications sections, and to provide a working knowledge of that content in basic terms. The specifications provisions presented here are examples only, and must be edited and customized to the requirements of each project's situation and varied circumstances.

The *Construction Specifications Practice Guide*, also published by CSI, contains a complete and comprehensive guide to specifying methods and practices. The *Construction Specifications Practice Guide* should be consulted with regard to more detailed information on specifications practice; the recommended practices contained in the *Sustainable Design and Construction Practice Guide* are based on the *Construction Specifications Practice Guide*, and supplement that information.

## 6.3.2 Procurement and Contracting Requirements Group

This document group within MasterFormat® will not typically contain extensive information regarding sustainable design requirements for a project. By definition, the solicitation and procurement documents only exist for those purposes, and provisions within those documents do not ultimately become contract documents. However, certain references

to the other components of the bidding and construction documents may be included in the advertisement or invitation to bid, request for proposals, instructions for procurement, available project information, and other procurement and contracting documents to direct the bidders' attention to sustainable design requirements for the project.

Sections included in this group that may contain relevant sustainable design information requirements include:

- Section 00 31 00, Available Project Information
- Section 00 72 00, General Conditions

**Section 00 31 00, Available Project Information** Information about the particular sustainable design standard or program should be provided to the bidders/proposers on the project, as well as to the contractor once the project is under contract with the owner. If not included in Division 01 (see below), this information can be provided as part of this document section. A copy of the published program description, rating system scorecard, or similar documentation should be copied and included in the project manual immediately following this document section. The following is an example of language that should be included in this section to affirmatively incorporate this information by reference:

**1.0X SUSTAINABLE DESIGN INFORMATION**

**A.** This information does not include specific work requirements and is included for information only.

**B.** A copy is included with this section.

**C.** Status of each sustainable design goal represents status as of the date of publication, and is subject to change during the construction period.

**D.** Owner and Architect reserve right to modify status of sustainable design goals at any time, based on factors yet to be determined, in a collaborative effort to achieve project certification goal [term to be defined, if not clear in this documentation].

1. Some design goals may be eliminated from pursuit and other design goals not listed may be pursued, at discretion of Owner.
2. Contractor will be required to cooperate fully with Owner and Architect, and may request necessary information or contract modification to assist with implementation of sustainable design goals required to achieve project certification goal.

(Option: MasterFormat® designates a preferred location for this information in Section 01 35 63; see discussion of Section 01 35 63 below.)

**Section 00 72 00, General Conditions** Standard general conditions of the contact for construction forms published by AIA, NSPE (EJCDC), ConsensusDOCS, and DBIA do not contain standard provisions that address sustainable design. These documents make general references to the "Contract Documents" which include the drawings and specifications. It is presumed by these references that the drawings and specifications contain requirements for sustainable design implementation. Some of those requirements may be the direct responsibility of the contractor. Refer to Section 6.1.3 of this *Practice Guide* and various sections below for further discussions regarding the contractual responsibilities of the various participants in the design and construction process.

## 6.3.3 Division 01—General Requirements Subgroup

This subgroup, under MasterFormat®'s Specifications Group, contains the majority of sustainable design and construction requirements in accordance with the Division 01 concept. The general requirements are segregated into administrative requirements, procedural requirements, temporary facilities requirements, and facility performance requirements.

### 6.3.3.1 Administrative Requirements

Sections included in this subgroup that may contain relevant sustainable design implementation requirements include:

- Section 01 20 00, Price and Payment Procedures
- Section 01 30 00, Administrative Requirements
- Section 01 35 63, Sustainability Certification Project Requirements
- Section 01 35 66, Sustainability Certification Project Procedures
- Section 01 79 00, Demonstration and Training
- Section 01 91 13, General Commissioning Requirements

*Suggested Text Examples:* The following are suggested text examples that should be included in the specification sections listed above. These examples are not intended to be comprehensive in nature, and do not represent all possible content that a specifier may choose to include in a particular specification section for a sustainable design project. These examples are intended to illustrate a basic approach to these provisions within each of these example specifications sections.

Text in [**brackets**] indicates an editing option. These examples use the term "sustainable design" in generic terms; when the term "sustainable design" is indicated, this term can be edited to name a specific sustainable design rating system or program without invalidating the example for other suggested text content.

**Section 01 20 00, Price and Payment Procedures** The following requirements should be considered for inclusion in PART 1—GENERAL of this section:

**1.0X APPLICATIONS FOR PROGRESS PAYMENTS**

**A.** Include the following with application:

1. Log of sustainable design submittals applicable to work for which application is being made [**see Section 01 35 66**].

**Section 01 30 00, Administrative Requirements** The following requirements should be included in PART 1—GENERAL of this section:

**1.0X PRECONSTRUCTION MEETING**

**A.** Agenda:

1. Sustainable design requirements.

(Optional: This requirement can be specified as a separate sustainable design meeting—see below)

### 1.0X PROGRESS MEETINGS

**A.** Agenda:

1. Sustainable design requirements.

(Optional: This requirement can be specified as a separate sustainable design meeting—see below)

### 1.0X SUSTAINABLE DESIGN MEETINGS

**A.** Schedule and administer sustainable design meetings throughout the progress of the Work at maximum [**monthly**] intervals.

**B.** Agenda will be prepared by [**Architect**][**Owner's sustainability consultant**], who will preside at meetings.

**C.** Required Attendance: [**Owner's sustainability consultant**,] Owner, Architect, Contractor, and project superintendent; include major subcontractors and suppliers, and Architect's consultants as appropriate to the agenda topics for each meeting.

**D.** Agenda:

1. Review sustainable design requirements, submittals, and work progress.
2. Review status of construction waste management, construction IAQ management, commissioning, and related compliance issues.
3. Other business related to sustainable design Work.

**E.** [**Owner's sustainability consultant**][**Architect**] will record minutes and distribute copies to participants within [7] days after meeting.

### 1.0X PROGRESS PHOTOGRAPHS

**A.** Indoor Air Quality Photographs: Take minimum [**6**] date-stamped photographs on three different dates, approximately equally spaced over time during construction, of relevant SMACNA requirements for [**IAQ**] compliance. For each set of photographs, provide brief description of SMACNA approach employed, documenting implementation of [**IAQ**] management measures including protection of ducts, air handler unit cleaning, filter installation, and absorptive materials installed or stored on site.

### 1.0X SUBMITTALS

**A.** Sustainable Design Submittals: See Section 01 35 66 for submittal requirements.

(Sustainable design submittal requirements can be specified in Section 01 30 00, but it is recommended they be specified in Section 01 35 66 according to MasterFormat®; see Section 01 35 66 below.)

**Section 01 35 63, Sustainability Certification Project Requirements** This section is an optional location for specifying the sustainable design program or rating system that is to be followed for the project, according to MasterFormat®. This section can incorporate documents such as a LEED® Scorecard, or other rating system point-tracking document, if available or appropriate for the sustainable design standard selected for use of the project.

**Section 01 35 66, Sustainability Certification Project Procedures** This section should be used to consolidate all administrative requirements related to sustainable design project procedures. By consolidating these requirements in a single section, editing and coordination of the specifications will be easier for the specifier, and these requirements

will also be given greater "visibility" within the context of the general requirements for the project.

The following is an example of suggested content which could be included in PART 1—GENERAL of this section. With only minor editing, this example can be used effectively on a LEED® or any other specific program-based sustainable design project.

**SECTION 01 35 66**

**SUSTAINABLE DESIGN CERTIFICATION PROCEDURES**

PART 1—GENERAL

**1.0X PROJECT CONDITIONS AND PROCEDURES—GENERAL**

**A.** A Sustainable Design Consultant has been employed by Owner to review sustainable design submittals and reports, in addition to review of those submittals by Architect.

**B.** Contractor is required to become familiar with the relevant sustainable design requirements and provide the necessary information and instruction to all subcontractors and installers.

1. Provide a sustainability field coordinator, assigned to work specifically on this project, who has worked on previous sustainable design projects, or has participated in a minimum of [**8**] contact hours of sustainable design training.

**E.** Contractor is required to provide complete compliance data and information for specified sustainable design requirements.

1. See Section [**00 31 00**][**01 35 63**], for information on Project goals related to specific sustainable design requirements.
2. See Section 01 60 00, Product Requirements, for project-wide product requirements.
3. See this Section and Section 01 30 00—Administrative Requirements, for relevant submittal and reporting requirements.
4. See Section 01 78 00, Closeout Submittals, for relevant sustainable design closeout submittal and reporting requirements.

