LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

LEED®

REFERENCE GUIDE FOR INTERIOR DESIGN AND CONSTRUCTION

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v4

U.S. Green Building Council
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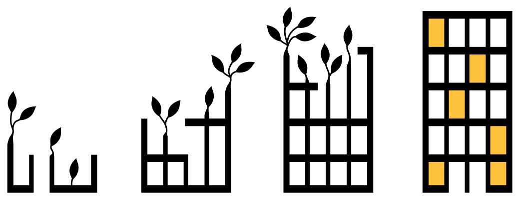


THE CASE FOR GREEN BUILDING

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

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

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

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

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

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

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

ABOUT LEED

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

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

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

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

LEED'S GOALS

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

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

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

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

BENEFITS OF USING LEED

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

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

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

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

LEED CERTIFICATION PROCESS

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

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

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

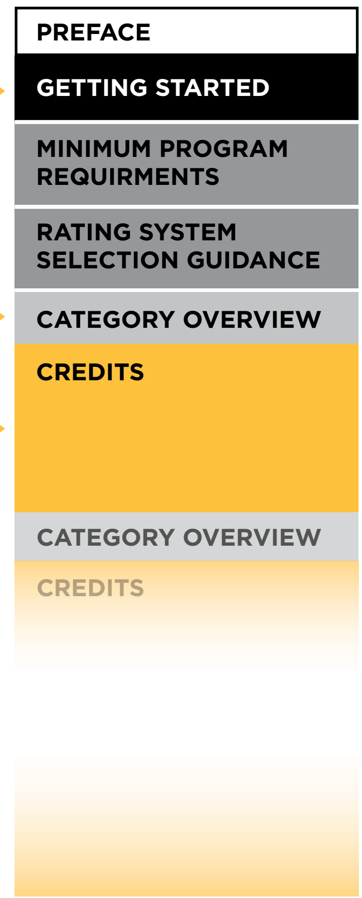
REFERENCE GUIDE OVERVIEW

GUIDE STRUCTURE

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

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

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



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

Getting Started (beginning of book)

Further Explanation (within same credit)

CREDIT STRUCTURE

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

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

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

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

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

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

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

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

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

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

DEFINITIONS gives the meaning of terms used in the credit.

Getting Started

HOW TO USE THIS REFERENCE GUIDE

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

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

CREDIT CATEGORIES

INTEGRATIVE PROCESS

LOCATION AND TRANSPORTATION (LT)

WATER EFFICIENCY (WE)

ENERGY AND ATMOSPHERE (EA)

MATERIALS AND RESOURCES (MR)

INDOOR ENVIRONMENTAL QUALITY (EQ)

INNOVATION (IN)

REGIONAL PRIORITY (RP)

MORE ABOUT THE FURTHER EXPLANATION SECTION

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

CAMPUS PROJECTS

Campus refers to the Campus Program for Projects on a Shared Site, which certifies multiple projects located on one site and under the control of a single entity. In the ID+C context, an example would be multiple nonconsecutive floors within a single office building with similar fit-out. Only project teams using the Campus Program need to follow the guidance in the Campus section; the guidance is not applicable to projects that are in a campus setting but not pursuing certification using the Campus Program.

There are two approaches to certifying multiple projects under the Campus Program:

- **Group Approach** allows project spaces that are substantially similar and are in a single location to certify as one project that shares a single certification.
- **Campus Approach** allows project spaces that share a single location and site attributes to achieve separate LEED certification for each project space or group on the master site.

For each approach, the reference guide gives any credit-specific information and notes two possible scenarios:

- **Group Approach**
  - "All project spaces in the group may be documented as one." The project spaces may meet the credit requirements as a single group by, for example, pooling resources or purchasing, and then submitting a single set of documentation.
  - "Submit separate documentation for each project space." Each project space in the group project must meet the credit requirements individually for the project to earn the credit.
- **Campus Approach**
  - "Eligible." This credit may be documented once at the level of the master site, and then individual projects within the master site boundary earn the credit without submitting additional documentation.
  - "Ineligible. Each LEED project may pursue the credit individually." Each project space within the campus boundary may earn the credit but each project space must document compliance separately.

PROJECTS OUTSIDE THE U.S.

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

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

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

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

TAKING AN INTEGRATIVE APPROACH TO DESIGN AND CONSTRUCTION

The realization of benefits associated with LEED starts with a transformation of the design process itself. Success in LEED and green building design is best accomplished through an integrative design process that prioritizes cost-effectiveness over both the short and long terms and engages all project team members in discovering beneficial interrelationships and synergies between systems and components. By integrating technical and living systems, the team can achieve high levels of building performance, human performance, and environmental benefits.[1]

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

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

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

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

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

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

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

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

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

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

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

DEVISING A LEED WORK PLAN

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

STEP 1. INITIATE DISCOVERY PHASE

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

STEP 2. SELECT LEED RATING SYSTEM

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

STEP 3. CHECK MINIMUM PROGRAM REQUIREMENTS

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

STEP 4. ESTABLISH PROJECT GOALS

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

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

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

STEP 5. DEFINE LEED PROJECT SCOPE

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

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

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

STEP 6. DEVELOP LEED SCORECARD

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

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

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

STEP 7. CONTINUE DISCOVERY PHASE

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

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

STEP 8. CONTINUE ITERATIVE PROCESS

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

STEP 9. ASSIGN ROLES AND RESPONSIBILITIES

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

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

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

STEP 10. DEVELOP CONSISTENT DOCUMENTATION

Consistent documentation is critical to achieving LEED certification.

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

STEP 11. PERFORM QUALITY ASSURANCE REVIEW AND SUBMIT FOR CERTIFICATION

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

MAINTAINING CONSISTENCY IN THE APPLICATION

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

INCOMPLETE SPACES

Spaces that earn LEED certification should be completed by the time they have submitted their final application for LEED certification. *Complete* means that no further work is needed and the project is ready for occupancy. For ID+C projects, spaces are considered incomplete if they do not include the furnishings, fixtures, and equipment intended for regular operations of the space. No more than 40% of the certifying gross floor area of a LEED project may consist of incomplete space. Additionally, projects that include incomplete spaces must use Appendix 2 Default Occupancy Counts to establish occupant counts for incomplete spaces.

For incomplete spaces in ID+C projects, the project team must provide supplemental documentation.

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

For prerequisites with established baselines (e.g., WE Prerequisite Indoor Water Use, EA Prerequisite Minimum Energy Performance) and the credits dependent on the calculations in the prerequisites, the proposed design must be equivalent to the baseline for the incomplete spaces. Project teams that wish to claim environmental performance or benefit beyond the baseline for incomplete spaces should provide a binding tenant sales and lease agreement for the incomplete space. This must be signed by the future tenant and include terms related to how the technical credit requirements will be carried out by the tenant. If the tenant and the owner are the same entity, a signed letter if commitment is sufficient. An unsigned or sample lease agreement is not acceptable.

PREVIOUS DEVELOPMENT

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

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

Tricky lands to assess include those with few buildings present. If the land previously had buildings, then it is considered previously developed even if those buildings have since been torn down. Another frequently confusing situation is parkland. Pay careful attention to the type of parkland. Improved parks with graded land and constructed features like playgrounds (e.g., a city park) are considered previously developed. Land maintained in a natural state (e.g., a forest preserve) is not considered previously developed, even if minor features like walking paths are present.

DENSITY

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

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

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

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

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

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

For example, on a site with 10,000 square feet (930 square meters) of buildable nonresidential land area, a building of 10,000 square feet (930 square meters) of floor area would have a FAR of 1.0. On the same site, a building of 5,000 square feet (465 square meters) would have a FAR of 0.5; a building of 15,000 square feet (1395 square meters) would have a FAR of 1.5; and a building of 20,000 square feet (1860 square meters) would have a FAR of 2.0.
To calculate the combined density for residential and nonresidential areas, use FAR.

OCCUPANCY

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

Regular Building Occupants

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

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

EQUATION 1.

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

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

EQUATION 2.

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

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

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

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

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

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

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

Visitors

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

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

Outpatients visit a hospital, clinic, or associated health care facility for diagnosis or treatment that lasts 23 hours or less.

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

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

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

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

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

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

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

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

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

c. Appendix 2 Default Occupancy Counts

d. Results from applicable studies.

If numbers vary seasonally, use occupancy numbers that are a representative daily average over the entire operating season of the building.
If occupancy patterns are atypical (shift overlap, significant seasonal variation), explain such patterns when submitting documentation for certification.

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

TABLE 1. Occupancy types for calculations, by project type variation

Prerequisite, credit	Regular building occupants	Average daily visitors	Peak visitors	Other	Notes
LT Credit Bicycle Facilities					
Commercial Interiors, Hospitality	X		X		
Retail	X				
WE Prerequisite and Credit Indoor Water Use					
Commercial Interiors, Hospitality, Retail	X	X			Retail customers are considered separately and not included in average daily visitors.

QUICK REFERENCE

TABLE 2. Credit Attributes

Category	Prerequisite/ Credit	Credit Name	Design/ Construction	Exemplary Performance	Points		
					Commercial Interiors	Retail	Hospitality
n/a	C	Integrative Process	D	no	2	2	2
LT Location and Transportation							
LT	C	LEED for Neighborhood Development Location	D	no	18	18	18
LT	C	Surrounding Density and Diverse Uses	D	no	8	8	8
LT	C	Access to Quality Transit	D	yes	7	7	7
LT	C	Bicycle Facilities	D	no	1	1	1
LT	C	Reduced Parking Footprint	D	yes	2	2	2
WE Water Efficiency							
WE	P	Indoor Water Use Reduction	D	no	Req	Req	Req
WE	C	Indoor Water Use Reduction	D	no	12	12	12
EA Energy and Atmosphere							
EA	P	Fundamental Commissioning and Verification	D	no	Req	Req	Req
EA	P	Minimum Energy Performance	D	no	Req	Req	Req
EA	P	Fundamental Refrigerant Management	D	no	Req	Req	Req
EA	C	Enhanced Commissioning	C	no	5	5	5
EA	C	Optimize Energy Performance	D	yes	25	25	25
EA	C	Advanced Energy Metering	D	no	2	2	2
EA	C	Renewable Energy Production	D	yes	3	3	3
EA	C	Enhanced Refrigerant Management	D	no	1	1	1
EA	C	Green Power and Carbon Offsets	C	no	2	2	2

TABLE 2. (CONTINUED) Credit Attributes

Category	Prerequisite/ Credit	Credit Name	Design/ Construction	Exemplary Performance	Points		
					Commercial Interiors	Retail	Hospitality
MR	P	Storage and Collection of Recyclables	D	no	Req	Req	Req
MR	P	Construction and Demolition Waste Management Planning	C	no	Req	Req	Req
MR	C	Long-term Commitment	C	no	1	1	1
MR	C	Interiors Life-Cycle Impact Reduction	C	yes	4	5	4
MR	C	Building Product Dislosure and Optimization—Environmental Product Declarations	C	yes	2	2	2
MR	C	Building Product Disclosure and Optimization—Sourcing of Raw Materials	C	yes	2	2	2
MR	C	Building Product Disclosure and Optimization—Material Ingredients	C	yes	2	2	2
MR	C	Construction and Demolition Waste Management	C	yes	2	2	2
EQ Indoor Environmental Quality							
EQ	P	Minimum Indoor Air Quality Performance	D	no	Req	Req	Req
EQ	P	Environmental Tobacco Smoke Control	D	no	Req	Req	Req
EQ	C	Enhanced Indoor Air Quality Strategies	D	yes	2	3	2
EQ	C	Low-Emitting Materials	C	yes	3	3	3
EQ	C	Construction Indoor Air Quality Management Plan	C	no	1	1	1
EQ	C	Indoor Air Quality Assessment	C	no	2	2	2
EQ	C	Thermal Comfort	D	no	1	1	1
EQ	C	Interior Lighting	D	no	2	2	2
EQ	C	Daylight	D	no	3	3	3
EQ	C	Quality Views	D	yes	1	1	1
EQ	C	Acoustic Performance	D	no	2	N / A	2
IN Innovation							
IN	C	Innovation		no	5	5	5
IN	C	LEED Accredited Professional		no	1	1	1
RP Regional Priority							
RP	C	Regional Priority		no	4	4	4

Minimum Program Requirements

INTRODUCTION

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

1. MUST BE IN A PERMANENT LOCATION ON EXISTING LAND

INTENT

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

REQUIREMENTS

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

ADDITIONAL GUIDANCE

Permanent location

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

Existing land

- Buildings located on previously constructed docks, piers, jetties, infill, and other manufactured structures in or above water are permissible, provided that the artificial land is previously developed, such that the land once supported another building or hardscape constructed for a purpose other than the LEED project.

2. MUST USE REASONABLE LEED BOUNDARIES

INTENT

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

REQUIREMENTS

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

ADDITIONAL GUIDANCE

Site

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

- The LEED project boundary may include other buildings.
  - If another building or structure within the LEED project boundary is ineligible for LEED certification, it may be included in the certification of the LEED project. It may also be excluded.
  - If another building within the LEED project boundary is eligible for LEED certification, it may be included in the certification if USGBC's multiple building guidance is followed. It may also be excluded.
- Projects that are phased sites with a master plan for multiple buildings must designate a LEED project boundary for each building or follow USGBC's master site guidance.
- The gross floor area of the LEED project should be no less than 2% of the gross land area within the LEED project boundary.

Building

- The LEED project should include the complete scope of work of the building or interior space.
- The LEED project can be delineated by ownership, management, lease, or party wall separation.
- Buildings or structures primarily dedicated to parking are not eligible for LEED certification. Parking that serves an eligible LEED project should be included in the certification.
- If the project consists of multiple structures physically connected only by circulation, parking or mechanical/storage rooms, it may be considered a single building for LEED purposes if the structures have programmatic dependency (spaces, not personnel, within the building cannot function independently without the other building) or architectural cohesiveness (the building was designed to appear as one building).
- An addition to an existing building may certify independently, excluding the existing building in its entirety. Alternatively, the addition and the entire existing building may certify as one project.

Interiors

- If a single entity owns, manages, or occupies an entire building and wishes to certify a renovated portion of the building that is not separated by ownership, management, lease, or party wall separation, they may do so if the project boundary includes 100% of the construction scope and is drawn at a clear, physical barrier.

Neighborhood

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

3. MUST COMPLY WITH PROJECT SIZE REQUIREMENTS

INTENT

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

REQUIREMENTS

All LEED projects must meet the size requirements listed below.

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

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

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

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

Rating System Selection Guidance

INTRODUCTION

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

RATING SYSTEM DESCRIPTIONS

LEED FOR BUILDING DESIGN AND CONSTRUCTION

Buildings that are new construction or major renovation. In addition, at least 60% of the project's *gross floor area* must be *complete* by the time of certification (except for LEED BD+C: Core and Shell).

- **LEED BD+C: New Construction and Major Renovation.** New construction or major renovation of buildings that do not primarily serve K-12 educational, retail, data centers, warehouses and distribution centers, hospitality, or healthcare uses. New construction also includes high-rise residential buildings 9 stories or more.
- **LEED BD+C: Core and Shell Development.** Buildings that are new construction or major renovation for the exterior shell and core mechanical, electrical, and plumbing units, but not a complete interior fit-out. LEED BD+C: Core and Shell is the appropriate rating system to use if more than 40% of the gross floor area is incomplete at the time of certification.
- **LEED BD+C: Schools.** Buildings made up of core and ancillary learning spaces on K-12 school grounds. LEED BD+C: Schools may optionally be used for higher education and non-academic buildings on school campuses.
- **LEED BD+C: Retail.** Buildings used to conduct the retail sale of consumer product goods. Includes both direct customer service areas (showroom) and preparation or storage areas that support customer service.
- **LEED BD+C: Data Centers.** Buildings specifically designed and equipped to meet the needs of high density computing equipment such as server racks, used for data storage and processing. LEED BD+C: Data Centers only addresses whole building data centers (greater than 60%).
- **LEED BD+C: Warehouses and Distribution Centers.** Buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings, such as self-storage.
- **LEED BD+C: Hospitality.** Buildings dedicated to hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.
- **LEED BD+C: Healthcare.** Hospitals that operate twenty-four hours a day, seven days a week and provide inpatient medical treatment, including acute and long-term care.
- **LEED BD+C: Homes and Multifamily Lowrise.** Single-family homes and multi-family residential buildings of 1 to 3 stories. Projects 3 to 5 stories may choose the Homes rating system that corresponds to the ENERGY STAR program in which they are participating.
- **LEED BD+C: Multifamily Midrise.** Multi-family residential buildings of 4 to 8 occupiable stories above grade. The building must have 50% or more residential space. Buildings near 8 stories can inquire with USGBC about using Midrise or New Construction, if appropriate.

LEED FOR INTERIOR DESIGN AND CONSTRUCTION.

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

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

LEED FOR BUILDING OPERATIONS AND MAINTENANCE.

Existing buildings that are undergoing *improvement* work or little to no construction.

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

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

LEED FOR NEIGHBORHOOD DEVELOPMENT

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

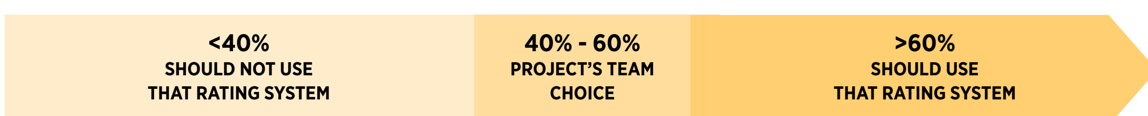
- **LEED ND: Plan.** PProjects in conceptual planning or master planning phases, or under construction.
- **LEED ND: Built Project.** Completed development projects.

CHOOSING BETWEEN RATING SYSTEMS

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

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

PERCENTAGE OF FLOOR AREA APPROPRIATE FOR A PARTICULAR RATING SYSTEM



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

CREDIT

Integrative Process

This credit applies to:

Commercial Interiors (2 points)
Retail (2 points)
Hospitality (2 points)

INTENT

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

REQUIREMENTS

Site Selection and Energy-Related Systems (1 point)

Starting in predesign and continuing throughout the design phases, identify and use opportunities to achieve synergies across disciplines and building systems. Use the analyses described below to inform the owner's project requirements (OPR), basis of design (BOD), design documents, and construction documents. Conduct analyses in site selection and energy-related systems (1 point).