**1.0X SUSTAINABLE DESIGN COMPLIANCE REQUIREMENTS**

**A.** Contract requirements intended to achieve specified sustainable design goals are specified in individual Sections of the specifications, and indicated on Drawings, as applicable.

**B.** Notify Architect in writing if specified sustainable design requirements cannot be met by Contractor. Include explanation of limitations or conditions preventing compliance with specified requirements, if any.

**1.0X REFERENCE STANDARDS**

**A.** ASTM E2129, Standard Practice for Data Collection for Sustainability Assessment of Building Products; 2005.

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

**A.** See Section 01 30 00, Administrative Requirements, for additional submittal procedures.

**B.** Submit sustainable design submittals and reports to Architect, unless otherwise indicated.

[OR]

B. Submit sustainable design submittals and reports directly to Owner's Sustainable Design Consultant, not to Architect, unless otherwise indicated.

C. Submit additional copy of sustainable design submittals and reports directly to Owner's Sustainable Design Consultant, and to Architect, unless otherwise indicated.

[OR]

C. Submit additional copy of sustainable design submittals and reports to Architect for transmittal to Owner's Sustainable Design Consultant, unless otherwise indicated.

D. General: Submit additional sustainable design submittals according to requirements included in other Sections of the Specifications.

1. Sustainable design submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated sustainable design requirements.
2. Clearly highlight, delineate, or otherwise indicate data within sustainable design submittals showing compliance with applicable sustainable design requirements.
3. Comply with ASTM E2129 for data collection and content requirements.

E. Project Materials Cost Data: For each product or material requiring cost data to support sustainable design compliance, provide statement indicating total cost for applicable building materials used for Project.

### Section 01 79 00, Demonstration and Training

The requirements for demonstration and training are not the same as commissioning. Commissioning requirements should not be specified in this section, however, these requirements should be carefully coordinated with the commissioning process to avoid conflicts of responsibility between the contractor and the commissioning authority/agent (CxA).

### Section 01 91 13, General Commissioning Requirements

Commissioning requirements that are applicable to the entire project should be specified in this Division 01 section, and should not be specified in any other section or division of the specifications. Other sections and divisions of the specifications should make explicit reference to this section by number and name for each product and system included in the commissioning program for the project.

This section should include the following detailed information, edited to specify those requirements applicable to the entire project. This section should also be carefully coordinated with the commissioning authority/agent (CxA) and the project engineering team, who should assist in its development. This section should include:

- Objectives of the commissioning process
- Scope of required commissioning; listed by system or other items to be commissioned
- Contractor's explicit responsibilities in the commissioning process
- Responsibilities of the commissioning authority/agent (CxA); this may include the CxA's responsibility to coordinate the IAQ plan and associated temporary facilities for the project
- Submittal requirements
- Test equipment requirements

- Commissioning plan
- Start-up plans and reports
- Prefunctional checklist procedures and requirements
- Functional tests and reporting requirements
- Correction requirements
- Acceptance requirements
- Sensor and actuator calibration
- Operation and maintenance manual requirements in addition to those specified in Section 01 78 00

### 6.3.3.2 Procedural Requirements

Sections included in this subgroup that may contain relevant sustainable design implementation requirements include:

Section 01 60 00, Product Requirements
Section 01 74 19, Construction Waste Management and Disposal

#### Section 01 60 00, Product Requirements

Product requirements for the entire project should be specified in this Division 01 section. Other sections and divisions of the specifications should make explicit reference to this section by number and name to activate these requirements for particular products specified in individual specification sections. Refer to Section 6.3.4 of this *Practice Guide* for a discussion of recommended procedures for making these explicit references to this and other Division 01 specification sections.

This section should be used to consolidate all product requirements, particularly those which are related to sustainable design. By consolidating these requirements in a single section, editing and coordination of the specifications with the applicable sustainable design program or rating system will be easier for the specifier, and these requirements will also be given greater "visibility" within the context of the general requirements for the project. Examples of these requirements include:

- Sustainable design compliance references applied to specific product requirements (i.e., "This provision is applicable to various credits in the LEED® Materials and Resources category").
- Use of specific terminology to identify product requirements that are referenced from other sections of the specifications. These terms are identified in the text of the example Section 01 60 00 (shown below) with "[**KEYWORD**] Term in Bold."

The following is an example of suggested sustainable design-related content which could be included in PART 1—GENERAL and PART 2—PRODUCTS of this section. With only minor editing, this example can be used effectively on a LEED® or any other specific program-based sustainable design project.

**SECTION 01 60 00**

**PRODUCT REQUIREMENTS**

PART 1—GENERAL

**1.0X SECTION INCLUDES**

**A.** Sustainable design-related product requirements.

### 1.0X RELATED REQUIREMENTS

A. Section 01 30 00, Administrative Requirements: Submittal procedures.

B. Section 01 35 66, Sustainable Design Certification Procedures: Requirements for sustainable design submittals.

### 1.0X DEFINITIONS

A. VOC-Restricted Products: All products of each of the following categories when installed or applied on-site in the building interior:

1. [**List products**].
2. Other products when specifically stated in the specifications.

B. Interior of Building: Anywhere inside the exterior weather barrier.

C. Adhesives: All gunnable, trowelable, liquid-applied, and aerosol adhesives, whether specified or not; including flooring adhesives, resilient base adhesives, and pipe jointing adhesives.

D. Sealants: All gunnable, trowelable, and liquid-applied joint sealants and sealant primers, whether specified or not; including firestopping sealants and duct joint sealers.

### 1.0X SUBMITTALS

A. See Section 01 30 00, Administrative Requirements [**, and Section 01 35 66, Sustainable Design Certification Procedures**], for submittal procedures.

B. Product Data Submittals:

1. For each VOC-restricted product used in the project, submit product data showing compliance, except when another type of evidence of compliance is required.

C. Evidence of Compliance: Submit for each different product in each applicable category.

1. Identify evidence submittals with the words "Sustainable Design Submittal."

D. Installer Certifications for Accessory Materials: Require each installer of any type of product (not just the products for which VOC restrictions are specified) to certify that either 1) no adhesives, joint sealants, paints, coatings, or composite wood or agrifiber products have been used in the installation of his products, or 2) that such products used comply with these requirements.

## PART 2—PRODUCTS

### 2.0X EXISTING PRODUCTS

A. Reused Products: Reused products include materials and equipment previously used in this or other construction, salvaged and refurbished as specified.

1. Wood fabricated from timber abandoned in transit after harvesting is considered reused, not recycled.

B. Overall Project Requirement: Use reused products for at least [**5**] percent of all products used on project.

C. Specific Products to be Re-used: The reuse of certain materials and equipment already existing on the project site is required.

1. See Section 01 10 00 for list of items required to be salvaged for reuse and relocation.
2. If reuse of other existing materials or equipment is desired, submit substitution request.

D. Sustainable Design Submittals: State cost of each reused product, quantity installed, and total cost of reused products.

**2.0X NEW PRODUCTS**

A. Products of each category that are installed in the project must comply; Owner's project requirements do not allow for partial compliance.

B. Provide new products unless specifically required or permitted by the Contract Documents.

C. Do not use products having any of the following characteristics:

1. Made using or containing CFC's or HCFC's.
2. Made of wood from newly cut old growth timber.
3. Made of composite wood containing added urea-formaldehyde; phenol-formaldehyde is acceptable.
4. VOC content restricted products.

D. Where all other criteria are met, give preference to products that:

1. Are extracted, harvested, and/or manufactured closer to the location of the project.
2. Have longer documented life span under normal use.
3. Result in less construction waste.
4. Are made of vegetable materials that are rapidly renewable.

E. [**KEYWORD**] Regionally-Sourced Products:

1. Overall Project Requirement: Provide materials amounting to a minimum of [**20**] percent of the total value of all materials (excluding plumbing, HVAC, electrical, elevators, and other equipment) that have been extracted, harvested, or recovered, as well as manufactured, within a radius of [**500**] miles from the project site.
2. Specific Product Categories: Provide regionally-sourced products as specified elsewhere.
3. Sustainable Design Submittals: Indicate location of manufacture; in all cases indicate location of final assembly; for harvested products, indicate location of harvest; for extracted (i.e., mined) products, indicate location of extraction; for products involving multiple manufacturing steps, indicate all locations of manufacture or assembly; provide manufacturer or supplier certification of location information.

F. Products with [**KEYWORD**] Rapidly Renewable Material Content:

1. Definition: Materials made from plants that are typically harvested within [**10**] years or less after planting.
2. Overall Project Requirement: Provide materials amounting to a minimum of [**2.5**] percent of the total value of all materials (excluding plumbing, HVAC, electrical, elevators, and other equipment) and products used on the project.
3. Specific Product Categories: Provide renewable material content as specified elsewhere.
4. Calculations: Where information about renewable material content is required to be submitted and an item is not made completely of rapidly renewable material, calculate content by dividing the renewable material content by weight by the total weight of the item.
5. Sustainable Design Submittals: State unit cost, renewable material content percentage, quantity installed, total material cost, and total renewable material

value; attach evidence of contents from either manufacturer or an independent agency.

G. Products with [**KEYWORD**] Recycled Content:

1. Overall Project Requirement: Provide products with recycled content such that the sum of post-consumer recycled content plus one-half of the post-industrial recycled content constitutes at least [**10**] percent of the total value of all products installed, excluding plumbing, HVAC, electrical, elevators, and other equipment.
2. Specific Product Categories: Provide recycled content as specified elsewhere.
3. Calculations: Where information about recycled content is required to be submitted:
   a. Determine percentage of post-consumer and post-industrial content separately, using the guidelines contained in [**cite applicable reference standard**].
   b. Previously used, reused, refurbished, and salvaged products are not considered recycled.
   c. Wood fabricated from timber abandoned in transit to original mill is considered reused, not recycled.
   d. Determine percentage of recycled content of any item by dividing the weight of recycled content in the item by the total weight of all material in the item.
   e. Determine value of recycled content of each item separately, by multiplying the content percentage by the value of the item.
4. Sustainable Design Submittals: State unit cost, post-consumer and post-industrial content percentages, quantity installed, total material cost, and total recycled content value; attach evidence of contents from either manufacturer or an independent agency.

H. [**KEYWORD**] Sustainably Harvested Wood Products:

1. Definition: Wood-based materials include but are not limited to structural framing, dimension lumber, flooring, wood doors, finishes, and furnishings that are permanently installed in the project. Wood and wood-based products not permanently installed in the project are not included in the definition.
2. Overall Project Requirement: Provide a minimum of [**50**] percent (by cost) of all wood-based materials made of sustainably harvested wood.
3. Specific Wood-Based Fabrications: Fabricate of sustainably harvested wood when so specified elsewhere.
4. Certification: Provide wood certified or labeled by an organization accredited by one of the following:
   a. [**Cite applicable accrediting agency or reference standard**].
5. Sustainable Design Submittals: State unit cost of each wood-based item, quantity installed, quantity certified as sustainably harvested, total wood-based material cost, and total sustainably harvested value; provide letter of certification signed by supplier of each item, indicating compliance with the specified requirements and identifying the certifying organization.
   a. Include the certifying organization's chain-of-custody certification numbers for each certified product, itemized on a line-item basis.
   b. Attach copies of invoices bearing the certifying organization's chain-of-custody certification numbers.

## 2.0X [KEYWORD] VOLATILE ORGANIC COMPOUND (VOC) CONTENT–RESTRICTED MATERIALS

**A.** All VOC-Restricted Products: Provide products having VOC content of types and volume not greater than those specified in [**cite applicable reference standard**].

1. Evidence of Compliance: Acceptable types of evidence are:
   a. [**Cite required types of evidence by reference standard or other applicable accrediting agency**].
2. Product data submittals showing VOC content are not acceptable forms of evidence.

**B.** Adhesives and Joint Sealants: Provide only products having volatile organic compound (VOC) content not greater than required by [**cite applicable reference standard**].

1. Evidence of Compliance: Acceptable types of evidence are:
   a. Report of laboratory testing performed in accordance with requirements.
   b. Published product data showing compliance with requirements.
   c. Certification by manufacturer that product complies with requirements.

**C.** Aerosol Adhesives: Provide only products having volatile organic compound (VOC) content not greater than required by [**cite applicable reference standard**].

1. Evidence of Compliance: Acceptable types of evidence are:
   a. Published product data showing compliance with requirements.

**D.** Paints and Coatings:

1. Provide coatings that comply with the most stringent requirements specified in the following:
   a. [**Cite applicable reference standard**].
   [OR]
   b. [**Cite applicable reference standard**]; specifically:
      1) Opaque, Flat: [**50**] g/L, maximum.
      2) Opaque, Nonflat: [**150**] g/L, maximum.
      3) Opaque, High Gloss: [**250**] g/L, maximum.
      4) Varnishes: [**350**] g/L, maximum.
      5) Anti-corrosive and Anti-rust, Opaque, High Gloss: [**250**] g/L, maximum.
   [AND (IF APPLICABLE)]
   c. Architectural coatings VOC limits of State in which the project is located.
2. Determination of VOC Content: Testing and calculation in accordance with [**cite applicable reference standard**], exclusive of colorants added to a tint base and water added at project site; or other method acceptable to authorities having jurisdiction.
3. Evidence of Compliance: Acceptable types of evidence are:
   a. Report of laboratory testing performed in accordance with requirements.
   b. Published product data showing compliance with requirements.
   c. Certification by manufacturer that product complies with requirements.

**E.** Clear Wood Finishes, Floor Coatings, Stains, and Shellacs Applied to Interior Elements: Provide products that do not exceed the VOC limitations established in [**cite applicable reference standard**]:

1. Clear Wood Finishes: Varnish: [**350**] g/L, maximum, Lacquer: 550 g/L, maximum.
2. Floor Coatings: [**100**] g/L, maximum.
3. Shellacs:
   a. Clear: [**730**] g/L, maximum.
   b. Pigmented: [**550**] g/L, maximum.

4. Sealers:
   a. Waterproofing Sealers: [**250**] g/L, maximum.
   b. Sanding Sealers: [**275**] g/L, maximum
   c. All Other Sealers: [**200**] g/L, maximum.
5. Stains: [**250**] g/L, maximum.

**F.** Flooring Systems: Elements installed in the interior of the building must meet the testing and product requirements of [**cite applicable reference standard**].

1. Evidence of Compliance: Require each installer to certify compliance and submit product data showing product content.

**G.** Carpet and Adhesive: Provide products having VOC content not greater than that required by [**cite applicable reference standard**].

1. Evidence of Compliance: Acceptable types of evidence are:
   a. Report of laboratory testing performed in accordance with requirements.

**H.** Carpet Cushion: Provide products having VOC content not greater than that required by [**cite applicable reference standard**].

1. Evidence of Compliance: Acceptable types of evidence are:
   a. Report of laboratory testing performed in accordance with requirements.

**I.** Carpet Tile and Adhesive: Provide products having VOC content not greater than that required by [**cite applicable reference standard**].

1. Evidence of Compliance: Acceptable types of evidence are:
   a. Report of laboratory testing performed in accordance with requirements.

**J.** Composite Wood and Agrifiber Products and Adhesives Used for Laminating: Provide products having no added urea-formaldehyde resins; phenol-formaldehyde is acceptable.

1. Evidence of Compliance: Acceptable types of evidence are:
   a. Current [**cite applicable reference standard**] certification.
   b. Published product data showing compliance with requirements.
   c. Certification by manufacturer that product complies with requirements.

**K.** Other Product Categories: Comply with limitations specified in individual specification Sections.

(Source: The preceding text example was derived from Building Systems Design (BSD) SpecLink-E®, with additional text and formatting added by the author; contact BSD at www.bsdsoftlink.com to inquire regarding copyright restrictions, if any.)

### Section 01 74 19, Construction Waste Management and Disposal

Construction waste management and disposal requirements for the entire project should be specified in this Division 01 section, and should NOT be specified in any other section or division of the specifications. Other sections and divisions of the specifications should make explicit reference to this section by number and name; however, it should not be necessary to include an explicit reference to this section from every section in the specifications. This specifications convention complies with the Division 01 concept presented in this *Practice Guide*.

This section should include the following detailed information, edited to specify only those requirements that are applicable to the project and required for compliance with the applicable sustainable design program or certification rating system.