SITE SELECTION:

Discovery
Before site selection, analyze project goals to identify and select the building site that will provide the most opportunities and fewest barriers for the tenant improvement project. Assess at least two potential locations or base building options, taking into consideration at least the following:

- **Building site attributes.** Assess the base building's location and site design characteristics.
- **Transportation.** Assess the tenant occupants' transportation needs for commuting to and from the site, including convenient access to alternative transportation that meets occupants' needs.
- **Building features.** Assess the base building's envelope, mechanical and electrical systems that will affect tenant space (e.g., controls, HVAC, plumbing fixtures, renewable energy supply), adaptability to future needs, and resilience in the event of disaster or infrastructure failure.
- **Occupants' well-being.** Assess the base building's ability to provide daylight and views, indoor air quality, and other indoor environmental quality characteristics.

Implementation
Document how the above analysis informed selection of a building site for the project's tenant improvement and informed the OPR and BOD and site selection for the interior design project, including the following, as applicable:

- suitability of the base building for meeting project goals relative to the building's site attributes;
- suitability of the base building site location for meeting daily occupants' commuting needs;
- suitability of the base building mechanical and electrical systems for meeting project goals;
- capability of the tenant space for meeting the project goals related to indoor environmental quality and occupant well-being; and
- other systems.

Commit to the establishment and use of ongoing feedback mechanisms that provide information about tenant space performance and occupants' satisfaction. Provide documentation of methods planned to gather feedback on occupants' satisfaction.

ENERGY-RELATED SYSTEMS

Discovery
Perform a preliminary energy analysis before the completion of schematic design that explores how to reduce energy loads for the interior design project and accomplish related sustainability goals by questioning default assumptions and testing options. Assess at least two potential options associated with each of the following in terms of project and human performance:

- **Basic envelope attributes.** Insulation values, window-to-wall ratios, glazing characteristics, shading, window operability.
- **Programmatic and operational parameters.** Multifunctioning spaces, operating schedules, space allotment per person, teleworking, reducing building area, ongoing operations and maintenance issues.
- **Lighting levels.** Interior surface reflectance values and lighting levels in occupied spaces.
- **Thermal comfort ranges.** Assess thermal comfort range options.
- **Plug and process load needs.** Reducing plug and process loads through programmatic solutions such as equipment and purchasing policies or layout options.

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

- building envelope and façade conditions;
- elimination and/or significant downsizing of building systems (e.g., HVAC, lighting, controls, exterior materials, interior finishes, functional program elements);
- methods planned to gather feedback on energy performance and occupants' satisfaction during operations; and
- other systems.

Project teams may also choose Option 1 for an additional point.

OPTION 1. WATER-RELATED SYSTEMS (1 POINT)

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

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

Implementation

Document how the above analysis informed interior design decisions in the OPR and BOD. Demonstrate how at least one on-site nonpotable water supply source was used to reduce the burden on municipal supply and/or wastewater treatment systems by contributing to the water demand components listed above. Demonstrate how the analysis informed the interior design and systems affected by the project, as applicable, for the following:

- plumbing systems;
- sewage conveyance and/or on-site treatment systems;
- process water systems;
- methods planned to gather feedback on the performance and efficiency of water-related systems during operations; and
- other systems.

BEHIND THE INTENT

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

The Integrative Process credit goes beyond checklists and encourages integration during early design stages, when clarifying the owner's aspirations, performance goals, and project needs will be most effective in improving performance. An integrative process comprises three phases.

The first—discovery—is also the most important and can be seen as an expansion of what is conventionally called predesign. Actions taken during discovery are essential to achieving a project's environmental goals cost-effectively. The second phase, design and construction, begins with what is conventionally called schematic design. Unlike its conventional counterpart, however, in the integrative process, design will incorporate all of the collective understandings of system interactions that were found during discovery. The third phase is the period of occupancy, operations, and performance feedback. Here, the integrative process measures performance and sets up feedback mechanisms. Feedback is critical to determining success in achieving performance targets, informing building operations, and taking corrective actions when targets are missed.

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

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

STEP-BY-STEP GUIDANCE

Discovery Steps

STEP 1. BECOME FAMILIAR WITH INTEGRATIVE PROCESS

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

STEP 2. COLLECT INFORMATION ABOUT POTENTIAL PROJECT SITES

Identify and collect data for at least two potential project sites.

- Refer to the credit requirements for specific features and qualities to consider.
- Determine whether potential project sites have nonpotable water sources, which may contribute to achievement of Option 1.

STEP 3. EVALUATE PROJECT SITES

Use the project goals and requirements to select the building site that will provide the most opportunities and fewest barriers to meeting the qualitative and performance aspirations for the project. Complete the site analysis worksheet, describing how the base building analysis informed site selection for the project's tenant improvement and informed the owner's project requirements and basis of design. Consider completing as many of the following steps as possible for all potential project sites to determine the most advantageous project location.

STEP 4. CONDUCT PRELIMINARY ENERGY RESEARCH AND ANALYSIS (IN CONCERT WITH STEP 5)

Complete energy-related research and analysis to support effective and informed discussions about potential integrative design opportunities (see *Further Explanation, Recommended Preliminary Data Collection*). Obtain the following for all base buildings under consideration for a tenant location, as appropriate:

- Collect information about the local climate, site conditions, energy sources, transportation options, and potential building features.
- Use the U.S. Environmental Protection Agency's Target Finder tool or other data sources to benchmark energy performance for the project's type, scope, occupancy, and location.
- Develop a "simple box" energy model (assuming a simplified building form) to generate a basic distribution of energy uses and identify dominant energy loads.
- Use this conceptual energy model to analyze design alternatives for potential load reduction strategies (see *Further Explanation, Recommended Preliminary Energy Analysis* and *Example – Light Level Analysis)*.

STEP 5. CONDUCT PRELIMINARY WATER RESEARCH AND ANALYSIS (IN CONCERT WITH STEP 4)

Complete water-related research and analysis to support effective and informed discussions about potential integrative design opportunities. Obtain the following for all base buildings under consideration for a tenant location, as appropriate:

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

STEP 6. CONVENE GOAL-SETTING WORKSHOP

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

- Introduce all project team members to the fundamentals of the integrative process.
- Share initial background research and analysis findings from Steps 2 through 5.
- Elicit the owner's and stakeholders' values and aspirations.
- Clarify functional and programmatic goals.
- Establish initial principles, benchmarks, metrics, and performance targets.
- Identify targeted LEED credits.
- Review the potential project sites.
- Generate potential integrative strategies for achieving performance targets.
- Determine the questions that must be answered to support project decisions.
- Identify initial responsibilities and deliverables.
- Initiate documentation of the owner's project requirements (OPR).

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

STEP 7. EVALUATE POSSIBLE ENERGY STRATEGIES (IN CONCERT WITH STEP 8)

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

Conduct preliminary comparative energy modeling using the "simple box" energy model before completing schematic design to evaluate energy load reduction strategies (see *Further Explanation, Recommended Preliminary Energy Analysis* and *Example—Determining Load Reduction Strategies*).

Consider the following aspects of all base buildings under consideration for a tenant location, as appropriate:

- **Site conditions.** Landscape solar shading, exterior lighting, feasibility for natural ventilation, adjacent site conditions.
- **Massing and orientation.** Number of floors, building footprint, configuration, solar orientation.
- **Building envelope attributes.** Wall and roof insulation, thermal mass, window size and orientation, exterior shading devices, window performance (U-values, solar heat gain coefficient, visible light transmittance).

Consider the following aspects for the tenant space, as appropriate:

- **Lighting levels.** Lighting power density, lighting needs in workspaces, reflectance values for ceiling and wall surfaces, high-efficiency lighting fixtures and controls, daylighting.
- **Thermal comfort ranges.** Temperature setpoints and thermal comfort parameters.
- **Plug and process loads.** Equipment and purchasing policies, other programmatic solutions, layout options.
- **Programmatic and operational parameters.** Hours of operation, space allotment per person, shared program spaces, teleworking policies.

Assess at least two optional strategies for the above aspects.

STEP 8. EVALUATE POSSIBLE WATER STRATEGIES (IN CONCERT WITH STEP 7)

Evaluate the proposed goals and performance targets for feasibility by exploring possible strategies for the project's water-related systems. Conduct a preliminary water budget analysis using research on potential water-use reduction strategies (Step 5). Consider the following aspects of all base buildings under consideration for a tenant location:

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

Gather data (in addition to that for Step 5) to assess and quantify the project's potential nonpotable supply sources, such as captured rainwater, graywater from flow fixtures, and condensate produced by initially assumed HVAC cooling equipment.

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

Implementation Steps

STEP 9. DOCUMENT HOW ANALYSIS INFORMED DESIGN

Describe how the analysis informed the selection of a building site (for the project's tenant improvement) and informed the OPR and basis of design (BOD) and site selection (for the interior design project).

- Address how the tenant space, base building, and site meet the project goals for the following, as applicable:
    - Building's site attributes, such as wildlife habitat, open space, recreational areas, and proximity to surrounding uses and alternative transportation options.
    - Occupants' daily commuting needs
    - Mechanical and electrical systems
    - Indoor environmental quality and occupants' well-being
    - Other systems

- Document energy-related research and analysis from the discovery phase. Describe how the energy-related analysis informed design decisions in the project's OPR and BOD, including the following, as applicable:
  - Building and site program
  - Building envelope and façade treatments on different orientations
  - Elimination or significant downsizing of building systems (e.g., HVAC, lighting, controls, exterior materials, interior finishes, and functional program elements)
  - Other systems
- Provide narrative explanations of the energy evaluation in the energy analysis section of the Integrative Process worksheet.
- Document water-related research and analysis from the discovery phase. Describe how the water-related analysis informed building and site design decisions in the project's OPR and BOD, including the following, as applicable:
  - Plumbing systems
  - Sewage conveyance and/or on-site treatment systems
  - Rainwater quantity and quality management systems
  - Landscaping, irrigation, and site elements
  - Roofing systems and/or building form and geometry
  - Other systems
- Provide narrative explanations of the water evaluation in the water analysis section of the Integrative Process worksheet.

STEP 10. CONSIDER OPTIONS FOR GATHERING FEEDBACK

Occupants' feedback is critical to ensuring that the project is operating as the design intended. Project teams should discuss with the owner the methods that are most feasible.

- **Methodology.** Surveys are commonly used for point-in-time analyses of multiple indicators. Depending on the project's size, some teams may find that short meetings can serve the same purpose. A public whiteboard or suggestion box accessible to occupants and responded to appropriately is a simple way to solicit information on building performance and occupants' satisfaction, though it may be useful to provide prompting questions to ensure that important topics are not overlooked.
- **Sample size.** There are no requirements for sample size, but understanding the needs and satisfaction of a large number of occupants will not only help identify the full spectrum of issues but also help in prioritizing responses.
- **Frequency.** There are no requirements for the frequency of obtaining feedback, but providing frequent, convenient opportunities for occupants to provide comments will benefit the project.

FURTHER EXPLANATION

RECOMMENDED PRELIMINARY DATA COLLECTION

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

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

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

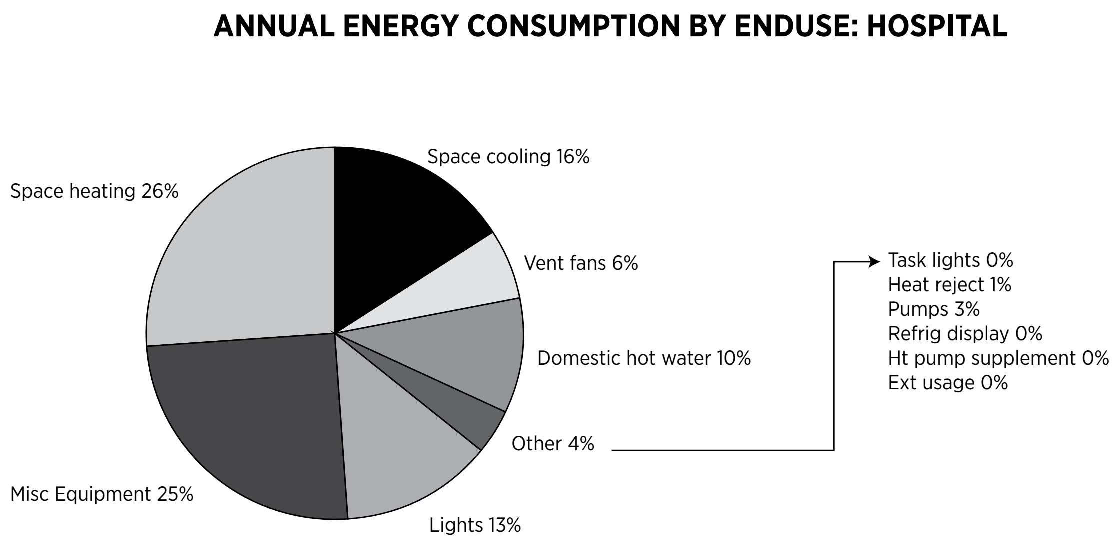


Figure 1. Example energy load distribution graph

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

For Steps 4 and 5, gather the information outlined for SS Credit Site Assessment, including solar and wind capacity, heating and cooling degree days, seasonal wind velocity and direction, precipitation, microclimate, available energy sources, utility providers, energy and peak load costs, potential financial incentives, and other issues likely to affect energy-related systems.

For Step 5, consider the location (distance from site), capacity, and type and level of treatment for the sewage system serving the site, including any sewage plant facilities. Include data on average water treatment cost.

For Step 5, consider the location, capacity, and type of water sources serving the site, such as reservoirs, aquifers, wells, lakes, rivers, nonpotable sources, and municipal supply. Include monthly and annual rainfall data and the average cost of potable (and/or nonpotable) water.

RECOMMENDED PRELIMINARY ENERGY ANALYSIS

An energy analysis can be used to evaluate potential energy strategies, such as insulation levels and window performance levels. This will not only inform potential load reduction strategies but also help the tenant determine whether the base building is appropriate.

Building envelope performance. Consider the following aspects of all base buildings under consideration for a tenant location:

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

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

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

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

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

EXAMPLES

Example 1. Light level analysis[1]

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

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

Example 2. Determining load reduction strategies

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

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

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

In both cases, significant energy load reduction can be achieved. The concept model can provide feedback on which combination of strategies is likely to be the most effective and guide the design team in preparation for

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

modeling HVAC systems. This allows HVAC systems to be properly sized and equipment efficiency improved in subsequent models; the team may be able to downsize or even eliminate equipment. The integrated approach can thus save both energy and capital costs of construction.

EXAMPLE WORKSHEET DOCUMENTATION

Provide a brief explanation of how the analysis informed tenant space selection.

The project team was considering two sites for the tenant space. One was a suburban location where most of the staff would need to drive to work, and the other was downtown, close to the office's current location. The client had not considered bringing the staff into the space selection process and viewed the move mainly as a rent reduction strategy. After forming a focus group and convening it to discuss location alternatives, the client discovered that a majority of the staff appreciated having an office close to public transportation, and many also took advantage of the childcare services in the vicinity. Some parents walked to a daycare center at lunch to visit their young children, and they wanted to be close by in case their children got sick. Although the suburban location would have saved the company several thousand dollars per year in rental cost, the current employees would have been leaving work more often and for longer periods if they were far from their children, and those who did not own cars would likely have quit their jobs, taking their years of experience with them; both results would have been costly to the company. This engagement process established that finding a downtown location close to services and alternative transit was a very high priority.

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	All projects
Integrative Process worksheet (site and energy analysis tabs, water tab optional)	X
Narrative explaining methods to gather feedback	X

RELATED CREDIT TIPS

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

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

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

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

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

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

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

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

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

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

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

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

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

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

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

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

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

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

Location and Transportation (LT)

OVERVIEW

The Location and Transportation (LT) category rewards thoughtful project team decisions about the location of their tenant space, with credits that encourage compact development, alternative transportation, and connection with amenities, such as restaurants and parks. The LT category is an outgrowth of the Sustainable Sites (SS) category, which formerly covered location-related topics.

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

If integrated into the surrounding community, a well-located tenant space can also offer distinct advantages to the owner and users of the space. For owners, locating the tenant space in a vibrant, livable community makes it a destination for residents, employees, customers, and visitors. For occupants, walkable and bikable locations can enhance health by encouraging daily physical activity, and proximity to services and amenities can increase happiness and productivity.

Design strategies that complement and build on the project location are also rewarded in the LT section. For example, by limiting parking, a project can encourage building users to take alternative transportation. By providing bicycle storage, a project can support users seeking transportation options.

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

CONSISTENT DOCUMENTATION

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

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

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

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

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

LOCATION AND TRANSPORTATION CREDIT

LEED for Neighborhood Development Location

This credit applies to:

Commercial Interiors (8-18 points)
Retail (8-18 points)
Hospitality (8-18 points)

INTENT

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

REQUIREMENTS

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

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

TABLE 1. Points for LEED ND location

Certification level	Points
Certified	8
Silver	10
Gold	12
Platinum	18

BEHIND THE INTENT

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

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

STEP-BY-STEP GUIDANCE

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

Identify an interior space within a building that is located fully within a LEED ND–certified neighborhood or certified plan area.

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

STEP 2. CONFIRM ELIGIBILITY OF LEED ND PROJECT

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

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

TABLE 2. Eligibility by LEED ND certification designation

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

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

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

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

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

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

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

STEP 4. DETERMINE FINAL CREDIT ACHIEVEMENT PATHWAY

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

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

STEP 5. GATHER AND CONFIRM LEED ND PROJECT INFORMATION

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

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

FURTHER EXPLANATION

CAMPUS

Group Approach

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

Campus Approach

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

REQUIRED DOCUMENTATION

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

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

LOCATION AND TRANSPORTATION CREDIT

Surrounding Density and Diverse Uses

This credit applies to:

Commercial Interiors (1–8 points)
Retail (1–8 points)
Hospitality (1–8 points)

INTENT

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

REQUIREMENTS

OPTION 1. SURROUNDING DENSITY (3–6 POINTS)

Locate on a site whose surrounding existing density within a ¼-mile (400-meter) radius of the project boundary meets the values in Table 1. Use either the "separate residential and nonresidential densities" or the "combined density" values.