- Waste management requirements and procedures
- Waste management facilities on the site
- Sustainable design project requirement (i.e., divert 75 percent by weight of potential landfill trash/waste by recycling or salvage)

- Waste disposal reporting
- Waste management plan
- Specification of unacceptable waste management practices (i.e., burning on-site, burial on- or off-site)
- Regulatory requirements related to waste management and disposal
- Submittal requirements
- Recycling incentive programs

#### 6.3.3.3 Temporary Facilities Requirements

Sections included in this subgroup that can contain relevant sustainable design implementation requirements include:

Section 01 57 13, Temporary Erosion and Sediment Control
Section 01 57 19, Temporary Environmental Controls

**Section 01 57 13, Temporary Erosion and Sediment Control**

Temporary erosion and sediment control requirements for the entire project should be specified in this Division 01 section, and should NOT be specified in another section or division of the specifications. Other relevant sections of the specifications, particularly in the Site and Infrastructure Subgroup, Divisions 31–35, should make explicit reference to this section by number and name when applicable.

This section should include the following detailed information, edited to specify only those requirements that are applicable to the project. This section should also be carefully coordinated with the site design team, particularly the civil engineer, who should assist in its development.

- Performance requirements for erosion and sediment control on the site and off-site during the construction period, and for a defined period of time after completion of construction:
  - Maintenance and inspection requirements for temporary control facilities
  - Submittal requirements
  - Erosion and sediment control materials
  - Installation and removal requirements for temporary control facilities

**Section 01 57 19, Temporary Environmental Controls**

Temporary environmental control (indoor air quality control) requirements for the entire project should be specified in this Division 01 section, and should NOT be specified in any other section or division of the specifications. Other relevant sections of the specifications, particularly in the Facility Services Subgroup, Divisions 21–28, should make explicit reference to this section by number and name only if necessary.

This section should include the following detailed information, edited to specify only those requirements that are applicable to the project. This section should also be carefully coordinated with the facility services design team, particularly the HVAC engineer, who should assist in its development.

- Environmental quality requirements for the project
- Submittal requirements
- IAQ management plan

- Testing and reporting requirements, including air contaminants, building flush-out, ventilation effectiveness, smoking rooms, documentation requirements (photographs and similar documentation)
- Restrictions on the use of permanent HVAC systems, and requirements for cleaning and providing new and proper filtration media in permanent systems
- Construction phase procedures, including smoking prohibitions, ventilation, storage of construction materials in prohibited spaces (electrical rooms, stairwells, and other means of egress), temporary barriers and barricades associated with the IAQ plan, progress cleaning during the construction period, sequencing of the application of potentially odorous materials

#### 6.3.3.4 Facility Performance Requirements

These requirements, according to MasterFormat®, are for use with Design-Build projects. These requirements are, by definition, those specified to achieve the ultimate performance goals of the completed facility. Therefore, sustainable design requirements specified in this group of sections should be limited to those criteria that are required to achieve the desired sustainability end result.

A section included in this subgroup that may contain relevant sustainable design implementation requirements is:

Section 01 81 13, Sustainable Design Requirements

**Section 01 81 13, Sustainable Design Requirements** This section, located under the MasterFormat® Level 2 heading of Facility Performance Requirements, should include specific design criteria that address the sustainable design goals for the project. Since these criteria are specified in this section, it is not necessary to repeat or reiterate these requirements in other sections in the 01 80 00 Facility Performance Requirements group. This section governs all other sections within the 01 80 00 Facility Performance Requirements group in much the same way that Division 01 General Requirements sections govern all other sections of the specifications.

### 6.3.4 Work Results Specifications Sections

According to MasterFormat®, the work results sections of the specifications are included in Divisions 02 through 49. If the Division 01 General Requirements sections of the specifications are written according to the Division 01 concept, the Work Results sections can address sustainable design requirements in a concise and streamlined manner by simply making specific references to sustainable design requirements in various Division 01 specification sections. These references will typically include:

- Administrative Requirements: Price and payment procedures, submittal requirements, sustainability certification project requirements, sustainability certification project procedures, closeout submittals, demonstration and training, and general commissioning requirements.
- Procedural Requirements: Product requirements and construction waste management and disposal
- Temporary Facilities Requirements: Temporary erosion and sediment control and temporary environmental controls

- Facility Performance Requirements: Sustainable design requirements for Design-Build projects and for performance requirements in conjunction with performance specifications in general.

Not all specifications sections will need to make references to all of these Division 01 requirements. Since Division 01 requirements apply to the entire project by definition, specific references need only be included in a particular work results specifications section if necessary to direct the user of the document to specific requirements that govern the corresponding requirement in the work results section.

It is fundamentally important that the specifier investigate the materials and products that will be specified, particularly on a sustainable design project. It is also critically important that the specifier confirm that the products and systems that are specified are actually available with the required sustainable material or product attributes. The specifier should not make assumptions regarding material or product attributes that are intended to comply with the sustainable material and product requirements that may be specified in Section 01 60 00, Product Requirements. The specifier, and each member of the design team who prepares or contributes to the preparation of the specifications, should diligently perform product and system evaluation and selection. For example, if a particular material or product is specified to comply with a project-wide VOC–content restriction, but the specified product is not available in a compliant form or option, the specification for that material or product is incorrect and therefore unachievable, and the contractor cannot be expected to comply. This situation may jeopardize the ability of the project to ultimately comply with the intended sustainable design standard or credit.

The following is a discussion of the potential content of certain work results specification sections that address sustainable design and construction requirements. These discussions are not intended to be comprehensive in nature, and do not represent all possible content that a specifier may choose to include in particular specifications sections for a sustainable design project. These discussions are intended to illustrate a basic approach to these provisions within each of these example specifications sections, and to provide a working knowledge of that potential content in basic terms. The specifications provisions presented here are examples only, and must be edited and customized to the requirements and circumstances of each project.

#### 6.3.4.1 Facility Construction Subgroup—Divisions 02–14 Sections

This specifications subgroup within MasterFormat® will typically contain the most extensive information regarding sustainable design requirements for a project. These sections generally contain building information which specifies the elements of the building envelope, building interior construction, and many other materials and products that are located within the building and on the site. With the exception of the specifications sections included in the Facility Services Subgroup (Divisions 21 through 28), this Division of the specifications will typically have the most significant and pervasive influence on the performance of the building from a sustainable design perspective.

Specification sections in this subgroup which may specify products or systems that are inherently "sustainable" by their very nature, composition, or application are too numerous to list here. These sections simply specify their respective materials or products as compliant with applicable product requirements in the form in which

they are commonly available. Typical examples include the following as a partial but representative list:

- Section 06 50 00, Structural Plastics (Recycled content plastic lumber)
- Section 07 31 33, Composite Rubber Shingles (Recycled content polymer shingles)
- Section 07 33 00, Natural Roof Coverings
- Section 07 50 00, Membrane Roofing (High solar reflectance values and recycled/recyclable membrane materials)
- Section 09 62 23, Bamboo Flooring
- Section 09 62 29, Cork Flooring
- Section 09 72 13, Cork Wall Coverings

Sections in this subgroup that may specify material or product components required to have sustainable attributes are too numerous to list here. However, typical examples include the following as a partial but representative list:

- Section 02 41 00, Demolition
- Section 03 30 00, Cast-in-Place Concrete
- Section 04 20 00, Unit Masonry
- Section 05 10 00, Structural Metal Framing
- Section 06 10 00, Rough Carpentry
- Section 07 92 00, Joint Sealants
- Section 08 43 13, Aluminum-Framed Storefronts
- Section 09 21 16, Gypsum Board Assemblies
- Section 09 30 00, Tiling
- Section 09 50 00, Ceilings
- Section 09 65 00, Resilient Flooring
- Section 09 68 00, Carpeting
- Section 09 90 00, Painting and Coating

These specification sections should not repeat sustainable design product requirements that are specified in Section 01 60 00, Product Requirements. These sections should only make general reference to Section 01 60 00 for groups of materials or products, or for specific materials and products, which are specified in individual work results sections of the specifications. These specification sections should:

Not make reference to specific sustainable design compliance criteria applied to applicable product requirements (i.e., "This provision is applicable to LEED Credit MR 5").

Use specific terminology used in Section 01 60 00 to identify product requirements that are specified in each specification section. In the examples below, these terms are identified in the text of the example section with "[**KEYWORD**] Term in Bold."

*Suggested Text Examples:* The following are suggested text examples that should be included in a representative selection of the specification sections listed above. These examples are not intended to be comprehensive in nature, and do not represent all possible content that a specifier may choose to include in a particular specification section for a sustainable design project. These examples are intended to illustrate a basic approach to these provisions within each of these example specifications sections.

Text in [**brackets**] indicates an editing option. These examples use the term "sustainable design" in generic terms; when the term "sustainable design" is indicated, this term can be edited to name a specific sustainable design rating system or program without invalidating the example for other suggested text content.

### Section 02 41 00, Demolition

The following requirements should be considered for inclusion in PART 3—EXECUTION of this Section:

#### 3.0X GENERAL PROCEDURES AND PROJECT CONDITIONS

A. Perform demolition in a manner that maximizes salvage and recycling of materials.
   1. Comply with requirements of Section 01 74 19, Construction Waste Management and Disposal.
   2. Set aside reusable, recyclable, and salvageable materials; store and deliver to collection point or point of reuse.

B. Reuse of Building Elements: Project has been design to maintain and reuse existing building elements as required to comply with specified [**sustainable design**] requirements. Do not demolish existing building elements beyond limits indicated on Drawings without [**Architect**]'s approval.
   1. Building Structure and Shell: [**75**][**100**] percent.
   2. Non-shell Elements: [**50**] percent.

### Section 03 30 00, Cast-in-Place Concrete

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

#### 1.0X SUSTAINABLE DESIGN SUBMITTALS

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Reports:
   1. Concrete Aggregates: Submit data for concrete aggregate materials that are provided from sources that provide post-consumer or post-industrial recycled materials. Include statement indicating costs for aggregate having recycled content.
   2. Fly Ash: If fly ash is used, submit data for fly ash materials that are provided from sources that provide post-industrial recycled material. Include statement indicating costs for fly ash admixture.

The following requirements should be considered for inclusion in PART 2—PRODUCTS this Section:

#### 2.0X CONCRETE MATERIALS

A. Fine and Coarse Aggregates: ASTM C33.
   1. Use recycled course aggregates in foundation and slab on grade mixes; limit use to [**50**] percent by weight of total course aggregate in each mix.
   2. Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

B. Fly Ash: ASTM C618, Class C or F.
   1. Limit use to [**20**] percent of cement content, by weight.
   2. Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

### Section 04 20 00, Unit Masonry

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Reports:

1. Submit documentation of masonry manufacturing process, location of harvested raw materials, and location of manufacture.
2. Submit documentation for masonry materials that are provided from sources that provide recycled materials; include statement indicating costs for masonry materials having recycled content.

The following requirements should be considered for inclusion in PART 2—PRODUCTS this Section:

**2.0X MATERIALS**

A. Masonry Materials—General: Comply with [**KEYWORD**] regionally sourced [**and** [**KEYWORD**] **recycled content**] product requirements specified in Section 01 60 00.

### Section 05 10 00, Structural Metal Framing

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Reports:

1. Submit documentation of steel mill process, location of mill, location of harvested raw materials, and location of manufacture.
2. Submit data for steel materials that are provided from sources that provide recycled materials. Include statement indicating costs for steel materials having recycled content.
3. Submit report for VOC content of primers.

The following requirements should be considered for inclusion in PART 2—PRODUCTS this Section:

**2.0X MATERIALS**

A. Steel—General: Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

B. Shop and Touch-Up Primer: Fabricator's standard, complying with [**KEYWORD**] volatile organic compound (VOC) content product requirements specified in Section 01 60 00.

C. Touch-Up Primer for Galvanized Surfaces: Fabricator's standard, complying with [**KEYWORD**] volatile organic compound (VOC) content product requirements specified in Section 01 60 00.

### Section 06 10 00, Rough Carpentry

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Report: Submit data for each different product made of [**KEYWORDS**] [**sustainably harvested wood, salvaged and reused wood, wood fabricated from recovered timber, and regionally-sourced**] wood. Include statement indicating costs for each different wood material.

1. Provide documentation for adhesives and composite wood products indicating that adhesives and bonding agents used contain no added urea formaldehyde resins.
2. Provide documentation of VOC content of all interior adhesives.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X GENERAL REQUIREMENTS**

A. Wood Materials: Comply with [**KEYWORD**] sustainably harvested wood and [**KEYWORD**] regionally-sourced wood product requirements specified in Section 01 60 00.

B. Lumber fabricated from old growth timber is not permitted.

C. Lumber salvaged from deconstruction or demolition of existing buildings or structures is permitted in lieu of sustainably harvested lumber provided it is clean, denailed, and free of paint and finish materials, and other contamination; identify source; see Section 01 60 00 for requirements for [**KEYWORD**] reused products.

1. Where salvaged lumber is used for structural applications, provide lumber regraded by an inspection service accredited by the American Lumber Standard Committee, Inc.; www.alsc.org.

E. Lumber fabricated from recovered timber (abandoned in transit) is permitted in lieu of sustainably harvested lumber, unless otherwise noted, provided it meets the specified requirements for new lumber and is free of contamination.

F. Composite Wood Products: Comply with [**KEYWORD**] volatile organic compound (VOC) content product requirements specified in Section 01 60 00.

### Section 07 92 00, Joint Sealants

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Report: Submit VOC content documentation for nonpreformed sealants and primers.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X SEALANTS**

A. General: Comply with [**KEYWORD**] volatile organic compound (VOC) content product requirements specified in Section 01 60 00.

### Section 08 43 13, Aluminum-Framed Storefronts

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Reports:

1. Submit documentation of aluminum extrusion process, location of extrusion plant, location of harvested raw materials, and location of manufacture.
2. Submit data for aluminum materials that are provided from sources that provide recycled materials. Include statement indicating costs for aluminum materials having recycled content.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X MATERIALS**

A. Aluminum Materials—General: Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

### Section 09 21 16, Gypsum Board Assemblies

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Reports:

1. For gypsum board, submit documentation of recycled content, location of harvested raw materials, and location of manufacture.
2. For steel stud and accessory products, submit documentation of steel mill process, location of mill, and location of manufacture.
   a. Submit data for steel stud and accessory materials that are provided from sources that provide recycled materials; include statement indicating costs for steel materials having recycled content.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X MATERIALS**

A. Metal Framing Materials—General: Comply with [**KEYWORD**] recycled content [**and** [**KEYWORD**] **regionally sourced**] product requirements specified in Section 01 60 00.

B. Gypsum Board Materials—General: Comply with [**KEYWORD**] recycled content [**and** [**KEYWORD**] **regionally sourced**] product requirements specified in Section 01 60 00.

**2.0X ACCESSORIES**

A. Acoustic Sealant: ASTM C834; non-hardening, non-skinning, formulated for use in conjunction with gypsum board.

1. Comply with [**KEYWORD**] volatile organic compound (VOC) content product requirements specified in Section 01 60 00.

**B.** Adhesive: ASTM C557.

1. Comply with [**KEYWORD**] volatile organic compound (VOC) content product requirements specified in Section 01 60 00.

**Section 09 90 00, Painting and Coating**

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

**A.** See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

**B.** Sustainable Design Report: Submit VOC content documentation for all interior opaque coatings actually used.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X PAINT MATERIALS**

**A.** General: Comply with [**KEYWORD**] volatile organic compound (VOC) content product requirements specified in Section 01 60 00.

### 6.3.4.2 Facility Services Subgroup—Divisions 21 through 28 Sections

This document group within MasterFormat® will typically contain extensive information regarding sustainable design requirements for a project. These sections generally contain building information that specifies the environmental control and facility services elements of the building, and many other products that are located within the building and on the site. With the exception of the specifications sections included in the Facility Construction Subgroup (Divisions 02 through 14), this division of the specifications will typically have the most significant and pervasive influence on the energy performance of the building from a sustainable design perspective.

Specification sections in this subgroup may specify products or systems that are inherently "sustainable" by their very nature, composition, or application. These sections simply specify their respective materials or products as compliant with applicable product requirements in the form in which they are commonly available. Typical examples include the following as a partial but representative list:

- Section 21 22 00, Clean-Agent Fire-Extinguishing System
- Section 22 30 00, Plumbing Equipment
- Section 22 40 00, Plumbing Fixtures
- Section 23 01 30.51, HVAC Air Duct Cleaning
- Section 23 21 13.33, Ground-Loop Heat-Pump Piping
- Section 23 40 00, HVAC Air Cleaning Devices
- Section 23 56 13, Heating Solar Collectors
- Section 23 72 23, Packaged Air-to-Air Energy Recovery Units
- Section 26 31 00, Photovoltaic Collectors

Sections in this subgroup that may specify commissioning requirements for systems within each division include the following:

- Section 21 08 00, Commissioning of Fire Suppression
- Section 22 08 00, Commissioning of Plumbing
- Section 23 08 00, Commissioning of HVAC
- Section 26 08 00, Commissioning of Electrical Systems
- Section 27 08 00, Commissioning of Communications
- Section 28 08 00, Commissioning of Electronic Safety and Security

These sections should specify commissioning requirements that are specific to the subject matter of the section. The commissioning requirements of each individual commissioning section should avoid specifying requirements that conflict or overlap with the general commissioning requirements specified in Section 01 91 13, General Commissioning Requirements.