TABLE 1A. Points for average density within ¼-mile of project (imperial units)

Combined density	Separate residential and nonresidential densities		Points
Square feet per acre of buildable land	Residential density (DU/acre)	Nonresidential density (FAR)	
22,000	7	0.5	3
35,000	12	0.8	6

TABLE 1B. Points for average density within 400 meters of project (metric units)			
Combined density	Separate residential and nonresidential densities		Points
Square meters per hectare of buildable land	Residential density (DU/hectare)	Nonresidential density (FAR)	
5 050	17.5	0.5	3
8 035	30	0.8	6

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

AND/OR

OPTION 2. DIVERSE USES (1–2 POINTS)

Construct or renovate a building or a space within a building such that the building's main entrance is within a ½-mile (800-meter) walking distance of the main entrance of four to seven (1 point) or eight or more (2 points) existing and publicly available diverse uses (listed in Appendix 1).

The following restrictions apply.

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

BEHIND THE INTENT

Because most people prefer to walk no more than a quarter of a mile (400 meters) or five minutes to casual destinations and no more than half a mile (800 meters) for regular trips such as a daily commute,[1] locating different kinds of destinations close to each other achieves a long list of documented environmental and social benefits. For example, doubling residential and nonresidential density reduces the length of vehicular trips and total air pollution by 30 percent.[2] Air particulate levels go down along with greenhouse gas emissions, reducing transportation's climate change effects.[3]

Furthermore, per capita pedestrian and bicycle injuries and deaths tend to be fewer in denser neighborhoods with more pedestrians and cyclists, since motorists must drive more slowly and carefully in these areas. The rate of car collision fatalities goes down, too, as the average length of vehicular trips grows shorter.

Moreover, density improves community members' health. As neighborhoods become more compact, residents who frequently walk, bike, or use transit are more physically fit and less likely to be overweight.[4] One study found that the probability of being overweight falls around 5% for every half-mile (800 meters) walked per day.[5] Finally, compact development capitalizes on existing infrastructure, saving money and resources while more efficiently using land and preserving habitat, farmland, and open space on the urban fringe.

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

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

STEP-BY-STEP GUIDANCE

STEP 1. SELECT BUILDING IN WHICH TO LOCATE

Use the criteria in the credit requirements to evaluate potential project locations. Follow these suggestions to maximize the chances of identifying an appropriate location:

- Limit site selection to areas within the central business district of a city or town center.
- Give preference to areas of development that include residential uses.

STEP 2. IDENTIFY ELIGIBLE OPTIONS

Select the appropriate option(s) for the project.

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

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

Option 1. Surrounding Density

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

On a map, plot a ¼-mile (400-meter) radius around the project site from the project boundary.

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

STEP 2. COLLECT INFORMATION ON DENSITY

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

- If the project team cannot determine the number of dwelling units in the surrounding land, use the combined density calculation.
- It might not be necessary to determine the total number of dwelling units or building floor area for all properties within the radius. If the area features a few extremely dense buildings, start with these first to see whether the threshold can be met without further calculations.

Provided that all land area within the radius is accounted for, project teams must collect only enough density information to demonstrate that values in Table 1 are met or exceeded.

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

If the information is available, calculate the density for each building type within the ¼-mile (400-meter) radius. Designate each building and its associated land area as residential, nonresidential, or mixed use (see *Getting Started, Density*).

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

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

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

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

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

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

STEP 4. CALCULATE COMBINED DENSITY, IF APPLICABLE

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

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

EQUATION 3. Combined density

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

STEP 5. DETERMINE POINTS EARNED

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

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

Option 2. Diversity of Uses

STEP 1. DOCUMENT NEARBY USES

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

To be eligible, uses that are planned but not currently operating must be occupied within one year of the date of the LEED project's initial certificate of occupancy.

Use the credit requirements to determine the number and category of uses that contribute to credit achievement. Note the restriction on the number of uses of each type (see *Further Explanation, Example 2*).

STEP 2. MAP WALKING ROUTES TO USES

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

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

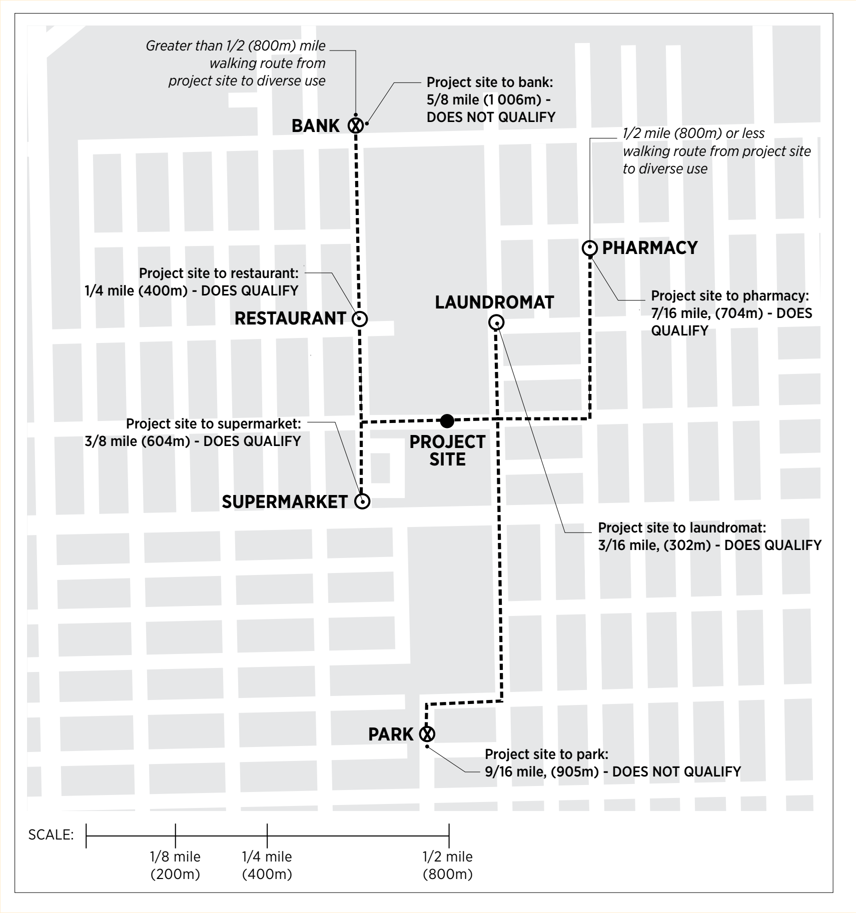


Figure 1. Example walking routes to diverse uses

FURTHER EXPLANATION

CALCULATIONS

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

EXAMPLES

Example 1. Residential and nonresidential density calculations

An interiors project in a new commercial building is surrounded by a variety of residential, nonresidential, and mixed-use buildings within a ¼-mile (400-meter) radius of the project boundary.

The project developer does not know the size of many of the residential buildings within the ¼-mile (400-meter) radius of the project site and therefore chooses to do a separate density calculation for residential and nonresidential densities. A survey of the area provides the following information:

TABLE 2. Land area

Building type	All types	Residential	Nonresidential	Mixed-use
Land area	130 acres (53 hectares)	60 acres (23 hectares)	60 acres (23 hectares)	10 acres (4 hectares)

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

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

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

TABLE 3. Adjusted land area

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

There are 680 dwelling units within ¼-mile (400 meters) (including all residential units in mixed-use buildings). The project team calculates density in dwelling units (DU) as follows:

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

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

Nonresidential density = 1,600,000 ft² / 2,700,720 = 0.59 FAR

(Nonresidential density = 148 645 m² / 250 905 = 0.59 FAR)

TABLE 4. Summary of densities

Building type	Total	Residential	Nonresidential
Land area	130 acres (53 hectares)	68 acres (28 hectares)	62 acres (25 hectares) 2,700,720 ft² (250 905 m²)
Dwelling units		680 DU	
Nonresidential building space		10 DU/acre (24 DU/hectare)	FAR 0.59

Since the density within ¼-mile (400 meters) is 10 dwelling units per acre (24 dwelling units per hectare) and the nonresidential FAR is 0.59, the project can earn 2 points.

Example 2. Diversity of uses
A commercial interiors project selects a building that is within a ½-mile (800-meter) walking distance of eight uses in three categories (Appendix 1).

TABLE 5. Summary of uses

	Category				
	Service	Food retail	Civic and community facilities		
Use type	Restaurant	Grocery	Child care	Library	Total
Number of uses	3	2	1	2	8
Eligible uses	2	2	1	2	7

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

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Area plan or map showing project site, previous development, surrounding area, location of residential and non-residential buildings, and ¼-mile (400-meter) radius from project site	X	
Description of the previous development on the site	X	
Area plan or map showing project site, location and type of each use, and walking routes		X

RELATED CREDIT TIPS

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

CHANGES FROM LEED 2009

- Points have been redistributed such that the credit's full value can be earned only if the requirements for both Options 1 and 2 are met.
- There are now thresholds for separate residential and non-residential densities.
- The radius for building density calculation is now specified as ¼-mile (400 meters) from the project boundary.
- Proximity to the diverse uses is now based on walking distance instead of a radius.
- Additional restrictions have been added to stipulate how diverse uses can be counted.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

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

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

diverse use a distinct, officially recognized business, nonprofit, civic, religious, or governmental organization, or dwelling units (residential use) or offices (commercial office use). It has a stationary postal address and is publicly available. It does not include automated facilities such as ATMs, vending machines, and touchscreens.

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

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

LOCATION AND TRANSPORTATION CREDIT

Access to Quality Transit

This credit applies to:

Commercial Interiors (1–7 points)
Retail (1–7 points)
Hospitality (1–7 points)

INTENT

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

REQUIREMENTS

Locate any functional entry of the project within a ¼-mile (400-meter) walking distance of existing or planned bus, streetcar, or rideshare stops, or within a ½-mile (800-meter) walking distance of existing or planned bus rapid transit stops, light or heavy rail stations, commuter rail stations, or commuter ferry terminals. The transit service at those stops and stations in aggregate must meet the minimums listed in Tables 1 and 2. Planned stops and stations may count if they are sited, funded, and under construction by the date of the certificate of occupancy and are complete within 24 months of that date.

Both weekday and weekend trip minimums must be met.

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

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

Weekday trips	Weekend trips	Points
72	40	2
144	108	5
360	216	7

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

Weekday trips	Weekend trips	Points
24	6	1
40	8	2
60	12	3

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

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

ALL OPTIONS

For all options, provide dedicated walking or bicycling lanes toward the transit lines. The lanes must extend from the school building to at least the end of the school property and may not have any barriers (e.g., fences). School grounds may be enclosed with fences during class hours for security purposes, provided the fences are open before and after class hours for traveling students, faculty, and staff.

BEHIND THE INTENT

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

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

Transit-oriented development locations support transit services by boosting ridership, while project occupants enjoy access to public transportation. Projects that are within walking distance of multiple transit routes will further encourage occupants and visitors to use public transportation.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY TRANSIT STOPS WITHIN ½-MILE (800 METERS)

On a site map, identify the location of any transit stops that appear to be within ½-mile (800 meters) of the building in which the project is located.

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

STEP 2. CLASSIFY TRANSIT BASED ON VEHICLE TYPES

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

- Classify the identified transit stops by transit vehicle type (e.g., bus, streetcar, rail).
- Transit stops for bus, streetcar, or rideshare between the ¼-mile (400-meter) and ½-mile (800-meter) distance do not contribute to credit compliance.

STEP 3. CONFIRM WALKABILITY

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

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

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

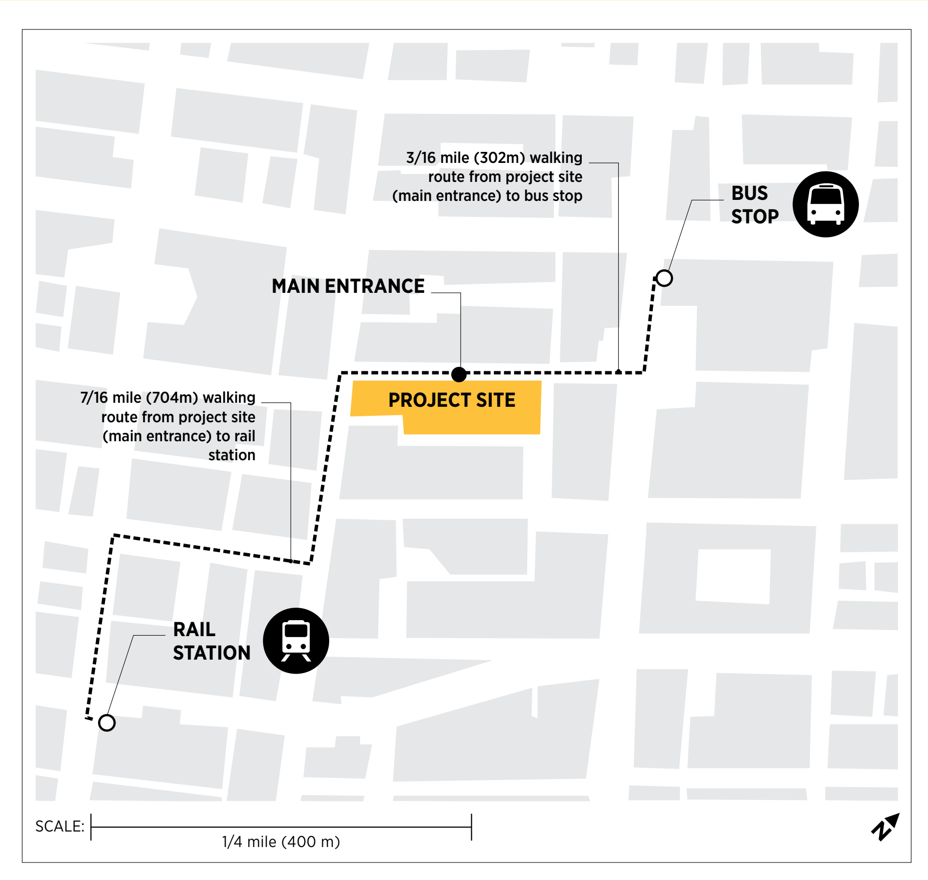


Figure 1. Example walking distance map

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

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

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

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

STEP 5. CALCULATE POINTS EARNED

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

- If weekday and weekend trips meet different point thresholds, then the lowest performing time period (weekday or weekend) determines the number of points documented.
- If there is sufficient diversity of transit service among multiple routes, projects may be eligible to earn 1 bonus point, as outlined in the credit requirements.

FURTHER EXPLANATION

CALCULATIONS

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

EXAMPLE

The project is a commercial office space pursuing ID+C: Commercial Interiors and the building has two functional building entries.

A light rail stop is within a ¼-mile (400-meter) walking distance of one of the functional building entries. A commuter rail station is within a ½-mile (800-meter) walking distance of the other functional building entry. This project meets the walkability requirement.

Both the light rail station and the commuter rail station have service in both directions. To determine the number of trips, the project team counts service in one direction and summarizes the service available at the eligible stops (Table 3).

TABLE 3. Example transit service summary

	Weekday	Weekend day A	Weekend day B	Weekend average
Light rail	80	60	54	57
Commuter rail	25	10	10	10
Total	105			67
Point threshold	1			1

Using the table for project with multiple transit types (Table 1) (light rail and commuter rail service), the project is eligible for 1 point.

The project team determines that the light rail provides more than 60% of the accessible transit (Table 4). The bonus point for having no service that exceeds 60% is therefore unavailable.

TABLE 4. Route diversity

	Weekday trips	Average weekend trips	Total
Light rail	80	57	137 (80% of trips)
Commuter rail	25	10	32 (20% of trips)
Total service	105	67	172

PROJECT TYPE VARIATIONS

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

CAMPUS

Group Approach

Submit separate documentation for each project space.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
Map showing project, project boundary, transit stop locations, and walking routes and distances to those stops	X
Timetables or other service level documentation	X
If applicable, documentation of planned transit or restoration of temporarily rerouted service	X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

- Transit service frequency is now included in the credit requirements.
- Access is now measured by walking distance to functional building entries.
- The credit now addresses both weekday and weekend availability.
- Point thresholds are now based on the number of transit trips available within the required walking distance.
- Modes of transportation have been expanded to include ferry, streetcar, rapid transit, and rideshare.
- Private shuttles cannot be used to comply with the requirement

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Double the highest transit service point threshold.

DEFINITIONS

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

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

light rail transit service using two- or three-car trains in a right-of-way that is often separated from other traffic modes. Spacing between stations tends to be ½-mile (800 meters) or more, and maximum operating speeds are typically 40–55 mph (65–90 kmh). Light-rail corridors typically extend 10 or more miles (16 kilometers).

rideshare a transit service in which individuals travel together in a passenger car or small van that seats at least four people. It can include human-powered conveyances, which must accommodate at least two people. It must include an enclosed passenger seating area, fixed route service, fixed fare structure, regular operation, and the ability to pick up multiple riders.

streetcar a transit service with small, individual rail cars. Spacing between stations is uniformly short and ranges from every block to ¼-mile (400 meters), and operating speeds are primarily 10–30 mph (15–50 kmh). Streetcar routes typically extend 2–5 miles (3-8 kilometers).

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

LOCATION AND TRANSPORTATION CREDIT

Bicycle Facilities

This credit applies to:

Commercial Interiors (1 point)
Retail (1 point)
Hospitality (1 point)

INTENT

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

REQUIREMENTS

COMMERCIAL INTERIORS, HOSPITALITY

Bicycle Network

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

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

All destinations must be within a 3-mile (4 800-meter) bicycling distance of the project boundary.

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

Bicycle Storage and Shower Rooms

Provide short-term bicycle storage for at least 2.5% or more of all peak visitors, but no fewer than two storage spaces per project.

Provide long-term bicycle storage for at least 5% of regular building occupants but no fewer than 2 spaces per project in addition to the short-term bicycle spaces.

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

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

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

RETAIL

Bicycle Network

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

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

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

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

Bicycle Storage and Shower Rooms

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

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

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

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

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

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

BEHIND THE INTENT

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

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

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY BICYCLE NETWORK AND ELIGIBLE DESTINATIONS

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

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

STEP 2. SELECT BIKE-FRIENDLY PROJECT LOCATION

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

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

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

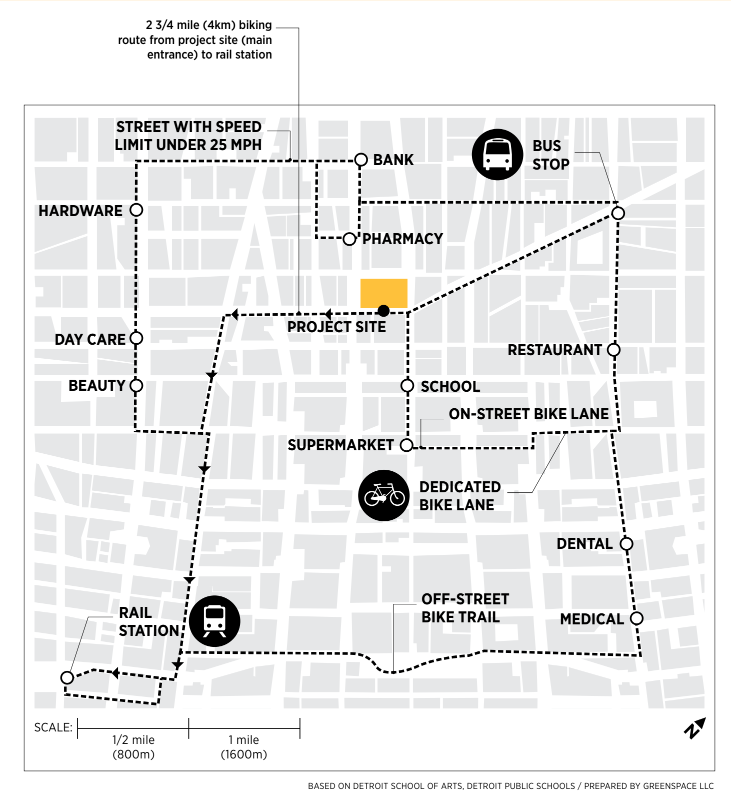


Figure 1. Example bicycle network

STEP 3. GATHER OCCUPANT COUNT INFORMATION

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

- For all rating systems except Retail, also determine the number of expected peak visitors.
- If actual occupancy is not known, see *Getting Started, Occupancy*.

STEP 4. DETERMINE NUMBER OF BICYCLE STORAGE SPACES REQUIRED

Calculate the number of required short-term and long-term bicycle spaces, using the following equations.

EQUATION 1. Short-term bicycle storage

$$\text{Short-term bicycle storage} = \text{Peak visitors} \times 0.025$$

EQUATION 2. Long-term bicycle storage

$$\text{Long-term bicycle storage} = \text{Regular building occupants} \times 0.05$$

EQUATION 3. Retail short-term bicycle storage

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

- For all rating systems except Retail, calculate the number of required bicycle spaces using Equations 1 and 2.
- For Retail, calculate the number of required long-term (Equation 2) and short-term (Equation 3) bicycle spaces. Short-term bicycle storage is based on the total floor area of the tenant space (see *Further Explanation, Rating System Variations*).

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

- Results must be rounded up to the nearest whole number.
- Storage spaces must be devoted to the project pursuing LEED certification and cannot be double-counted. For example, a project team may not count the storage of other tenants toward its own storage requirements if that storage is already allocated to the other building's tenants. In addition, if any non-LEED project occupants have access to the storage, then either sufficient spaces must be provided for all occupants with access to amenities or the storage must be designated for the occupants of the LEED project only.

STEP 5. DETERMINE NUMBER OF SHOWER AND CHANGING FACILITIES REQUIRED

For all rating systems except Retail, use Equation 4 to determine the number of showers with changing facilities required and incorporate these facilities into the project design (see *Further Explanation, Rating System Variations*).

EQUATION 4. Shower facilities

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

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

- Results must be rounded up to the next whole number. For projects with 100 or fewer regular building occupants, only one shower is required.
- Showers are required for commercial or institutional spaces only. For residential spaces, no additional showers are required beyond those provided inside dwelling units. Projects with hotel guests may exclude these occupants from shower calculations.
- If space for shower and changing facilities is limited, free access to on-site shower facilities or health club shower facilities may be provided to all occupants in lieu of in-house facilities. Health club or shower facilities must be accessible to occupants without their having to go outdoors and available during the project's hours of operation.

STEP 6. INSTALL BICYCLE STORAGE

Locate short-term and long-term bicycle storage facilities within 100 feet (30 meters) of main and functional entrances, respectively. Bicycle storage spaces are more likely to be used if they are located in a well-lit, safe, and accessible area (see *Further Explanation, Selecting Bicycle Storage*).

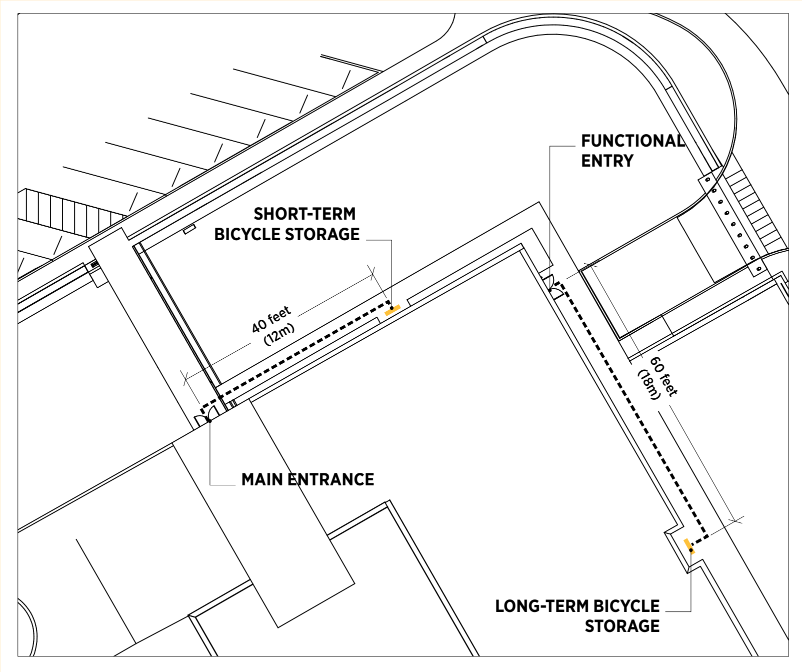


Figure 2. Example bicycle storage locations

RETAIL

STEP 7. INSTITUTE PROGRAMS TO SUPPORT BICYCLING USE

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

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

FURTHER EXPLANATION

CALCULATIONS

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

SELECTING BICYCLE STORAGE

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

EXAMPLE

A 30,000-square-foot (2 700-square-meter) retail space pursuing Retail has met the bicycle network requirement by being within 3 miles' (5 kilometers') bicycling distance of 10 diverse uses on a bicycle network. The building will have 31 full-time employees plus 18 part-time employees who each work 20 hours per week. To determine the number of bicycle storage and shower and changing facilities required, the team calculates regular building occupants for the building (see *Getting Started, Occupancy*):

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

The team uses Equation 3 to determine the number of short-term bicycle storage spaces:

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

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

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

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

RATING SYSTEM VARIATIONS

Commercial Interiors, Hospitality
At least two short-term and two long-term bicycle storage spaces are required.

Retail
At least two short-term and two long-term spaces are required. Short-term spaces are based upon building floor area, per Equation 3. Showers are not required. A bicycle maintenance or route assistance program is required. See *Further Explanation, Example*.

CAMPUS

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

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	Commercial Interiors, Hospitality	Retail
Vicinity map showing bicycle network and route and distance along network to eligible destination(s)	X	X
Calculations for storage and shower facilities (if applicable)	X	X
Site plan showing bicycle storage locations	X	X
Description of programs to support bicycle use		X

RELATED CREDIT TIPS

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

CHANGES FROM LEED 2009

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

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

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

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

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

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

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

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

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

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

LOCATION AND TRANSPORTATION CREDIT

Reduced Parking Footprint

This credit applies to:

Commercial Interiors (1–2 points)
Retail (1–2 points)
Hospitality (1–2 points)

INTENT

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

REQUIREMENTS

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

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

Case 1. Baseline Location

Projects that have not earned points under LT Credit Surrounding Density and Diverse Uses or LT Credit Access to Quality Transit must achieve a 20% (1 point) or 40% (2 points) reduction from the base ratios.

Case 2. Dense and/or Transit-Served Location

Projects earning 1 or more points under either LT Credit Surrounding Density and Diverse Uses or LT Credit Access to Quality Transit much achieve a 40% (1 point) or 60% (2 points) reduction from the base ratios.

FOR ALL PROJECTS

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

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

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

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

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

BEHIND THE INTENT

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

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

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

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE LOCAL CODE REQUIREMENTS

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

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

STEP 2. CALCULATE BASE RATIOS AND BASELINE PARKING CAPACITY

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

STEP 3. IDENTIFY APPROPRIATE CASE

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

STEP 4. ESTIMATE PARKING DEMAND

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

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

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

STEP 5. DEVELOP AND IMPLEMENT STRATEGIES TO REDUCE PARKING DEMAND

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

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

Incorporate the selected strategies into the project.

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

STEP 6. DETERMINE PROJECT'S REDUCED PARKING CAPACITY

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

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

EQUATION 1. Percentage of parking capacity reduction

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

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

STEP 7. PROVIDE CARPOOL PARKING

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

FURTHER EXPLANATION

CALCULATIONS

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

BASE RATIOS

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

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

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

Use	Size or condition	Parking spaces
Government office building		Use Office Building radio if general office only; otherwise, parking study prepared for complex
Health, fitness club		7/1,000 ft^2 (7.5/100 m^2)
Heavy, hard goods, furniture store, carpet store		2.5/1,000 ft^2 (2.7/100 m^2)
High school		Higher of 0.3/auditorium or gym seat, or 0.3/student
High-turnover restaurant	No bar	15/1,000 ft^2 (16/100 m^2)
High-turnover restaurant	With bar	20/1,000 ft^2 (21.5/100 m^2)
Hospital		1.1/employee
Hotel, motel		1.25/room. Add 10/1,000 ft^2 (10.8/100 m^2) for lounge/restaurant. Add conference/banquet at following rates: 1. < 20 ft^2/room (1.86 m^2/room): none 2. 20 ft^2/room (1.86 m^2/room) to 50 ft^2/room (4.65 m^2/room): Scaled If x is ft^2 per room, 30-[10 x (x-20)/30] spaces per 1,000 ft^2 GLA conference banquet If y is m^2 per room, 32.3-[10.8 x (y-1.86)/2.79] spaces per 100 m^2 GLA conference banquet 3. > 50 ft^2/room (4.65 m^2/room): 20/1,000 ft^2 (21.5/100 m^2)
Junior or community college	School population: students, faculty and staff	0.25/school population
Live theater		0.4/seat
Medical, dental office building	Not on hospital campus	4.5/1,000 ft^2 (4.8/100 m^2)
Medical, dental office building	On hospital campus	4/1,000 ft^2 (4.3/100 m^2)
Mini-warehouse		1.75/100 units
Movie theater with matinee	1 screen	0.5/seat
Movie theater with matinee	2 to 5 screens	0.33/seat
Movie theater with matinee	5 to 10 screens	0.3/seat
Movie theater with matinee	more than 10 screens	0.27/seat
Nightclub		19/1,000 ft^2 (20.5/100 m^2)
Nursing home		0.5/bed
Office building	< 25,000 ft^2 (2 325 m^2)	3.8/1,000 ft^2 (4.1/100 m^2)
Office building	25,000 to 100,000 ft^2 (2 325 to 9 300 m^2)	Scaled If x is ft^2, 3.8-[0.4 x (x-25,000)/75,000] spaces per 1,000 ft^2 If y is m^2, 4.1-[0.43 x (y-2325)/6975] spaces per 100 m^2
Office building	100,000 ft^2 (9 300 m^2)	3.4/1,000 ft^2 (3.67/100 m^2)
Office building	100,000 to 500,000 ft^2 (9 300 to 46 500 m^2)	Scaled If x is ft^2, 3.4-[0.6 x (x-100,000)/400,000] spaces per 1,000 ft^2 If y is m^2, 3.67-[0.67 x (y-9300)/37 200] spaces per 100 m^2
Office building	more than 500,000 ft^2 (more than 46 500 m^2)	2.8/1,000 ft^2 (3.0/100 m^2)
Other public assembly		0.25/person in permitted capacity where not seated, or 0.3/seat where seated
Owned accessory dwelling unit		1/Accessory DU. Den must be counted as bedroom if it has closet. Ratios include 0.15 space per unit for visitors.

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

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

DU = dwelling unit

GLA = gross leasable area

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

TOTAL VEHICLE PARKING CAPACITY

When determining total parking capacity, include all off-street spaces available to users of the tenant space seeking certification. This includes spaces within and outside the project boundary.

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

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

- New and existing surface parking spaces
- New and existing garage or multilevel parking spaces
- Any off-street parking spaces outside the project boundary that are available to users of the tenant space

Exclude the following:

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

PREFERRED PARKING

Preferred parking is the spaces with the shortest walking distance to the main entrance to the tenant space or building in which the tenant space is located, exclusive of designated spaces for persons with disabilities. If parking is provided on multiple levels of a facility, locate preferred spaces on the level closest to the main entrance.

If the parking area is subdivided by user type (e.g., customers versus employees, staff versus students, VIP parking for ranking military officials), the required number of preferred parking spaces may be distributed proportionally across each parking area. Alternatively, provide one preferred parking area for all user types while maintaining separate parking areas for nonpreferred vehicles.

TRANSPORTATION DEMAND MANAGEMENT STRATEGIES

Examples of transportation demand management strategies include the following.

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

EXAMPLE

A 20,000-square-foot (1 900-square-meter) commercial office space is adjacent to a movie theater complex and a high-frequency light rail line, earning 1 point under LT Credit Access to Quality Transit. The project narrowly missed achieving LT Credit Surrounding Density and Diverse Uses because there were not enough nearby neighborhood uses, but it still must comply with Case 2 since it achieved LT Credit Access to Quality Transit.

Tables 18-2–18-4 in the Transportation Planning Handbook indicate a baseline of 3.8 parking spaces per 1,000 square feet for an office building space smaller than 25,000 square feet (2 325 square meters), or 76 parking spaces for this project. According to Case 2 requirements, the project should provide no more than 45 spaces (a 40% reduction from 76 baseline spaces) to earn 1 point.

The project team reduces overall parking demand by providing secure bicycle storage spaces, arranging carpools among employees, and being located within walking distance to transit. The project team then secures 40 spaces on one level of the movie theater's off-site, multilevel parking garage that can be leased and used by project occupants; it provides no other parking. In addition, two of the 40 spaces are preferred parking for carpool use, meeting the required 5% minimum. This parking reduction of 48% (40 instead of 76 spaces) earns the credit under Case 2.

PROJECT TYPE VARIATIONS

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

Separated Employee or Visitor Parking
Projects with separate parking areas for visitors, employees or students must apply the proportion of preferred parking for carpools must be applied to each pool of parking.

CAMPUS

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

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

REQUIRED DOCUMENTATION

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

RELATED CREDIT TIPS

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

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

CHANGES FROM LEED 2009

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

REFERENCED STANDARDS

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

EXEMPLARY PERFORMANCE

Case 1. Achieve a 60% parking capacity reduction from the base ratios.

Case 2. Achieve a 80% parking capacity reduction from the base ratios.

DEFINITIONS

None.

Water Efficiency (WE)

OVERVIEW

The Water Efficiency (WE) section addresses water holistically, looking at indoor use, outdoor use, specialized uses, and metering. The section is based on an "efficiency first" approach to water conservation. As a result, each prerequisite looks at water efficiency and reductions in potable water use alone. Then, the WE credits additionally recognize the use of nonpotable and alternative sources of water.

The conservation and creative reuse of water are important because only 3% of Earth's water is fresh water, and of that, slightly over two-thirds is trapped in glaciers.[1] Typically, most of a building's water cycles through the building and then flows off-site as wastewater. In developed nations, potable water often comes from a public water supply system far from the building site, and wastewater leaving the site must be piped to a processing plant, after which it is discharged into a distant water body. This pass-through system reduces streamflow in rivers and depletes fresh water aquifers, causing water tables to drop and wells to go dry. In 60% of European cities with more than 100,000 people, groundwater is being used faster than it can be replenished.[2]

In addition, the energy required to treat water for drinking, transport it to and from a building, and treat it for disposal represents a significant amount of energy use not captured by a building's utility meter. Research in California shows that roughly 19% of all energy used in this U.S. state is consumed by water treatment and pumping.[3]

In the U.S., buildings account for 13.6% of potable water use,[4] the third-largest category, behind thermoelectric power and irrigation. Designers and builders can construct green buildings that use significantly less water than conventional construction by incorporating native landscapes that eliminate the need for irrigation, installing water-efficient fixtures, and reusing wastewater for nonpotable water needs. The Green Building Market Impact Report 2009 found that LEED projects were responsible for saving an aggregate 1.2 trillion gallons (4.54 trillion liters) of water.[5] LEED's WE credits encourage project teams to take advantage of every opportunity to significantly reduce total water use.

1. *U.S. Environmental Protection Agency, Water Trivia Facts, water.epa.gov/learn/kids/drinkingwater/water_trivia_facts.cfm* (*accessed September 12, 2012*).
2. *Statistics: Graphs & Maps, UN Water, http://www.unwater.org/statistics_use.html* (*accessed March 8, 2013*).
3. *energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF.*
4. *USGBC, Green Building Facts, http://www.usgbc.org/articles/green-building-facts.*
5. *Green Outlook 2011, Green Trends Driving Growth* (*McGraw-Hill Construction, 2010*), *aiacc.org/wp-content/uploads/2011/06/greenoutlook2011.pdf* (*accessed September 12, 2012*).