Each of these sections should include the following requirement in PART 1—GENERAL of this Section:

**1.0X RELATED REQUIREMENTS**

A. See Section 01 91 13, General Commissioning Requirements, for project-wide commissioning requirements and procedures.

Sections in this subgroup that may specify material or product components required to have sustainable attributes include the following as a partial but representative list:

- Section 21 07 19, Fire Suppression Piping Insulation
- Section 22 07 16, Plumbing Equipment Insulation
- Section 22 07 19, Plumbing Piping Insulation
- Section 23 07 16, HVAC Equipment Insulation
- Section 23 07 19, HVAC Piping Insulation
- Section 23 40 00, HVAC Air Cleaning Devices

These specification sections should not repeat sustainable design product requirements that are specified in Section 01 60 00, Product Requirements. These sections should only make general reference to Section 01 60 00 for groups of materials or products, or for specific materials and products that are specified in individual work results sections of the specifications. These specification sections should:

- Not make reference to specific sustainable design compliance criteria applied to applicable product requirements (i.e., "This provision is applicable to LEED Credit MR 5").
- Use specific terminology which is used in Section 01 60 00 to identify product requirements that are specified in each specification section. In the examples below, these terms are identified in the text of the example section with "[**KEYWORD**] Term in Bold."

*Suggested Text Examples:* The following are suggested text examples that should be included in a representative selection of the specification sections listed above. These examples are not intended to be comprehensive in nature, and do not represent all possible content that a specifier may choose to include in a particular specification

section for a sustainable design project. These examples are intended to illustrate a basic approach to these provisions within each of these example specifications sections.

Text in [**brackets**] indicates an editing option. These examples use the term "sustainable design" in generic terms; when the term "sustainable design" is indicated, this term can be edited to name a specific sustainable design rating system or program without invalidating the example for other suggested text content.

### Section 22 07 19, Plumbing Piping Insulation

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Report: Submit recycled material content documentation for piping insulation actually used.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X INSULATION MATERIALS**

A. General: Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

[OR]

**2.0X INSULATION MATERIALS**

A. Insulation Type [ _____ ]: [ _____ ].

1. Comply with [KEYWORD] recycled content product requirements specified in Section 01 60 00.

### Section 23 40 00, HVAC Air Cleaning Devices

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Report: Submit data on filtration media actually used; include filtration media performance documentation, filter assemblies, and dimensions.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X FILTRATION MEDIA**

A. [ _____ ] Type Filters: [ _____ ].

1. Minimum Efficiency Reporting Value (MERV): [**13**], when tested according to ASHRAE 52.2.

**Notes:**

1. Temporary filtration media is specified in Section 01 57 19, Temporary Environmental Controls.

### 6.3.4.3 Site and Infrastructure Subgroup—Divisions 31 through 35 Sections

This document group within MasterFormat® will typically contain significant information regarding sustainable design requirements for a project. These elements are generally limited to pavements, landscaping elements and systems, fencing and wall systems, and utility poles and piping.

Specification sections in this subgroup may specify products or systems that are inherently "sustainable" by their very nature, composition, or application. These sections simply specify their respective materials or products as compliant with applicable product requirements in the form in which they are commonly available. Typical examples include the following as a partial but representative list:

- Section 32 01 16, Flexible Paving Rehabilitation
- Section 32 14 13.19, Porous Precast Concrete Unit Paving
- Section 32 14 43, Porous Unit Pavement
- Section 32 84 23, Underground Sprinklers (Designed for low water usage)
- Section 32 90 00, Planting (Low water plant selections)

Sections in this subgroup that may specify material or product components that are required to have sustainable attributes include the following as a partial but representative list:

- Section 31 10 00, Site Clearing
- Section 31 23 00, Excavation and Fill (Earthwork)
- Section 32 12 16, Asphalt Paving
- Section 32 13 13, Concrete Paving
- Section 32 31 13, Chain Link Fences and Gates
- Section 32 31 19, Decorative Metal Fences and Gates
- Section 32 32 23, Segmental Retaining Walls
- Section 33 05 13, Manholes and Structures
- Section 33 41 00, Storm Utility Drainage Piping
- Section 33 71 16.33, Wood Electrical Utility Poles

These specification sections should not repeat sustainable design product requirements that are specified in Section 01 60 00, Product Requirements. These sections should only make general reference to Section 01 60 00 for groups of materials or products, or for specific materials and products that are specified in individual work results sections of the specifications. These specification sections should:

- Not make reference to specific sustainable design compliance criteria applied to applicable product requirements (i.e., "This provision is applicable to LEED Credit MR 5").
- Use specific terminology which is used in Section 01 60 00 to identify product requirements that are specified in each specification section. In the examples below, these terms are identified in the text of the example Section with "[**KEYWORD**] Term in Bold."

*Suggested Text Examples:* The following are suggested text examples that should be included in a representative selection of the specification sections listed above. These examples are not intended to be comprehensive in nature, and do not represent all possible content that a specifier may choose to include in a particular specification section for

a sustainable design project. These examples are intended to illustrate a basic approach to these provisions within each of these example specifications sections.

Text in [**brackets**] indicates an editing option. These examples use the term "sustainable design" in generic terms; when the term "sustainable design" is indicated, this term can be edited to name a specific sustainable design rating system or program without invalidating the example for other suggested text content.

### Section 31 10 00, Site Clearing

The following requirements should be considered for inclusion in PART 3—EXECUTION of this Section:

**3.0X SITE CLEARING**

A. Limit site clearing to comply with specified sustainable design requirements.
   1. Coordinate site clearing with earthwork requirements.

**3.0X VEGETATION**

A. Do not remove or damage vegetation beyond the [**following limits:**][**limits indicated on Drawings.**]
   1. [**40**] feet outside building perimeter.
   2. [**10**] feet each side of surface walkways, patios, surface parking, and utility lines less than [**12**] inches in diameter.
   3. [**15**] feet each side of roadway curbs and main utility trenches.
   4. [**25**] feet outside perimeter of pervious paving areas that must not be compacted by construction traffic.
   5. Exception: Specific trees and vegetation indicated on Drawings to be removed.
   6. Exception: Selective thinning of undergrowth [**specified in other Sections**] [**indicated on Drawings**].

### Section 31 23 00, Excavation and Fill (Earthwork)

The following requirements should be considered for inclusion in PART 3—EXECUTION of this Section:

**3.0X ROUGH GRADING**

A. Limit area of rough grading to strictly comply with specified sustainable design requirements.
   1. See Drawings for supplemental information on limits of rough grading.
   2. Coordinate rough grading with site clearing requirements.

**3.0X EXCAVATING**

A. Limit area of excavation to strictly comply with specified sustainable design requirements.
   1. See Drawings for supplemental information on limits of excavating.
   2. Coordinate excavating with site clearing requirements.

### Section 32 12 16, Asphalt Paving

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Report: Submit data and certification letter indicating percentages by weight of recycled content for asphalt paving materials having recycled content; include statement indicating costs for asphalt paving having recycled content.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X MATERIALS**

A. Aggregates for Paving [**and Base Courses**]: Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

### Section 32 31 13, Chain Link Fences and Gates

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Report: Submit data and certification letter indicating percentages by weight of recycled content for steel fencing materials having recycled content; include statement indicating costs for fencing materials having recycled content.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X MATERIALS**

A. Fencing Materials—General: Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

**Notes:**

1. Concrete materials associated with this fencing system may be specified in Section 03 30 00 or in this Section; principles for specifying recycled content for concrete materials are the same, regardless of location specified.