CROSS-CUTTING ISSUES

The focus of the interiors version of the WE category is indoor water for fixtures, appliances, and processes. Several kinds of documentation span these components, depending on the project's specific water-saving strategies.

Floor plans. Floorplans are used to document the location of fixtures, appliances, and process water equipment (e.g., cooling towers, evaporative condensers), as well as submeters.

Fixture cutsheets. Projects must document their fixtures (and appliances as applicable) using fixture cutsheets or manufacturers' literature. This documentation is used in the Indoor Water Use Reduction prerequisite and credit.

Occupancy calculations. The Indoor Water Use Reduction prerequisite and credit require projections based on occupants' usage. The Location and Transportation credit category also uses project occupancy calculations. Review the occupancy section in *Getting Started* to understand how occupants are classified and counted. Also see WE Prerequisite Indoor Water Use Reduction for additional guidance specific to the WE section.

WATER EFFICIENCY PREREQUISITE

Indoor Water Use Reduction

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To reduce indoor water consumption.

REQUIREMENTS

BUILDING WATER USE

For the fixtures and fittings listed in Table 1, as applicable to the project scope, reduce aggregate water consumption by 20% from the baseline. Base calculations on the volumes and flow rates shown in Table 1.

All newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled (or a local equivalent for projects outside the U.S.).

Projects where fixtures or fixture fittings are not within the tenant spaces are exempt from this prerequisite.

TABLE 1. Baseline water consumption of fixtures and fittings

Fixture or fitting	Baseline (IP units)	Baseline (SI units)
Toilet (water closet)*	1.6 gpf	6 lpf
Urinal*	1.0 gpf	3.8 lpf
Public lavatory (restroom) faucet	0.5 gpm at 60 psi** all others except private applications	1.9 lpm at 415 kPa, all others except private applications
Private lavatory faucets*	2.2 gpm at 60 psi	8.3 lpm at 415 kPa
Kitchen faucet (excluding faucets used exclusively for filling operations)	2.2 gpm at 60 psi	8.3 lpm at 415 kPa
Showerhead*	2.5 gpm at 80 psi per shower stall	9.5 lpm at 550 kPa per shower stall

*WaterSense label available for this product type

gpf = gallons per flush gpm = gallons per minute psi = pounds per square inch

lpf = liters per flush lpm = liters per minute kPa = kilopascals

Appliance and Process Water Use

Install appliances, equipment, and processes within the project scope that meet the requirements listed in the tables below.

TABLE 2. Standards for appliances

Appliance	Requirement
Residential clothes washers	ENERGY STAR or performance equivalent
Commercial clothes washers	CEE Tier 3A
Residential dishwashers (standard and compact)	ENERGY STAR or performance equivalent
Prerinse spray valves	≤ 1.3 gpm (4.9 lpm)
Ice machine	ENERGY STAR or performance equivalent and use either air-cooled or closed-loop cooling, such as chilled or condenser water system

gpm = gallons per minute lpm = liters per minute

TABLE 3. Standards for appliances

Process	Requirement
Heat rejection and cooling	No once-through cooling with potable water for any equipment or appliances that reject heat
Cooling towers and evaporative condensers	Equip with • makeup water meters • conductivity controllers and overflow alarms • efficient drift eliminators that reduce drift to maximum of 0.002% of recirculated water volume for counterflow towers and 0.005% of recirculated water flow for cross-flow towers

gpm = gallons per minute lpm = liters per minute

RETAIL AND HOSPITALITY ONLY

In addition, water-consuming appliances, equipment, and processes must meet the requirements listed in Tables 4 and 5.

TABLE 4. Standards for appliances

Kitchen equipment		Requirement (IP units)	Requirement (SI units)
Dishwasher	Undercounter	≤ 1.6 gal/rack	≤ 6.0 liters/rack
	Stationary, single tank, door	≤ 1.4 gal/rack	≤ 5.3 liters/rack
	Single tank, conveyor	≤ 1.0 gal/rack	≤ 3.8 liters/rack
	Multiple tank, conveyor	≤ 0.9 gal/rack	≤ 3.4liters/rack
	Flight machine	≤ 180 gal/hour	≤ 680 liters/hour
Food steamer	Batch	≤ 6 gal/hour/pan	≤ 23 liters/hour/pan
	Cook-to-order	≤ 10 gal/hour/pan	≤ 38 liters/hour/pan
Combination oven	Countertop or stand	≤ 3.5 gal/hour/pan	≤ 13 liters/hour/pan
	Roll-in	≤ 3.5 gal/hour/pan	≤ 13 liters/hour/pan

TABLE 5. Process requirements

Process	Requirement
Discharge water temperature tempering	Where local requirements limit discharge temperature of fluids into drainage system, use tempering device that runs water only when equipment discharges hot water **OR** Provide thermal recovery heat exchanger that cools drained discharge water below code-required maximum discharge temperatures while simultaneously preheating inlet makeup water **OR** If fluid is steam condensate, return it to boiler
Venturi-type flow-through vacuum generators or aspirators	Use no device that generates vacuum by means of water flow through device into drain

BEHIND THE INTENT

Potable water usage in buildings constitutes a large portion of freshwater consumption. Strategies to reduce potable water use in buildings entail the selection of efficient plumbing fittings, fixtures, and equipment. Fixtures that use 20% to 50% less water than code-required levels are now widely available. The WaterSense label was developed by the U.S. Environmental Protection Agency to identify these efficient fixtures and ensure that higher efficiency does not come at the cost of performance. The WaterSense label has been incorporated as a requirement for this credit to ensure that fixtures in a LEED building are both water efficient and high performing.

In some buildings, intensive appliance and process water use can exceed water use from fixtures and landscape combined. This is especially true for buildings with cooling towers or evaporative condensers. Appliance and process water use is therefore addressed specifically with a separate set of requirements.

Because the WE section is designed around an "efficiency first" model, the prerequisite deals only with the efficiency of fixtures and fittings; alternative or nonpotable water sources that offset potable water demand are also addressed in the corresponding credit.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT COMPLIANCE PATH

Determine the appropriate compliance path(s) for the project.

- Compliance Path 1 is for projects whose installed fixtures do not exceed WaterSense maximum levels. Compliance is documented through product cutsheets or fixture schedules.
- Compliance Path 2 is for projects that cannot demonstrate the 20% reduction for each fixture, based on manufacturers' documentation. The project team must perform calculations to show that, in aggregate, the fixtures comply with prerequisite requirements. Projects pursuing points under WE Credit Indoor Water Use Reduction must use this compliance path.

Calculations for the prerequisite are based only on the fixtures within the tenant space (note that this differs for WE Credit Indoor Water Use).

Commercial interiors projects do not need to comply with the cooling tower or other building systems requirements if these systems are outside the project's scope of work.

STEP 2. SELECT WATERSENSE-LABELED PRODUCTS

Select WaterSense-labeled products for all new fixtures within the project by verifying that the manufacturer and model are listed on the WaterSense website. The WaterSense label can be found for fixtures in the following product categories:

- Tank-type toilet (water closet)
- Water-using urinals
- Private lavatory faucets
- Showerheads

The following fixture types are not labeled by WaterSense and must comply with the percentage reduction criteria:

- Tankless toilets
- Composting toilets and waterless toilets
- Waterless urinals
- Public lavatory faucets

Using aerators is an acceptable water savings strategy.

- Newly installed aerators or flow restrictors added to private lavatories or showers must be WaterSense labeled.
- For private lavatories, WaterSense requires a maximum flow rate of 1.5 gallons per minute at 60 pounds per square inch and a minimum flow rate of 0.8 gallons per minute at 20 pounds per square inch. The installed fixtures in the design case must use the rated flow rate from the manufacturer, and the underlying assumptions must remain consistent between the baseline and design cases.

For projects in countries where WaterSense-labeled products are not readily available, see *Further Explanation, International Tips*.

STEP 3. SELECT HIGH-EFFICIENCY FIXTURES

For all product categories, including those covered by WaterSense, specify low-flow fixtures. Where possible, select fixtures that meet or exceed the 20% reduction indicated in the prerequisite requirements.

- Some equipment does not need to meet the 20% reduction threshold (see *Further Explanation, Excluded Water-Using Equipment*).
- The distinctions between public and private determine which thresholds each fixture and fitting must meet (see *Further Explanation, Public versus Private Lavatories*).
- For guidance on unusual fixtures, see *Further Explanation, Unique or Nonstandard Water Closets*.
- Sinks can be defined as public, private, kitchen, or process, depending on use and location. Kitchen sinks include all sinks in public or private buildings that are used with patterns and purposes similar to residential kitchen sinks. Hotel or motel kitchenette sinks, office kitchenette sinks, staff lounge sinks, pantry or nutrition station sinks, school classroom sinks (if used similarly to residential kitchen sinks), and commercial (food service) kitchen hand sinks that do not pass through a grease interceptor are considered kitchen sinks.

STEP 4. SELECT HIGH-EFFICIENCY APPLIANCES

Select appliances that meet the labeling or performance requirements outlined in the prerequisite requirements. ENERGY STAR may not be readily available in all areas (see *Further Explanation, International Tips*).

STEP 5. DESIGN PROCESS WATER SYSTEMS

Where applicable, select and design appliances and equipment that meet the standards for process water in the prerequisite requirements.

Compliance Path 1. Prescriptive Achievement (Prerequisite Only)

STEP 1. CONFIRM PRESCRIPTIVE COMPLIANCE

Ensure that all selected fixtures meet the following prescriptive flush or flow rate thresholds.

TABLE 6. Maximum installed flush or flow rates for prescriptive path

Fixture or fitting	Maximum installed flush or flow rate	Maximum installed flush or flow rate	Threshold below code baseline
Toilet (water closet)*	1.28 gpf**	4.8 lpf**	20%
Urinal*	0.50 gpf	1.9 lpf	50%
Public lavatory (restroom) faucet	0.40 gpm	1.5 lpm	20%
Private lavatory faucets*	1.50 gpm	5.7 lpm	32%
Kitchen faucet	1.75 gpm	6.7 lpm	20%
Showerhead*	2.00 gpm	7.6 lpm	20%

* The WaterSense label is available for this fixture type.
**The average flush rate for dual-flush toilets must be calculated as the average flush volume of one full flush and two reduced flushes, using a 1:2 (high flush:low flush) ratio.

gpf = gallons per flush   gpm = gallons per minute   lpf = liters per flush   lpm = liters per minute

STEP 2. COLLECT MANUFACTURERS' INFORMATION

Compile fixture cutsheets or manufacturers' information for all fixtures and appliances. The fixture data must highlight the flush or flow rate(s). A plumbing fixture schedule is acceptable, provided it contains the flush or flow rate information.

Compliance Path 2. Usage-Based Calculation

STEP 1. COMPILE CUTSHEETS OR PREPARE PLUMBING FIXTURE SCHEDULE

For each fixture, compile manufacturer's data that indicate its flush or flow rate.

- To simplify the collection of calculation data, consider creating a table or plumbing fixture schedule that indicates the flush or flow rate information for each fixture.
- For ease of documentation, collect fixture model, flush or flow rate, percentage of occupants with access to the fixture, and so on.

STEP 2. GATHER INFORMATION FOR CALCULATOR

The indoor water use calculator provided by USGBC requires the following information:

- **Project occupancy.** Count occupants consistently across all LEED credits (see *Further Explanation, Occupant Types*).
  - If the project has different sets of fixtures for different parts of the building, create a separate table for each subset. If fixtures are uniform across the project and restroom access is unrestricted, multiple calculations are not necessary; one calculation can cover all building fixtures and occupants.
  - A separate calculation to accommodate visitors is not necessary because the calculator automatically assigns them a lower daily usage rate. For example, it assumes that visitors do not use kitchen faucets.
- **Gender ratio.** The default gender mix is half male and half female. Assumptions that differ from the default must be supported by a narrative and supporting data (see *Further Explanation, Gender Ratio*).
- **Days of operation.** The default number of days of operation per year is 365.
  - If the project is in use for only a portion of the year or closes on specific days, the days of operation can be reduced.
  - The same number of days of operation must be applied to both the baseline and the design cases.
  - Ensure that the number of days of use is consistent with the building's operating schedule and prepare supporting documentation.
- **Fixture types used in the project.**

STEP 3. COMPLETE CALCULATIONS

Complete the calculations for the design case (installed) flush and flow fixtures. The following information is required:

- Fixture type
- Flush or flow rate
- Fixture manufacturer and model (which should match cutsheets)
- Percentage of occupants using each fixture model. The total for all fixtures of each type must total 100% of occupants for standard fixture types.

The calculator determines usage based on the following equation (see *Further Explanation, Calculations* and *Default Durations and Uses*).

EQUATION 1. Basic indoor water use reduction calculation

$$\text{Daily water use for each fixture type} = \text{Fixture flush or flow rate} \times \text{Duration of use} \times \text{Users} \times \text{Uses per person per day}$$

- The duration of use, number of users, and uses per person per day must be the same in both the baseline and the design cases.
- Dual-flush toilet flush rates must be calculated as the average using a 1:2 (high flush:low flush) ratio.
- Metering faucets measured in gallons (liters) per cycle (gpc, lpc) and cycle duration in manufacturer's documentation must be converted to a flow rate in gallons (liters) per minute (gpm, lpm). Use Equation 2 to perform the conversion.

EQUATION 2. Faucet flow rate conversion

$$\text{Flow rate (gpm)} = \left\{ \frac{\text{Gallons per cycle (gpc)} \times 60 \text{ sec}}{\text{Cycle duration (seconds)}} \right\}$$

$$\text{Flow rate (lpm)} = \left\{ \frac{\text{Liters per cycle (lpc)} \times 60 \text{ sec}}{\text{Cycle duration (seconds)}} \right\}$$

For example, convert a 0.2 gpc metering faucet with a 12-second cycle duration as follows:

$$\left\{ \frac{0.2 \text{ gpc} \times 60 \text{ sec}}{12 \text{ sec}} \right\} = 1 \text{ gpm}$$

Likewise, convert a 0.76 lpc metering faucet with a 12-second cycle duration as follows:

$$\left\{ \frac{0.76 \text{ lpc} \times 60 \text{ sec}}{12 \text{ sec}} \right\} = 3.8 \text{ lpm}$$

Similarly, convert a 0.083 gpc metering faucet with a 10-second cycle duration as follows:

$$\left\{ \frac{0.083 \text{ gpc} \times 60 \text{ sec}}{10 \text{ sec}} \right\} = 0.5 \text{ gpm}$$

Likewise, convert a 0.314 lpc metering faucet with a 10-second cycle duration as follows:

$$\left\{ \frac{0.314 \text{ lpc} \times 60 \text{ sec}}{10 \text{ sec}} \right\} = 1.9 \text{ lpm}$$

Provide manufacturer's documentation and a brief narrative to confirm the flow rate conversion.

FURTHER EXPLANATION

CALCULATIONS

See equations in *Step-by-Step Guidance*. Calculations are built into the indoor water use calculator; the following is provided for reference.

The usage-based calculation for the project is the difference between the calculated design case and a baseline case. The percentage is determined by dividing the design case reduction by the baseline reduction. In traditional plumbing design, calculations are based on fixture counts; the methodology under this prerequisite calculates water use according to fixture consumption rates and estimated use. Occupants' estimated use is determined by counting full-time-equivalent and transient occupants and applying appropriate fixture use rates to each. The calculator estimates the percentage reduction of potable water use, compared with the baseline, using the following equation (see *Further Explanation, Default Durations and Uses* for more about this equation's variables).

EQUATION 1. Basic indoor water use reduction calculation

$$\text{Daily water use for each fixture type} = \text{Fixture flush or flow rate} \times \text{Duration of use} \times \text{Users} \times \text{Uses per person per day}$$

The calculator produces the following:

- Annual baseline water consumption (gallons or liters per year)
- Annual design case water consumption (gallons or liters per year)
- Percentage savings between baseline and design cases

EQUATION 3. Indoor water-use reduction

$$\text{\% improvement from baseline} = \left\{ \frac{\text{Baseline volume} - \text{Performance volume}}{\text{Baseline volume}} \right\} \times 100$$

This prerequisite deals only with the water efficiency of fittings and fixtures, appliances, and processes that use potable water. Water derived from alternative sources, such as captured rainwater, is not considered under this prerequisite but can be used to document additional savings in WE Credit Indoor Water Use Reduction.

PUBLIC VERSUS PRIVATE LAVATORIES

Lavatory faucets must be classified as public or private. The Uniform Plumbing Code, International Plumbing Code, and the National Standard Plumbing Code each define private as those fixtures in residences, hotel or motel guest rooms, and private rooms in hospitals. All other applications are deemed to be public.

Fixtures used by residential occupants and fixtures used by residential-type occupants who use the building for sleeping accommodations fall into the private classification. Resident bathrooms in dormitories, patient bathrooms in hospital and nursing homes, and prisoner bathrooms are considered private use.

If it is unclear whether the classification should be public or private, default to public use flow rates in performing the calculations.

Lavatory faucets are intended for hand washing (Table 7). Private lavatory faucets are subject to the federal standard of 2.2 gallons per minute at 60 pounds per square inch (8.3 liters per minute at 415 kilopascals). Public lavatory faucets are subject to the federal standard of 0.5 gallons per minute at 60 pounds per square inch (1.9 liters per minute at 415 kilopascals).

TABLE 7. Typical public and private lavatory faucet applications	
Lavatory faucet	**Classification**
Restroom sink School classroom sinks (if used primarily for hand washing)	Public (baseline: 0.5 gpm, 1.9 lpm)
Residential bathroom sink Hotel or motel bathroom sink Dormitory bathroom sink Patient room sink Patient bathroom sink in hospital or nursing home	Private (baseline: 2.2 gpm, 8.3 lpm)

gpm = gallons per minute lpm = liters per minute

OCCUPANT TYPES

Identify the daily average number of building users by type (see *Getting Started, Occupancy*). The indoor water use calculator requires total occupant counts in the following categories:

- Employees and staff, expressed as full-time-equivalent (FTE) employees.
- Residents
  - Determine the number of residents—residential occupants in dormitories, hospital in-patients, prisoners, hotel guests, and any other people who use the building for sleeping accommodations. For apartments or multifamily residences where resident occupancy is unknown, estimate the default resident number as the total number of bedrooms + 1 for each residential unit. For example, assume two residents per one-bedroom unit, three residents per two-bedroom unit, and so forth, unless a different assumption is warranted.
  - Include inpatients at health care facilities with residents.
  - Include hotel guests with residents. Calculate the number of overnight hotel guests based on the number and size of units in the project. Assume 1.5 occupants per guest room and multiply the resulting total by 60% (average hotel occupancy, per American Hotel and Lodging Association).
- K–12 students. See *Further Explanation, Rating System Variations.*
- Retail customers
- Visitors (excluding retail customers)
  - Include outpatients and higher education students.
  - Report visitors as a daily average total.

Regular building occupants and occupancy counts are calculated based on the tenant occupancy of the lease space.

If occupancy is known, use the actual occupant counts for calculating occupancy. Use occupancy numbers that are a representative daily average over the course of the year. If the occupancy is not known, see *Getting Started, Occupancy*.

Tables 8 and 9 (see *Further Explanation, Default Duration and Uses*) provide default fixture use values for different occupancy types. These values should be used in the calculations unless special circumstances warrant modifications.

For office and retail establishments that are open Saturdays but not Sundays, assume 313 days of operation.

GENDER RATIO

The default gender ratio for full-time-equivalent occupants is 50:50. In special circumstances, where an alternative ratio may be justified, provide a narrative and supporting documentation. Modifications to the 50:50 ratio must be shown to apply for the life of the building.

Acceptable special circumstances include projects specifically designed for an alternative gender ratio—for example, a single-gender educational facility. Such projects must show that flush and flow fixtures have been distributed to account for the modified ratio. Project teams must provide documentation of the code-required plumbing fixture counts per gender so that the review team can verify that the flush-fixture ratio installed in the project supports the alternative gender ratio.

Gender ratio affects water usage only when urinals are installed. If the project does not include urinals, a 50:50 or 0:100 male:female ratio should yield the same usage results.

UNIQUE AND NONSTANDARD WATER CLOSETS

For unique or nonstandard toilets and fixtures, the following may apply:

- **Toilets with flush valve control and separate bowls.** The flush rates should be based on installed flush valve. Confirm that bowl and flush valve rates are compatible to ensure performance.
- **Prison fixtures.** Flow rates and flushing mechanisms must conform to the same design standards as commercial toilets.
- **Children's toilets.** Flow rates and flushing mechanisms must conform to the same design standards as commercial toilets. Confirm that the flush rates of the flush valves are compatible with the bowl sizes to ensure performance.
- **Squat (floor-mounted) toilets.** Flow rates and flushing mechanisms must conform to the same design standards as commercial toilets covered by EPA WaterSense.

EXCLUDED WATER-USING EQUIPMENT

Appliances and equipment that use water on materials intended for human consumption may be excluded. For example, bread and produce misters, soda machines, coffee-making machines, and fixtures used to fill sinks for washing produce are excluded.

Fixtures whose flow rates are regulated by health codes may be excluded from the calculation. For example, regulated medical equipment is considered a process water user and is excluded from fixture calculations.

Process water sinks are excluded from the fixture water-use reduction calculations.

The following list provides examples of process water sink fixtures that are excluded.

Specialized

- Janitor sinks
- Laboratory sinks regulated for medical or industrial purposes

Commercial kitchens (food service)

- Commercial kitchen (food service) sinks and prep sinks, including pot filling sinks, wash-down, and cleaning sinks

Health care

- Surgical scrub sinks
- Exam or procedure room sinks for clinical use
- Medication room sinks

General

- Janitor closet sinks
- Soiled utility room flushing rim sinks
- Soiled utility room hand-washing sinks
- Clean utility room hand-washing sinks

DEFAULT DURATIONS AND USES

Duration of use and uses per day are calculated using defaults (Tables 8 and 9).

TABLE 8. Nonresidential default fixture uses

Fixture type	Duration (sec)	Uses per day			
		Employees (FTE)	Visitors	Retail customers	Students
Water closet (female)	n/a	3	0.5	0.2	3
Water closet (male)	n/a	1	0.1	0.1	1
Urinal (female)	n/a	0	0	0	0
Urinal (male)	n/a	2	0.4	0.1	2
Public lavatory faucet	30	3	0.5	0.2	3
Shower	300	0.1	0	0	0
Kitchen sink	15	1	0	0	0

TABLE 9. Residential default fixture uses

Equipment	Duration (sec)	Uses per day
Water closet (female)	n/a	5
Water closet (male)	n/a	5
Private lavatory Faucet	60	5
Shower	480	1
Kitchen sink	60	4

For residents, hospital inpatients, hotel guests, prisoners, or any other residential occupants who use the building for sleeping accommodations, use the default residential fixture usage assumptions.

PROJECT TYPE VARIATIONS

Mixed-Use Projects
If a mixed-use project uses the same fixtures throughout the building, complete one calculation for building water use. If the spaces use different fixtures or have dramatically different patterns of occupancy, complete the indoor water use calculator separately for each space type.

INTERNATIONAL TIPS

For fixtures that require the WaterSense label in countries where the label is unavailable, look up acceptable WaterSense substitutes at usgbc.org. Projects in unlisted countries must comply with the 20%-below-baseline requirement but have no additional performance requirements.

For appliances that require the ENERGY STAR label, a project outside the U.S. may install products that are not labeled under the ENERGY STAR program if they meet the ENERGY STAR product specifications, available on the ENERGY STAR website. All products must meet the standards of the current version of ENERGY STAR as of the date of their purchase.

For appliances that require the Consortium for Energy Efficiency (CEE) label, a project outside the U.S. may purchase products that have not been qualified or labeled by CEE if they meet the CEE product criteria for efficiency.

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	Fixtures		Appliances	Process water
	Compliance Path 1	Compliance Path 2		
Product cutsheets, manufacturers' information	X	X	X	X
Indoor water use calculator		X		

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

This prerequisite now includes requirements for water-using appliances and processes, as well as cooling towers and evaporative condensers.

The WaterSense label requirements were recommended in LEED 2009. They are now mandatory in the U.S.

The prescriptive compliance path (based on demonstrating that all fixtures are 20% below baseline) is new.

REFERENCED STANDARDS

Energy Policy Act (EPAct) of 1992 and as amended: eere.energy.gov/femp/regulations/epact1992.html

EPAct 2005: eere.energy.gov/femp/regulations/epact2005.html

International Association of Plumbing and Mechanical Officials Publication IAPMO / ANSI UPC 1-2006, Uniform Plumbing Code 2006, Section 402.0, Water-Conserving Fixtures and Fittings: iapmo.org

International Code Council, International Plumbing Code 2006, Section 604, Design of Building Water Distribution System: iccsafe.org

ENERGY STAR: energystar.gov/

Consortium for Energy Efficiency: cee1.org/

WaterSense: epa.gov/watersense/

IgCC/ASHRAE 189.1 – cooling tower and evaporative condenser requirements:
ashrae.org/resources--publications/bookstore/standard-189-1

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

baseline water consumption a calculated projection of building water use assuming code-compliant fixtures and fittings with no additional savings compared with the design case or actual water meter data

nonpotable water water that does not meet drinking water standards

potable water water that meets or exceeds U.S. Environmental Protection Agency drinking water quality standards (or a local equivalent outside the U.S.) and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells or municipal water systems

process water water that is used for industrial processes and building systems, such as cooling towers, boilers, and chillers. It can also refer to water used in operational processes, such as dishwashing, clothes washing, and ice making.

WATER EFFICIENCY CREDIT

Indoor Water Use Reduction

This credit applies to:

Commercial Interiors (2-12 points)
Retail (2-12 points)
Hospitality (2-12 points)

INTENT

To reduce indoor water consumption.

REQUIREMENTS

Further reduce fixture and fitting water use from the calculated baseline in WE Prerequisite Indoor Water Use Reduction. Additional potable water savings can be earned above the prerequisite level using alternative water sources. Include fixtures and fittings necessary to meet the needs of the occupants. Some of these fittings and fixtures may be outside the tenant space. Points are awarded according to Table 1.

TABLE 1. Points for reducing water use

Percentage reduction	Points (Commercial Interiors)	Points (Retail)	Points (Hospitality)
25%	2	2	2
30%	4	4	4
35%	6	6	6
40%	8	8	8
45%	10	10	10
50%	12	—	11

RETAIL AND HOSPITALITY ONLY

Meet the percentage reduction requirements above.

AND

Appliance and Process Water

Install equipment within the project scope that meets the minimum requirements in Table 2, 3, 4, or 5. One point is awarded for meeting all applicable requirements in any one table. All applicable equipment listed in each table must meet the standard.

Retail projects can earn a second point for meeting the requirements of two tables.

To use Table 2, the project must process at least 120,000 lbs (57 606 kg) of laundry per year.

TABLE 2. Compliant commercial washing machines

Washing machine	Requirement (IP units)	Requirement (SI units)
On-premise, minimum capacity 2,400 lbs (1 088 kg) per 8-hour shift	Maximum 1.8 gals per pound *	Maximum 7 liters per 0.45 kilograms *

* Based on equal quantities of heavy, medium, and light soil laundry.

To use Table 3, the project must serve at least 100 meals per day of operation. All process and appliance equipment listed in the category of kitchen equipment and present on the project must comply with the standards.

TABLE 3. Standards for commercial kitchen equipment

Kitchen equipment		Requirement (IP units)	Requirement (SI units)
Dishwasher	Undercounter	ENERGY STAR	ENERGY STAR or performance equivalent
	Stationary, single tank, door	ENERGY STAR	ENERGY STAR or performance equivalent
	Single tank, conveyor	ENERGY STAR	ENERGY STAR or performance equivalent
	Multiple tank, conveyor	ENERGY STAR	ENERGY STAR or performance equivalent
	Flight machine	ENERGY STAR	ENERGY STAR or performance equivalent
Food steamer	Batch (no drain connection)	≤ 2 gal/hour/pan including condensate cooling water	≤ 7.5 liters/hour/pan including condensate cooling water
	Cook-to-order (with drain connection)	≤ 5 gal/hour/pan including condensate cooling water	≤ 19 liters/hour/pan including condensate cooling water
Combination oven	Countertop or stand	≤ 1.5 gal/hour/panincluding condensate cooling water	≤ 5.7 liters/hour/pan including condensate cooling water
	Roll-in	≤ 1.5 gal/hour/pan including condensate cooling water	≤ 5.7 liters/hour/pan including condensate cooling water
Food waste disposer	Disposer	3-8 gpm, full load condition, 10 minute automatic shutoff; or 1 gpm, no-load condition	11–30 lpm, full load condition, 10-min automatic shutoff; or 3.8 lpm, no-load condition
	Scrap collector	Maximum 2 gpm makeup water	Maximum 7.6 lpm makeup water
	Pulper	Maximum 2 gpm makeup water	Maximum 7.6 lpm makeup water
	Strainer basket	No additional water usage	No additional water usage

gpm = gallons per minute gph = gallons per hour lpm = liters per minute lph = liters per hour

To use Table 4, the project must be a medical or laboratory facility.

TABLE 4. Compliant laboratory and medical equipment

Lab equipment	Requirement (IP units)	Points (Schools, Retail, Hospitality, Healthcare)
Reverse-osmosis water purifier	75% recovery	75% recovery
Steam sterilizer	For 60-inch sterilizer, 6.3 gal/U.S. tray For 48-inch sterilizer, 7.5 gal/U.S. tray	For 1520-mm sterilizer, 28.5 liters/DIN tray For 1220-mm sterilizer, 28.35 liters/DIN tray
Sterile process washer	0.35 gal/U.S. tray	1.3 liters/DIN tray
X-ray processor, 150 mm or more in any dimension	Film processor water recycling unit	
Digital imager, all sizes	No water use	

To use Table 5, the project must be connected to a municipal or district steam system that does not allow the return of steam condensate.

TABLE 5. Compliant municipal steam systems

Steam system	Standard
Steam condensate disposal	Cool municipally supplied steam condensate (no return) to drainage system with heat recovery system or reclaimed water
OR	
Reclaim and use steam condensate	100% recovery and reuse

BEHIND THE INTENT

See *Behind the Intent* in WE Prerequisite Indoor Water Use Reduction.

STEP-BY-STEP GUIDANCE

STEP 1. COMPLETE CALCULATIONS IN PREREQUISITE

Follow the instructions in WE Prerequisite Indoor Water Use Reduction to determine water savings resulting from efficiency of fixtures and fittings.

STEP 2. CONSIDER ALTERNATIVE WATER SOURCES

Alternatives to potable water include municipally supplied reclaimed water ("purple pipe" water), graywater, rainwater, stormwater, condensate, foundation dewatering water, used process water, and reverse osmosis reject water.

- Untreated water sources ineligible for this credit include raw water from naturally occurring surface bodies of water, streams, rivers, groundwater, well water, seawater, and water discharged from an open-loop geothermal system.
- When choosing alternative sources of water, target the uses that require the least treatment first. In most cases, water can be reused outside the building (for irrigation) or inside (for toilet flushing) with minimal treatment, but other uses will require more energy-intensive treatment.

STEP 3. CALCULATE ADDITIONAL SAVINGS FROM USING NONPOTABLE WATER

If the project is using an alternative, nonpotable water source, calculate the total annual projected water savings, using Equation 1.

EQUATION 1. Indoor water-use reduction with nonpotable supply

$$\text{Total \% improvement from baseline} = \left\{ \frac{\text{Annual baseline water consumption} - \left(\text{Annual design case water consumption} - \text{Annual nonpotable water supply}\right)}{\text{Annual baseline water consumption}} \right\} \times 100$$

- Prepare documentation, including a narrative describing the nonpotable water source, plumbing system design drawings that highlight the nonpotable water system, and supply and demand calculations that confirm the available quantity of nonpotable water.
- Address any change to the calculated usage demand of seasonal availability or storage capacity. If the nonpotable water is used for multiple applications—for example, flush fixtures and landscape irrigation—a sufficient quantity must be available to meet the demands of all uses. The amount of nonpotable water meant for indoor and outdoor uses cannot exceed the total annual nonpotable water supply.

STEP 4. SELECT HIGH-EFFICIENCY SPECIALIZED APPLIANCE AND PROCESS WATER SYSTEMS, WHERE APPLICABLE

Retail and Healthcare projects may earn additional points for selecting appliance or process water systems that meet the standards in the credit requirements.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance* and in the indoor water use calculator provided by USGBC.

RATING SYSTEM VARIATIONS

Retail

Include fixtures necessary to meet occupants' needs, including customers. If restrooms are not provided for customers within the retail project, the nearest public or common area restrooms within the mall or base building must be included in the calculations for this credit (not required in prerequisite calculations).

PROJECT TYPE VARIATIONS

Mixed-Use Projects

If a mixed-use project uses the same fixtures throughout the building, complete one calculation for building water use. If the spaces use different fixtures or have dramatically different patterns of occupancy, complete the indoor water use calculator separately for each space type.

INTERNATIONAL TIPS

For fixtures that require the WaterSense label in countries where the label is unavailable, look up acceptable WaterSense substitutes at usgbc.org. Projects in unlisted countries must comply with the 20%-below-baseline requirement but have no additional performance requirements.

For appliances that require the ENERGY STAR label, a project outside the U.S. may install products that are not labeled under the ENERGY STAR program if they meet the ENERGY STAR product specifications, available on the ENERGY STAR website. All products must meet the standards of the current version of ENERGY STAR as of the date of their purchase.

For appliances that require the Consortium for Energy Efficiency (CEE) label, a project outside the U.S. may purchase products that have not been qualified or labeled by CEE if they meet the CEE product criteria for efficiency.

CAMPUS

Group Approach

Submit separate documentation for each project space.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Fixtures	Appliances	Process water
		(Retail, Hospitality projects only)	
Alternative water source calculations (if applicable)	X		
Plumbing system design drawings (if applicable)	X		
Alternative water narrative	X		
Cutsheets, manufacturers' information	X	X	X
Indoor water use calculator	X		

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

- Appliance and process water savings can earn credit under the Retail and Hospitality rating systems.
- The WaterSense label requirements, merely recommended in LEED 2009, are now mandatory in the U.S.
- To earn points, project teams must include fixtures necessary to meet occupants' needs. When no facilities are available within project boundaries, the closest available restrooms must be included in credit calculations. These additional restrooms can be excluded from prerequisite compliance requirements.

REFERENCED STANDARDS

The Energy Policy Act (EPAct) of 1992 and as amended: eere.energy.gov/femp/regulations/epact1992.html

EPAct 2005: eere.energy.gov/femp/regulations/epact2005.html

International Association of Plumbing and Mechanical Officials Publication IAPMO / ANSI UPC 1-2006, Uniform Plumbing Code 2006, Section 402.0, Water-Conserving Fixtures and Fittings: iapmo.org

International Code Council, International Plumbing Code 2006, Section 604, Design of Building Water Distribution System: iccsafe.org

ENERGY STAR: energystar.gov/

WaterSense: epa.gov/watersense/

IgCC/ASHRAE 189.1 – cooling tower and evaporative condenser requirements:
ashrae.org/resources--publications/bookstore/standard-189-1

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

conductivity the measurement of the level of dissolved solids in water, using the ability of an electric current to pass through water. Because it is affected by temperature, conductivity is measured at 25°C for standardization.

drift water droplets carried from a cooling tower or evaporative condenser by a stream of air passing through the system. Drift eliminators capture these droplets and return them to the reservoir at the bottom of the cooling tower or evaporative condenser for recirculation.

makeup water water that is fed into a cooling tower system or evaporative condenser to replace water lost through evaporation, drift, bleed-off, or other causes

nonpotable water water that does not meet drinking water standards

potable water water that meets or exceeds U.S. Environmental Protection Agency drinking water quality standards (or a local equivalent outside the U.S.) and is approved for human consumption by the state or local authorities having jurisdiction; it may be supplied from wells or municipal water systems

process water water that is used for industrial processes and building systems, such as cooling towers, boilers, and chillers. It can also refer to water used in operational processes, such as dishwashing, clothes washing, and ice making.