### Section 33 41 00, Storm Utility Drainage Piping

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Reports:

1. Submit data and certification letter indicating percentages by weight of recycled content for concrete materials having recycled content; include statement indicating costs for concrete materials having recycled content.
2. Submit data for steel reinforcing materials that are provided from sources that provide recycled materials. Include statement indicating costs for steel materials having recycled content.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X MATERIALS**

A. Concrete Pipe: Reinforced precast concrete in accordance with ASTM C76 (ASTM C76M), Class [**III**], with wall type [**B**]; mesh reinforcement; bell and spigot end joints.
   1. Comply with [**KEYWORD**] recycled content product requirements specified in Section 01 60 00.

**Section 33 71 16.33, Wood Electrical Utility Poles**

The following requirements should be considered for inclusion in PART 1—GENERAL of this Section:

**1.0X SUSTAINABLE DESIGN SUBMITTALS**

A. See Section 01 35 66, Sustainable Design Certification Procedures, for submittal procedures.

B. Sustainable Design Reports:
   1. Submit data for poles made of sustainably harvested wood, salvaged and reused wood, wood fabricated from recovered timber, as well as regionally-sourced wood. Include statement indicating costs for wood material made of sustainably harvested wood, salvaged and reused wood, wood fabricated from recovered timber, as well as regionally-sourced wood.
   2. Submit data and certification letter indicating percentages by weight of recycled content for steel materials having recycled content; include statement indicating costs for steel materials having recycled content.

The following requirements should be considered for inclusion in PART 2—PRODUCTS of this Section:

**2.0X POLES**

A. Wood Poles: ANSI O5.1, treated [**Douglas Fir**] poles.
   1. [**List pole characteristics**].
   2. Comply with [[**KEYWORD**] **reused or recovered wood**][[**KEYWORD**] **regionally sourced**][[**KEYWORD**] sustainably harvested wood] product requirements specified in Section 01 60 00.

B. Cross Arms and Timbers: Straight-grained [**Douglas Fir**]; free of twists to within 0.1 inch per foot (one percent) of length, with bends and twists in only one direction.
   1. [**List timber characteristics**].
   2. Comply with[[**KEYWORD**] **reused or recovered wood**][[**KEYWORD**] **regionally sourced**][[**KEYWORD**] **sustainably harvested wood**] product requirements specified in Section 01 60 00.

**2.0X POLE HARDWARE**

A. Cross Arm Braces: Structural steel conforming to ASTM A675/A675M, galvanized after forming in accordance with ASTM A153/A153M.
   1. Comply with [**KEYWORD**] recycled content product.

#### 6.3.4.4 Process Equipment Subgroup—Divisions 40 through 49 Sections

This document group within MasterFormat® will not typically contain extensive information regarding sustainable design requirements for a project.

Certain specification sections in this subgroup may specify products or systems that are inherently "sustainable" by their very nature, composition, or application. These sections simply specify their respective materials or products as compliant with applicable product requirements in the form in which they are commonly available.

Other specification sections in this subgroup may specify material or product components that are required to have sustainable attributes. These specification sections should not repeat sustainable design product requirements which are specified in Section 01 60 00, Product Requirements. These sections should only make general reference to Section 01 60 00 for groups of materials or products, or for specific materials and products which are specified in individual work results sections of the specifications. These specification sections should:

- Not make reference to specific sustainable design compliance criteria applied to applicable product requirements (i.e., "This provision is applicable to LEED Credit MR 5").
- Use specific terminology which is used in Section 01 60 00 to identify product requirements that are specified in each specification Section.
- Refer to text examples for the Facility Construction, Facility Services, and Site and Infrastructure subgroups above for guidance on how to properly include appropriate specification content in Process Equipment subgroup specification sections.

## 6.4 Construction Drawings

### 6.4.1 Role of Drawings

The drawings are a fundamentally important component of construction documents. The drawings support and compliment the specifications and other contract documents. The various components of the construction documents must work together in a seamless way to effectively communicate the requirements for the construction of a facility. The Uniform Drawing System (UDS) developed by the Construction Specifications Institute, which is included in the US National CAD Standard (NCS), is an organizational and graphic standard for construction drawings which are produced in CAD and BIM software environments. The UDS/NCS defines a series of subsets that organize the drawings into logical groups according to design discipline or subject content. These drawing subsets are designated in proper order as follows:

G – General Information
H – Hazardous Materials
V – Survey and Mapping
B – Geotechnical
W – Civil Works
C – Civil
L – Landscape
S – Structural

A – Architectural
I – Interiors
Q – Equipment
F – Fire Protection
P – Plumbing
D – Process
M – Mechanical
E – Electrical
T – Telecommunications
R – Resource
X – Other Disciplines
Z – Contractor/Shop Drawings
O – Operations

On sustainable design projects, the drawings may be used to support or augment specified sustainable design requirements. It should be noted, however, that information on drawings for sustainable design projects should be minimal, and should only be used to directly support or augment key specified sustainable design requirements. These include administrative and procedural requirements, temporary facilities, and certain work scope items. Sustainable design requirements that may need drawings to support them include the following as a partial but representative list:

- Alternates (Section 01 23 00)
- Temporary Erosion and Sediment Control (Section 01 57 13)
- Temporary Environmental Controls (Section 01 57 19)
- Construction Waste Management and Disposal (Section 01 74 19)
- Demolition (Section 02 41 00)
- Site Clearing (Section 31 10 00)
- Excavation and Fill (Earthwork) (Section 31 23 00)

Aside from items similar to those listed above, all other sustainable design requirements should be included in the specifications. Specifications requirements may include all product attributes and characteristics, harvesting of raw materials and manufacturing requirements, and other inherent characteristics. Such inherent product characteristics and requirements included in the specifications should not also be noted on the drawings. This is to avoid redundancy and the possibility of conflicts within the construction documents.

The following is a discussion of certain drawings that can be used to support or augment specified sustainable design requirements.

## 6.4.2 Alternates

### 6.4.2.1 Bid and Pricing Alternates

Alternative construction materials or assemblies may be incorporated into the construction documents so that the owner will have the option to select those that provide the best value or quality of construction to fulfill the overall objectives of the project.

In most cases, alternative materials can be specified exclusively in the specifications. This is accomplished by including specification sections for both the base bid material and the alternative material in the specifications, and including appropriate references to Section 01 23 00, Alternates, where a brief but complete description of the base bid material and the alternative material should be located (Division 01 concept). This procedure is discussed in more detail in CSI's *Construction Specifications Practice Guide*.

However, there may be a need to graphically indicate the alternative material or system on the drawings for a variety of reasons. Those reasons may include different attachment or mounting requirements, different flashing and waterproofing requirements, or similar alternative requirements. In these cases, it is appropriate to include drawing details to fully describe the alternative material or system requirements. The alternative drawing details should be clearly identified as an Alternate, by Alternate number (1, 2, 3, etc.), which should be correlated to the listing of Alternates in Section 01 23 00, Alternates.

## 6.4.3 Temporary Facilities

### 6.4.3.1 Erosion and Sedimentation Control

Many municipal, county, state, and federal jurisdictional authorities have requirements to provide temporary erosion control design and documentation as part of the approval and permitting process for a project. In most cases, these requirements include drawings of the site showing all temporary erosion control measures, their location and extents, and details of the individual erosion control components.

Since temporary erosion control requirements are, by definition, temporary facilities, these requirements should be specified in Division 01 (Section 01 57 13, Temporary Erosion and Sediment Control), and should not be specified in a Division 31 or Division 32 section of the specifications. These requirements should include, at a minimum, all administrative requirements for submittals, reports, and similar requirements in PART 1—GENERAL of the section, as well as all installation and removal requirements in PART 3—EXECUTION of the section. Products and materials can either be specified in PART 2—PRODUCTS of the section, or can be specified on the drawings. Refer to the discussion of this specifications section in Section 6.3.3 of this *Practice Guide*.

While most jurisdictions will likely require site plan drawings and details for erosion control as a minimum requirement for building permits, it is possible that these temporary facilities and controls could be specified as performance requirements. In that instance, the contractor would be required to design the temporary erosion control facilities to conform to the specified performance requirements, and submit them to the jurisdictional authority for approval and construction permit.

Drawings that are dedicated exclusively to temporary erosion controls should be located in the G-Series drawing subset according to the UDS/US National CADD Standard. Drawings that combine temporary erosion controls with permanent site construction should be located either in the G-Series drawing subset with carefully developed annotations coordinated with the site construction drawings, or in the C-Series drawings subset with carefully developed annotations which clearly delineate temporary erosion control facilities and permanent site construction elements.

### 6.4.3.2 Temporary Environmental Controls

Temporary environmental controls are not typically a Building Code requirement, though emerging trends in Code development may eventually incorporate requirements

for indoor air quality and similar temporary facilities and controls during the construction period.

Temporary environmental controls, including ventilation and air quality measures during construction, should be specified in Division 01 (Section 01 57 19, Temporary Environmental Controls), and should not be specified in a Division 23 section of the specifications. Since these requirements are most closely associated with HVAC systems, it is advisable to consult with the project HVAC systems engineering consultant or environmental design consultant to assist with the preparation of this section of the specifications.

These temporary facilities and controls are typically specified as performance requirements, which require the contractor to use the HVAC subcontractor or other design consultant to design these systems for temporary installation in the project. However, it may be necessary to use drawings to show the layout of ductwork, filtration media locations and details, and other aspects of these temporary facilities. The use of drawings may be particularly necessary if the temporary facilities use some or all of the permanent HVAC systems as temporary facilities for environmental control during construction. In these instances, the drawings should include very explicit annotations to indicate which components of these temporary facilities and controls are temporary, and which components are to remain as permanent construction.

Drawings that are dedicated exclusively to temporary environmental controls should be located in the G-Series drawing subset according to the UDS/NCS. Drawings that combine temporary environmental controls with permanent construction should be located either in the G-Series drawing subset with carefully developed annotations coordinated with the HVAC drawings, or in the M-Series drawings subset with carefully developed annotations which clearly indicate temporary facilities and permanent construction.

#### 6.4.3.3 Construction Waste Management and Disposal

Construction waste management is not typically a Building Code requirement, though some jurisdictions may have adopted waste management and disposal regulations into their Codes.

Extensive construction waste management and disposal requirements should be specified in Division 01 (Section 01 74 19, Construction Waste Management and Disposal). More conventional or very cursory construction waste management requirements may alternatively be specified in Section 01 50 00, Temporary Facilities and Controls. Typically, it is sufficient to include only written specifications for these temporary project controls, which specify performance requirements for the contractor which govern and control the management of construction waste and disposal for the duration of the construction period.

Drawings should only be used to support or augment these specifications requirements if the nature or location of the waste management facilities is of particular concern to the owner or to the jurisdictional authorities. In this instance, the location, extents, screening, access, and other critical aspects of these temporary facilities may require plan, elevation, and detail drawings to communicate these requirements to the contractor. In any case, it is customarily the contractor's responsibility to comply with specified requirements and the jurisdictional authority's requirements under his overall authority over means and methods of execution on the project. The design professional should be careful to avoid assuming inappropriate responsibility for the design of these temporary facilities and controls unless contractually required to do so.

Drawings that are dedicated exclusively to temporary waste management controls should be located in the G-Series drawing subset according to the UDS/NCS.

## 6.4.4 Facility Construction

### 6.4.4.1 Demolition

Sustainable design and construction projects involving existing buildings will most likely include some degree of demolition scope. Depending on the sustainable design objectives for the project, demolition may be required to be limited in scope to certain elements of the existing building, or to certain percentages of different elements of the existing building. Examples may include a requirement to maintain a minimum of 50 percent of the nonshell elements of the building, or maintaining 75 percent of the structural frame and shell elements of the building.

The specifications should include general demolition scope requirements in Section 02 41 00, Demolition. Other requirements related to demolition and alteration projects may also be specified in Division 01 (Section 01 30 00, Alteration Project Procedures), and should not be specified in other divisions or sections of the specifications (i.e., HVAC demolition requirements for HVAC systems specified in a Division 23 section). Refer to the text example for demolition requirements in Section 6.3.4.1 of this *Practice Guide.*

If the project has specific requirements for limits of demolition, and the specifications cannot adequately describe those requirements, drawings may be required to supplement the specifications. In these instances, the drawings can be used to dimensionally indicate the limits of demolition for various building elements, systems, and individual components. Drawing annotations should not make reference to applicable sustainable design compliance criteria, but should only indicate the limitations and extents of demolition requirements for the project to supplement specified demolition requirements.

Drawings that are dedicated exclusively to building demolition scope should be located in the G-Series drawing subset according to the UDS/NCS. An alternative approach is to include demolition scope in various drawing subsets associated with each applicable aspect of the project. Examples include showing HVAC system demolition scope in the M-Series subset, and electrical system demolition scope in the E-Series subset. If this alternative approach is taken, the specifications sections that govern each of these drawing subsets should make a simple and direct reference to the general Alteration Project Procedures and Demolition requirements for the project.

### 6.4.4.2 Building Products

Individual products that are indicated on the drawings should be identified by the specification section name or keyword in the specifications that defines the attributes, characteristics, and installation requirements for each product. Drawing annotations should not include references to sustainable design requirements (i.e., “Sealant – VOC-compliant”), which should be exclusively located in the specifications.

### 6.4.4.3 Building Assemblies

Building assemblies that are indicated on the drawings should be identified by the specification section name or keywords in the specifications that define the components of the assembly and the installation requirements for the assembly. Drawing annotations

should not include extensive annotations for each component or individual product within the assembly, nor should such annotations include references to sustainable design requirements (i.e., "Structural Metal Framing System – Recycled content-compliant"), which should be exclusively located in the specifications.

## 6.4.5 Facility Services

### 6.4.5.1 Plumbing, HVAC, and Electrical Systems

Facility services system components, fixtures, and equipment indicated on the drawings should be identified by the keyword in the specifications that defines the attributes, characteristics, and installation requirements for each product. Many of these system components, fixtures, and equipment items can be scheduled either on the drawings or in the specifications, using alphanumeric designators to identify them on the drawings.

The design professional should select and specify components, fixtures, and equipment items to inherently comply with applicable sustainable design objectives for the project. Specifications may contain design or performance requirements for each item for purposes of establishing substitution approval criteria for each item. Drawing annotations should not include references to sustainable design requirements (i.e., "Toilet Type T-1 – Max. [**0.6**] gpf"), which should be exclusively located in the specifications or in the schedule of equipment which specifies the inherent attributes and characteristics of each component, fixture, or equipment item.

## 6.4.6 Site and Infrastructure

### 6.4.6.1 Site Clearing and Excavation Limits

Sustainable design and construction projects involving new buildings will most likely include extensive site clearing and earthwork scope. Depending on the sustainable design objectives for the project, site clearing and earthwork may be required to limit the scope and extents to preserve natural habitats or to limit the physical impact on the existing environmental conditions on the site. Examples include a requirement to limit building excavations to 40 feet beyond the face of the building perimeter, or to specifically protect from damage or disturbance certain existing habitat environments on the site.

The specifications should include site clearing and earthwork scope requirements in Division 31 (Section 31 10 00, Site Clearing and Section 31 23 00, Excavation and Fill). Refer to the text examples for these specification sections in Section 6.3.4.3 of this *Practice Guide.*

If the project has specific requirements for limits of site clearing, habitat protection, excavation limits, and similar scope requirements, and the specifications cannot adequately describe those requirements, drawings may be required to supplement the specifications. In these instances, the drawings can be used to dimensionally indicate the limits of excavations and other site disturbance for various building and site and building construction elements. The drawing annotations should not make references to applicable sustainable design compliance criteria, but should only indicate the limitations of the excavation and habitat protection requirements for the project that supplement the specified requirements.

Drawings that are dedicated exclusively to site clearing and excavation (earthwork) should be located in the C-Series drawing subset according to the UDS/NCS. Other

site construction drawings which may indicate other construction elements such as site lighting fixtures (E-Series), site signage (L-Series or A-Series), and similar items should be carefully coordinated with the primary C-Series drawings to be sure that excavations and site disturbance associated with these other site construction elements does not compromise the sustainable design objectives for the project.

#### 6.4.6.2 Site Construction Elements

Site construction elements indicated on the drawings should be identified by the specification section name or keywords in the specifications that define the attributes, characteristics, and installation requirements for each element. Site construction elements include concrete paving, asphalt paving, porous paving, stormwater facilities, landscaping, underground irrigation systems, site furnishings, site signage, and many other elements depending on the design of the project.

The design professional should design and specify these elements to comply with applicable sustainable design objectives for the project. The specifications may contain design or performance requirements for site construction elements for purposes of establishing substitution approval criteria for those elements. Drawing annotations should not include references to sustainable design requirements (i.e., "Concrete Paving – Min. SRI [**79**]"), which should either be an inherent design attribute or characteristic of the indicated site construction element, or compliance requirements should be exclusively located in the specifications for the indicated site construction element.

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