Energy and Atmosphere (EA)

OVERVIEW

The Energy and Atmosphere (EA) category approaches energy from a holistic perspective, addressing energy demand reduction, energy-efficient design strategies, and renewable energy sources.

The current worldwide mix of energy resources is weighted heavily toward oil, coal, and natural gas.[1] In addition to emitting greenhouse gases, these resources are nonrenewable: their quantities are limited or they cannot be replaced as fast as they are consumed.[2] Though estimates regarding the remaining quantity of these resources vary, it is clear that the current reliance on nonrenewable energy sources is not sustainable and involves increasingly destructive extraction processes, uncertain supplies, escalating market prices, and national security vulnerability. Accounting for approximately 40% of the total energy used today,[3] buildings are significant contributors to these problems.

Energy efficiency in a green building starts with a focus on design that reduces overall energy needs, such as building orientation and glazing selection, and the choice of climate-appropriate building materials. Strategies such as passive heating and cooling, natural ventilation, and high-efficiency HVAC systems partnered with smart controls further reduce a building's energy use. Interior Design and Construction projects can encourage these methods by choosing to locate in buildings that have been designed with efficiency in mind and then continuing the process through actions such as installing efficient lighting and appliances. The generation of renewables on the project site or purchase of green power allows portions of the remaining energy consumption to be met with non–fossil fuel energy, helping to balance the demand on traditional sources.

The commissioning process is critical to ensuring high-performing buildings. Early involvement of a commissioning authority helps prevent long-term maintenance issues and wasted energy by verifying that the design meets the owner's project requirements and functions as intended. In an operationally effective and efficient building, the staff understands what systems are installed and how they function.

The American Physical Society has found that if current and emerging cost-effective energy efficiency measures are employed in new buildings and in existing buildings as their heating, cooling, lighting, and other equipment is

1. *iea.org/publications/freepublications/publication/kwes.pdf*
2. *cnx.org/content/m16730/latest/*
3. *unep.org/sbci/pdfs/SBCI-BCCSummary.pdf*

replaced, the growth in energy demand from the building sector could fall from a projected 30% increase to zero between now and 2030.[4] The EA section supports the goal of reduced energy demand through credits related to reducing usage, designing for efficiency, and supplementing the energy supply with renewables.

4. *Energy Future: Think Efficiency* (American Physical Society, September 2008), aps.org/energyefficiencyreport/report/energy-bldgs.pdf (accessed September 13, 2012).

ENERGY AND ATMOSPHERE PREREQUISITE

Fundamental Commissioning and Verification

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.

REQUIREMENTS

COMMISSIONING PROCESS SCOPE

Complete the following commissioning (Cx) process activities for mechanical, electrical, plumbing, and renewable energy systems and assemblies, in accordance with ASHRAE Guideline 0-2005 and ASHRAE Guideline 1.1–2007 for HVAC&R Systems, as they relate to energy, water, indoor environmental quality, and durability.

Requirements for exterior enclosures are limited to inclusion in the owner's project requirements (OPR) and basis of design (BOD), as well as the review of the OPR, BOD and project design. NIBS Guideline 3-2012 for Exterior Enclosures provides additional guidance.

- Develop the OPR.
- Develop a BOD.

The commissioning authority (CxA) must do the following:

- Review the OPR, BOD, and project design.
- Develop and implement a Cx plan.
- Confirm incorporation of Cx requirements into the construction documents.

- Develop construction checklists.
- Develop a system test procedure.
- Verify system test execution.
- Maintain an issues and benefits log throughout the Cx process.
- Prepare a final Cx process report.
- Document all findings and recommendations and report directly to the owner throughout the process.

The review of the exterior enclosure design may be performed by a qualified member of the design or construction team (or an employee of that firm) who is not directly responsible for design of the building envelope.

COMMISSIONING AUTHORITY

By the end of the design development phase, engage a commissioning authority with the following qualifications.

- The CxA must have documented commissioning process experience on at least two building projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy;
- The CxA may be a qualified employee of the owner, an independent consultant, or an employee of the design or construction firm who is not part of the project's design or construction team, or a disinterested subcontractor of the design or construction team.
    - For projects smaller than 20,000 square feet (1 860 square meters), the CxA may be a qualified member of the design or construction team. In all cases, the CxA must report his or her findings directly to the owner.

Project teams that intend to pursue EA Credit Enhanced Commissioning should note a difference in the CxA qualifications: for the credit, the CxA may not be an employee of the design or construction firm nor a subcontractor to the construction firm.

CURRENT FACILITIES REQUIREMENTS AND OPERATIONS AND MAINTENANCE PLAN

Prepare and maintain a current facilities requirements and operations and maintenance plan that contains the information necessary to operate the building efficiently. The plan must include the following:

- a sequence of operations for the building;
- the building occupancy schedule;
- equipment run-time schedules;
- setpoints for all HVAC equipment;
- set lighting levels throughout the building;
- minimum outside air requirements;
- any changes in schedules or setpoints for different seasons, days of the week, and times of day;
- a systems narrative describing the mechanical and electrical systems and equipment;
- a preventive maintenance plan for building equipment described in the systems narrative; and
- a commissioning program that includes periodic commissioning requirements, ongoing commissioning tasks, and continuous tasks for critical facilities.

Interior Design and Construction projects are responsible for completing the above tasks for all systems and equipment included in their scope, including items furnished by the base building, but modified or relocated as part of tenant fit-out. Information such as sequences of operations, schedules, equipment setpoints, and outside air requirements for tenant equipment and spaces must be coordinated with base building requirements.

BEHIND THE INTENT

The commissioning (Cx) process is an integrated set of activities intended to ensure that the project meets both the design intent and the owner's operational needs. An owner's goals and objectives should drive the project team. The value of Cx lies in its power to verify that those goals and objectives have been met and that systems and equipment within the space perform as intended.

A properly executed Cx process clearly expresses the owner's project requirements, often leading to fewer change orders and system deficiencies, fewer corrective actions implemented while contractors are on-site, improved planning and coordination, reduced energy consumption, and overall lower operating costs. Another benefit of Cx is occupants' health and comfort because of better temperature and ventilation control.

The qualified commissioning authority (CxA) chosen to represent the owner's needs should be brought in early in the design process. As a third party, the CxA can verify early on that the architects' and engineers' designs meet the owner's project requirements. During the construction phase, the commissioning team, led by the CxA, will verify that contractors install and program the systems correctly according to the design.

STEP-BY-STEP GUIDANCE

STEP 1. DEVELOP OWNER'S PROJECT REQUIREMENTS

The owner, with the help of the design team and other stakeholders, should develop the initial owner's project requirements (OPR) in the predesign stage (see the Integrative Process Credit and *Further Explanation, Owner's Project Requirements*).

- This document establishes the owner's goals and the project's intended function and operation.
- The owner will use this document as the foundation for all design, construction, acceptance, and operational decisions.
- The OPR must cover all systems to be commissioned. If the building envelope is part of the project's scope of work, it must be included in the OPR.

STEP 2. DEVELOP BASIS OF DESIGN

Create a basis of design (BOD) to provide clear technical guidance for the project. Start this in the schematic design phase and update it throughout the design and construction process (see *Further Explanation, Basis of Design*).

- The BOD is the project team's interpretation of the OPR.
- Any revisions to the OPR should also be reflected in the BOD so that both documents align.
- If the building envelope is part of the project's scope of work, it must be included in the BOD.

STEP 3. ENGAGE COMMISSIONING AUTHORITY

Identify a CxA with the proper experience and credentials to develop and implement effective commissioning. Though the CxA must be engaged by the design development phase, earlier engagement allows the CxA to be involved in the development of the OPR and BOD and see the design intent through to completion.

- The CxA should have direct experience with at least two similar projects and must have been involved from the early design phase through at least 10 months after occupancy begins (see *Further Explanation, Commissioning Authority Qualifications*).
- CxA requirements differ depending on the scope and size of the project. The project team should engage a CxA that has appropriate qualifications for the goals of the program.
- The CxA will facilitate and ultimately oversee the Cx process for all systems to be commissioned; additional expertise may be brought in (see *Further Explanation, Systems to Be Commissioned*).
- Work with the CxA to determine the systems that need to be commissioned for compliance with the OPR and the credit requirements.

STEP 4. DEVELOP PRELIMINARY COMMISSIONING PLAN

Establish a preliminary plan for the Cx to outline the scope of commissioning and systems to be tested (see *Further Explanation, Cx Plan*).

- Project roles and responsibilities, the commissioning team's project directory, and schedule of commissioning activities should all be included in the Cx plan.
- The Cx plan is a living document that is updated throughout the life of the project and will become the basis for the final commissioning report.

STEP 5. REVIEW OPR, BOD, AND DESIGN DOCUMENTS

The CxA completes a review of the OPR, BOD, and design documents to verify that the program's goals are properly included in the design documents.

- The intent of the review is to have a third party, acting as an advocate for the owner, ensure that the BOD reflects the OPR and that the design documents reflect the BOD and the OPR.
- The review should be conducted on middesign documents so that the project team has time to make any necessary changes.
- Earlier and additional reviews at other project milestones are advisable and often beneficial to project performance but are not required.
- Record the review comments in an issues log that details the drawing set or document version that was used for performing the review (see *Further Explanation, Issues Log for the Design Review*).

STEP 6. DEVELOP CX REQUIREMENTS AND INCORPORATE INTO CONSTRUCTION DOCUMENTS

Before construction begins, develop commissioning requirements based on the systems included in the design and incorporate them into the construction documents.

- Cx specifications inform the contractors of their roles and responsibilities throughout the commissioning process.
- ASHRAE Guideline 0–2005, Table L-1, identifies titles, contents, and scopes for each commissioning-related specification section and may be used as guidance (see *Further Explanation, Example Issues Log*).

STEP 7. UPDATE OPR, BOD, AND CX PLAN

If necessary, the owner should update the OPR, the design team should update the BOD, and the CxA should update the Cx plan. Items such as design changes, value engineering modifications, new or reassigned team members, or updated operating conditions would warrant an update.

STEP 8. CONDUCT CX KICKOFF MEETING

Assemble the team of stakeholders and hold a kickoff meeting to introduce the team members, review roles and responsibilities, and review all remaining Cx activities. The CxA should provide information on the process and requirements for the following:

- Installation verification (construction) checklists
- Functional performance tests
- Issues log
- Team meetings
- Contractors' and subcontractors' participation on the Cx team
- Schedule

The CxA should update and redistribute the Cx plan as necessary. The CxA is also responsible for setting up periodic Cx meetings, developing a communication protocol, and managing the schedule for all Cx-related activities.

STEP 9. DEVELOP CONSTRUCTION CHECKLISTS

The CxA, the design team, or the contactor prepares construction checklists (also known as installation verification checklists and prefunctional checklists) for the project.

- Checklists provide confirmation to the CxA that the systems have been installed, started up, programmed, tested, and balanced, and that the team is ready to proceed with functional testing.
- In general, contractors are responsible for filling out the checklists and returning them to the CxA.
- Construction checklists must be completed for all equipment, assemblies, and systems included in Cx scope. Sampling strategies are not permitted.

STEP 10. CONDUCT PREFUNCTIONAL INSPECTIONS

Communicate with the contractors to determine the exact schedule for prefunctional inspections to verify proper installation and handling of systems to be commissioned. Several activities that can be considered prefunctional inspections include site visits, field observations, and review of start-up forms, construction checklists, and complete test-and-balance reports.

- The CxA may conduct site visits as necessary to inspect the installation of individual systems and components. Site visits are an important opportunity to observe equipment installation and identify issues before a system becomes difficult to access or change.
- It is good practice to document the site visit findings in a field observation report that is distributed to the relevant parties. The CxA should report any noncompliance to the owner and project team for them to help resolve.
- The number of site inspections depends on the project's size and scope.

STEP 11. DEVELOP FUNCTIONAL TEST SCRIPTS

The CxA, with the design team or contractor, must write and develop the functional test scripts for the project.

- Functional testing scripts typically follow the sequence of operations developed by the engineer. If a controls contractor created the sequence of operations, the design engineer must approve the controls submittal to ensure it adheres to the BOD.
- Provide contractors and design engineers with the functional tests before testing to allow them the opportunity to review the scripts, verify proper operating modes, and comment on any modifications to match actual operation (see *Further Explanation, Functional Performance Tests*).

STEP 12. EXECUTE FUNCTIONAL TESTING

Perform functional performance testing once all system components are installed, energized, programmed, balanced, and otherwise ready for operation under part- and full-load conditions.

- Some systems may require deferred or seasonal testing or verification for proper operation in each mode.
- The systems or modes that require seasonal or deferred testing must be noted in the Cx report. A report addendum discusses the deferred testing results can then be issued.
- The functional performance testing follows the functional performance test scripts developed by the CxA in Step 11.
- The CxA generally oversees the testing; the contractors execute the testing.
- Sampling strategies may be implemented for functional testing. An acceptable sampling rate is "10 or 10%," meaning that for multiple units of the same type with the same components and sequences (e.g., fan coil units or variable air volume systems), the commissioning team may test only 10 units or 10% of the units, whichever is greater.
- When possible, include the building engineer or owner in the testing execution to provide training for future operation of the systems.

STEP 13. DOCUMENT FINDINGS

Use the issues log to track any deficiencies discovered and any benefits identified through functional testing.

- The CxA is responsible for documenting the test results and maintaining the issues log.
- Documentation should include the status and responsible party for the correction or improvement actions.

STEP 14. PREPARE CX REPORT

The CxA should write the Cx report after installation inspections and functional performance test verification. The report covers all components of the commissioning process, including the following:

- Executive summary of commissioning process and results, system deficiencies identified and resolution, and outstanding issues
- Project directory
- Cx process overview
- Owner's project requirements
- Basis of design
- Submittals
- Design review log

- Cx specifications
- List of systems commissioned
- Installation verification checklists
- Functional performance tests
- Issues log, detailing open and closed issues

STEP 15. COMPILE CURRENT FACILITY REQUIREMENTS AND OPERATIONS AND MAINTENANCE PLAN

Prepare and maintain a current facility requirements (CFR) and operations and maintenance (O&M) plan that contains the information necessary to operate the space efficiently. This information is covered in the OPR, BOD, and functional test scripts, but more information may be taken from specific submittals or equipment operations and maintenance manuals. The plan must include the following:

- Sequences of operation for the project space
- Project tenant space occupancy schedule
- Equipment run-time schedules
- Setpoints for all HVAC equipment
- Lighting levels throughout the project space
- Minimum outside air requirements
- Changes in schedules or setpoints for different seasons, days of the week, and times of day
- Systems narrative describing the mechanical and electrical systems and equipment
- Preventive maintenance plan for equipment described in the systems narrative
- Cx program that includes periodic Cx requirements and ongoing Cx tasks

Where possible, pertinent building-level information should be included as well.

FURTHER EXPLANATION

SYSTEMS TO BE COMMISSIONED

The rating system refers to commissioning of HVAC&R systems "as they relate to energy, water, indoor environmental quality, and durability." That is, energy- and water-consuming equipment must operate efficiently and according to the design intent and owner's operational needs.

Efficient operations can be defined as the controlling of equipment such that it uses the minimum amount of energy or water to maintain setpoints and comfort levels. Control is generally accomplished via a building automation system and per the sequences of operation, with setpoints that are correct for the design and equipment schedules.

For indoor environmental quality, the equipment must meet the OPR, BOD, and environmental codes and standards. For durability, the equipment must not cause unnecessary wear and tear on the system.

Systems that must be commissioned for this prerequisite include the following:

- Mechanical, including HVAC&R equipment and controls
- Plumbing, including domestic hot water systems, pumps, and controls
- Electrical, including service, distribution, lighting, and controls, including daylighting controls
- Renewable energy systems dedicated to the project space

The envelope must be included in OPR and BOD if it is part of the scope of work, but actual commissioning is not required.

Systems that are not required to be commissioned under this prerequisite but may be added to the Cx scope at the request of the owner include the following:

- Life safety systems
- Communications and data systems
- Process equipment

COMMISSIONING AUTHORITY (CxA) QUALIFICATIONS

The CxA must have documented commissioning process experience on at least two projects with a similar scope of work. The experience must extend from early design phase through at least 10 months of occupancy. The similar scope of work may be defined by the size of project, the types of equipment being commissioned, or the function of the space. However, the appropriate or acceptable level of "similar experience" should be defined by the owner. Examples include the following:

- A 10,000-square-foot (930-square-meter) office space, with baseboard heating and VAV cooling provided by the base building
- A 50,000-square-foot (4 645-square-meter) retail space, with ventilation provided by dedicated rooftop units and chilled water provided by a base building central plant

If the project is pursuing fundamental commissioning only, the CxA may be a qualified employee of the owner, an independent consultant, or an employee of the design or construction firm who is not part of the project's design or construction team, or a disinterested subcontractor of the design or construction team. Special circumstances include the following:

- For projects smaller than 20,000 square feet (1 860 square meters), the CxA may be a qualified member of the design or construction team.
- If specialized knowledge of specific systems is required (e.g., manufacturing, data centers), the CxA may be a qualified employee of the design or construction team. If the project is a data center, a qualified employee may be the CxA only if the peak cooling load is less than 2,000,000 Btu/h (600 kW) or the total computer room peak cooling load is less than 600,000 Btu/h (175 kW).
- If an owner requires a single contract through one entity (such as a government agency contracting through a general contractor), the CxA may be a qualified employee of the design or construction team for this prerequisite. If the project team is also attempting the enhanced commissioning credit, however, the CxA must be independent of the design or construction firm.

In all cases, the CxA must report findings directly to the owner.

TABLE 1. Who can be the CxA?

Can ...	who is ...	be CxA for ...	
		fundamental Cx?	enhanced Cx?
an employee of the architecture or engineering firm	a member of the design team (e.g., a project architect, engineer, or energy modeler who is also the HVAC designer)	No, unless project is under 20,000 ft² (1 860 m²)	NO
	not a member of the design team (e.g., a LEED administrator or energy modeler who is not participating in the design)	YES	NO
a subconsultant to the architecture or engineering firm	a member of the design team (e.g., a project engineer subcontracted to the architect)	No, unless project is under 20,000 ft² (1 860 m²)	NO
	not a member of the design team (e.g., a LEED administrator, Cx specialist, energy modeler)	YES	YES
an employee or subcontractor of the general contractor or construction manager	a member of the construction team	No, unless project is under 20,000 ft² (1 860 m²)	NO
	not a member of the construction team	YES	NO
an employee of the owner or an independent consultant contracted to the owner		YES	YES

OWNER'S PROJECT REQUIREMENTS

The owner, CxA, and project team must complete the OPR before any contractor submittals for Cx equipment or systems are approved. Ideally, the initial document is completed at the early stages of pre-design. Updates during the design and construction process are the primary responsibility of the owner.

The OPR details the functional requirements as well as the expectations for use and operation of the project space. The intention is to document the owner's requirements and objectives for the project to verify those goals are carried through the life of the project. There is no required format; an OPR outline might include the following:

- **Key project requirements.** Items that the Cx process will focus on and that the owner has deemed critical to the project.
- **Occupant requirements.** Functions, number of occupants, and schedules.
- **Budget considerations and limitations.** The expected cost restrictions and considerations for the project's design, construction, and commissioning process.
- **Target goals.** The owner's overall goals, such as energy efficiency and sustainability.
- **Performance criteria.** The standards by which the project will be evaluated by the Cx team. Each criterion should be measurable and verifiable. Potential topics include general, economic, user requirements, construction process, operations, systems, and assemblies.
- **Operations and maintenance requirements.** Established criteria for ongoing operations and maintenance, as well as training requirements for personnel.

BASIS OF DESIGN

The design team must document the basis of design before any contractor submittals for commissioned equipment or systems are approved. Updates during the design and construction process are the primary responsibility of the design team.

The BOD explains how the construction and other details will execute the OPR. The intention is to document the thought processes and assumptions behind design decisions made to meet the OPR. There is no required format; a BOD outline might include the following:

- **Systems and assemblies.** A general overview of the systems and assemblies and how they are intended to meet the OPR.
- **Performance criteria and assumptions.** The standards that the system was designed to meet and the expectations regarding system operation and maintenance, both linked to the OPR.
- **Descriptions.** A description of the tenant space, base building, envelope, HVAC, electrical, water, and other systems and a statement of operation that describes how the facility is expected to operate under various situations and modes.
- **Governing codes and standards.** Specific codes, standards, and guidelines considered during the design of the facility and the designer's response to these requirements.
- **Owner directives.** Assumptions regarding usage of the facility.
- **Design development guidelines.** Concepts, calculations, decisions, and product selections; the specific design methods, techniques, and software used in design; information regarding ambient conditions (climatic, geologic, structural, existing construction) used during design; and specific manufacturer makes and models used as the basis of design for drawings and specifications.
- **Revision history.** A summary of changes made throughout the project phases.

Cx PLAN

The commissioning team develops the Cx plan with input from the project team. Updates during the design and construction process are the primary responsibility of the CxA.

The Cx plan begins with a program overview:

- Goals and objectives
- General project information
- Systems to be commissioned

It describes the Cx team:

- Team members, roles, and responsibilities
- Communication protocol, coordination, meetings, and management

Finally, it summarizes the Cx process activities:

- Reviewing the OPR
- Reviewing the BOD
- Developing systems functional test procedures
- Verifying system performance
- Reporting deficiencies and the resolution process
- Accepting the installed systems

ISSUES LOG FOR THE DESIGN REVIEW

It is useful to include the following information in the design review issues log:

- Date of the review
- Drawing number or page where the issue was found
- Comments
- Party responsible for addressing the issue
- Response
- Date the issue was closed

FUNCTIONAL PERFORMANCE TESTS

The functional performance test reports typically have the following sections:

- **Date and time of test**
- **Individuals present during testing**
- **Visual inspection observations.** Before testing, the CxA should perform a visual inspection and document any issues or relevant observations.
- **Sensor checks.** The sensors are checked individually to make sure they are reading properly and are in the correct locations per the design documents.
- **Device checks.** Each device is checked to verify that it can open, close, modulate, start, stop, energize in stages, etc.
- **Operating mode tests.** A system is run through each type of operating mode including but not limited to start up, shutdown, capacity modulation, emergency and failure modes, alarm scenarios, occupied mode and unoccupied mode, and interlocks with other equipment.
- **Results.** Indicate whether the system passed, failed, or requires retesting.

EXAMPLE ISSUES LOG

TABLE 2. Example Issues Log

LEED design review of commissioned systems				
Mechanical				
Comment number	**Sheet**	**Comment**	**Design team response**	**Final review comment, status**
M-1	01M-0.0	LEED EA Credit Advanced Energy Metering is being pursued. Verify proper metering devices are installed.	Metering equipment is being installed to monitor (on floor-by-floor basis) lighting, HVAC, computer power, water heating.	
M-2	BOD	BOD discusses using demand-controlled ventilation in conference rooms as well as return ducts to "monitor" outside air for each floor to comply with ASHRAE 62.1. Clarify how "monitoring" of outside air is achieved and how it's going to be reset based on demand.	Central outside air riser supplies floor-by-floor VAV boxes that measure outside air delivery via integral flow measurement. See comment 4 below for sequence of operation.	
M-3	08M-2.0	Note 4 indicates, "install CO_2 sensors per LEED EQ Credit Enhanced Indoor Air Quality Strategies" but BOD states that CO_2 sensors will be used to maintain ASHRAE 62.1. Note 4 also states that CO_2 levels must be maintained at 400 ppm or less in most critical zone. ASHRAE 62.1 allows for CO_2 levels to be controlled up to 1400 ppm or more depending on type of space. Codes sometimes restrict this down to 1000 ppm. Should include EQ credit requirements under specification section. "Maximum allowable CO_2 levels" should be defined.	New CO_2 sensors for high-occupancy spaces along with existing return air CO_2 sensors will be monitored by BAS. If any zone rises to more than 700 ppm above 400 ppm ambient CO_2 threshold, OA damper will be opened in stages with appropriate time delays using PID control to satisfy critical zone CO_2 setpoint. We will add this credit to sustainable design requirements listing.	
E-1	01E-2.0	No lighting controls, including occupancy sensors or daylight sensors, appear to be provided for lobby. BOD indicates that all lighting within perimeter will have daylight sensors and step dimming. Clarify how this lighting will be controlled.	Design intent is to provide daylight sensors and step dimming. Design documents will be modified to reflect this.	
P-1	BOD	LEED criteria for sink faucet do not match description of SK-1 or SK-2.	Will update document.	
P-2	BOD	SH-1 and SH-1A identified in BOD were not included on plumbing drawings.	Will be included in later design as required.	

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	All projects
CxA previous experience	X
Confirmation of OPR and BOD contents	X
List of systems to be commissioned	X
Verification of CxA activities and reviews	X
Cx plan	X
Documentation of testing and verification	X
CFR, O&M plan	X
Cx report	X

RELATED CREDIT TIPS

Integrative Process Credit. Early analysis of energy- and water-related systems can affect site parameters, programming, geometry, envelope and façade treatments, HVAC capacities and quantities, lighting control strategies, or fixture specifications. The related credit can inform the OPR, BOD, and design documents.

EA Credit Advanced Energy Metering. Meeting the related credit requirements will help projects teams achieve the ongoing commissioning portions of this prerequisite.

EA Credit Renewable Energy Production. Renewable energy systems installed on site must be commissioned under this prerequisite.

EA Credit Enhanced Commissioning. If a project team wishes to pursue Enhanced Commissioning, confirm that the CxA chosen for this prerequisite is appropriate. An early decision about the level of commissioning may demonstrate that achieving the credit is feasible.

CHANGES FROM LEED 2009

- LEED v4 now requires the CxA to be engaged before the design development phase is complete.
- The electrical and plumbing scopes have been expanded.
- One design review and one operations and maintenance plan are now required.

REFERENCED STANDARDS

ASHRAE Guideline 0–2005, The Commissioning Process: ashrae.org

ASHRAE Guideline 1.1–2007, HVAC&R Technical Requirements for The Commissioning Process: ashrae.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

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

commissioning (**Cx**) the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements

commissioning authority (**CxA**) the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

operations and maintenance (**O&M**) **plan** a plan that specifies major system operating parameters and limits, maintenance procedures and schedules, and documentation methods necessary to demonstrate proper operation and maintenance of an approved emissions control device or system

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

systems manual provides the information needed to understand, operate, and maintain the systems and assemblies within a building. It expands the scope of the traditional operating and maintenance documentation and is compiled of multiple documents developed during the commissioning process, such as the owner's project requirements, operation and maintenance manuals, and sequences of operation.

ENERGY AND ATMOSPHERE PREREQUISITE

Minimum Energy Performance

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems.

REQUIREMENTS

OPTION 1. TENANT-LEVEL ENERGY SIMULATION

Demonstrate a 3% improvement in the proposed performance rating compared with the baseline performance rating for portions of the building within the tenant's scope of work. Calculate the baseline according to ANSI/ASHRAE/IESNA Standard 90.1–2010, Appendix G, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), using a simulation model for all tenant project energy use.

Projects must meet the minimum percentage savings before application of renewable energy systems.

The proposed design must meet the following criteria:

- compliance with the mandatory provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata, or a USGBC–approved equivalent standard for projects outside the U.S.);
- inclusion of all energy consumption and costs within and associated with the tenant project; and
- comparison against a baseline tenant project that complies with Standard 90.1–2010, Appendix G, with errata but without addenda (or a USGBC-approved equivalent standard outside the U.S.).

Exception: the baseline project envelope must be modeled according to Table G3.1(5) (baseline), Sections a–e, and not Section f.

Document the energy modeling input assumptions for unregulated loads. Unregulated loads should be modeled accurately to reflect the actual expected energy consumption of the tenant project.

If unregulated loads are not identical for both the baseline and the proposed performance ratings, and the simulation program cannot accurately model the savings, follow the exceptional calculation method (ANSI/ASHRAE/IESNA Standard 90.1–2010, G2.5). Alternatively, use the COMNET modeling guidelines and procedures to document measures that reduce unregulated loads.

RETAIL ONLY

OPTION 1. TENANT-LEVEL ENERGY SIMULATION

Process loads for retail may include refrigeration equipment, cooking and food preparation, clothes washing, and other major support appliances.. Many of the industry standard baseline conditions for commercial kitchen equipment and refrigeration are defined in Appendix 3, Tables 1–4. No additional documentation is necessary to substantiate these predefined baseline systems as industry standard.

OR

OPTION 2. PRESCRIPTIVE COMPLIANCE

Comply with the mandatory and prescriptive provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

- Reduce connected lighting power density by 5% below ASHRAE 90.1-2010 using the space-by-space method or by applying the whole-building lighting power allowance to the entire tenant space.
- Install ENERGY STAR appliances, office equipment, electronics, and commercial food service equipment (HVAC, lighting, and building envelope products are excluded) for 50% (by rated-power) of the total ENERGY STAR eligible products in the project. Projects outside the U.S. may use a performance equivalent to ENERGY STAR.

BEHIND THE INTENT

An optimized project design can substantially reduce energy use—often for a modest initial cost and in a short payback period—when it includes load reduction, improved mechanical system efficiency, and smart operational strategies. An integrated project design can lower operating and maintenance costs and improve indoor air quality, thermal comfort, and access to daylight. Either a prescriptive or a performance approach may be used to attain such results.

A simplified, prescriptive approach—applicable to small buildings and certain project types, such as offices and retail stores—presents a limited set of system choices with mandatory performance characteristics; it is well suited to projects with small budgets and straightforward design. Interiors projects commonly use a prescriptive approach, since many of the complex energy conservation strategies or scenarios that could be explored through an energy simulation, such as envelope and base building HVAC systems, may be outside the scope.

Alternatively, the performance path offers a more flexible, tailored way to evaluate the interactive effects of efficiency measures. This option uses energy modeling to simulate the energy performance of the entire project, including the tenant space and any systems that will be modified to accommodate it, such as an upgrade to a base building HVAC system. The performance option may be appropriate if there are opportunities for system upgrades beyond typical lighting and equipment retrofits, if the improvements exceed the prescriptive thresholds of ASHRAE 90.1–2010, or if the project team wants to earn additional points under the related credit, Optimize Energy Performance. If the base building has already been modeled, the simulation may be modified to incorporate tenant-specific improvements.

Partnering with the design team, qualified energy modelers will be able to prepare a tenant-level simulation and interpret the results of these complicated analyses to maximize the benefits to the project. When initiated early in the design process, an energy simulation serves as a design tool instead of a compliance check. One of the greatest benefits of early energy modeling is better integration of interrelated design issues, which encourages dialogue about assumptions concerning building components and systems. Information on energy use and costs thereby plays a bigger role as design decisions are made.

ASHRAE 90.1–2010 was chosen as the standard on which to base the requirements because it continues to push building design toward greater energy efficiency. Specifically, a study by the U.S. Department of Energy showed an average improvement of 18% across all building types when ASHRAE 90.1–2010 was applied instead of ASHRAE 90.1–2007.[1]

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE CLIMATE ZONE

Identify the project's climate zone according to ASHRAE 90.1, Appendix B (see *Further Explanation, Climate Zone Determination*).

STEP 2. DETERMINE SCOPE OF TENANT IMPROVEMENTS

List all the systems and components in the tenant spaces and the systems and components that serve the tenant spaces in the LEED project boundary. Identify those that are addressed by the prescriptive and mandatory provisions of ASHRAE 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

- Determine which elements and systems are considered part of the base building and which are part of the tenant improvement.
- Upgrades to the base building systems requested by the tenant or required to fulfill the space needs must meet the requirements of ASHRAE 90.1–2010. If applicable, prescriptive requirements must also be met.
- Typical systems and equipment in a tenant scope of work include lighting, appliances and equipment, terminal units for HVAC systems (e.g., fan coils, VAV boxes, water source heat pumps), packaged HVAC systems for spaces with unusual schedules, and point-of-use service water heaters.

1. *ANSI/ASHRAE/IES 90.1–2010 Final Determination Quantitative Analysis, p. 29, http://www.energycodes.gov/status/documents/FinalQuantitativeAnalysisReport901–2010Determination.pdf.*

- Base building systems often include central HVAC, power, the building envelope, and service water heating. Consider reviewing these systems for potential upgrades and improvements that the building owner could complete, since the project may be able to take credit for base building system improvements.

STEP 3. REVIEW ASHRAE MANDATORY COMPLIANCE REQUIREMENTS

Early in the design process, review the mandatory provisions of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.).

- Focus on the areas and systems included in the project scope.
- Ensure that the project complies with the mandatory measures throughout the design, construction, and commissioning process, particularly when major design decisions are implemented.
- Confirm that compliant components are included in the final construction documents.

STEP 4. IDENTIFY ENERGY USE TARGET

Set an energy goal for the project early in the design process. Identifying an energy goal can help prioritize efficiency strategies, integrate systems, reduce first costs, and improve project performance.

- For EA Credit Optimize Energy Performance, the target must be established as energy use intensity (EUI) in kBtu per square foot-year (kWh per square meter-year) of source energy use.
- Consider using ENERGY STAR's Target Finder to develop the EUI goal. The Target Finder results are derived from averaged values for typical climate zones, project types, and building orientations; they may not account for specific features of the tenant space, such as large, west-facing windows.
- The ENERGY STAR target must be based on all energy, whether or not it is intended to be metered in the project space. Include the following:
  - Space lighting
  - Receptacle, appliance, and process loads
  - HVAC and service water heating in the space
  - The portion of the HVAC and water-heating energy for HVAC systems outside the project area that serve the space (e.g., fans, cooling compressors, furnaces, chilled water or hot water). See *Further Explanation, Contribution of Base Building HVAC and Service Water-Heating Systems.*
- The allocation of energy from systems outside the project space is based on the implemented energy efficiency measures.
  - For example, if the project receives energy from the building plant but is not seeking any credit for that energy, report the type of energy as "chilled water" and "hot water" in the ENERGY STAR tool.
  - If the project is taking credit for the efficiency of the central plant, report the relative contribution of the central plant's fuel or electricity use that will be used to generate and distribute chilled water and hot water to the project space.
  - See *Further Explanation, Project Type Variations, Central Plant or District Energy Systems*.

STEP 5. SELECT ONE OPTION

Select the appropriate option for the project (see *Further Explanation, Selecting an Option*).

- Option 1 is available to all projects and takes advantage of trade-offs between prescriptive requirements of ASHRAE 90.1–2010.
  - Consider this option if the project team wants to continually review the energy effects of design decisions, or if the team is pursuing EA Credit Optimize Energy Performance, since energy modeling makes the project eligible to earn more points.
  - Select Option 1 if the project includes on-site renewable energy and intends to use the energy produced for additional points in EA Credit Optimize Energy Performance.
  - The existence of a base building energy model available for use by the projet design team may reduce the effort required to use energy modeling.
- Option 2 is appropriate if the primary efficiency upgrades will focus on lighting, equipment, and appliances.
  - For smaller tenant improvement projects, this may be a more cost effective option.
  - This option limits the number of points the team can pursue under EA Credit Optimize Energy Performance.

Option 1. Tenant-Level Energy Simulation

STEP 1. REVIEW PREREQUISITE AND CREDIT REQUIREMENTS

Thoroughly review the criteria and referenced standards for both EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance before beginning the simulation.

- The prerequisite and credit are integrally linked. Teams that intend to pursue the credit should focus on the expanded scope necessary for credit achievement.
- Projects that meet the requirements for earning points under the credit, including mandatory requirements and excluding any credits from renewable energy, automatically achieve the prerequisite.
- Review the Integrative Process Credit to identify the requirements for concept-level energy modeling.

STEP 2. IDENTIFY ENERGY MODELER

Engage an energy modeler to perform the energy analysis.

- It is recommended that the qualifications of the energy modeler be carefully reviewed to ensure that the simulation will be prepared accurately, according to the prerequisite requirements.
- Qualified energy modelers who have experience with numerous simulations for a variety of building and project types can help the design team interpret the results to develop an efficient design (see *Further Explanation, Energy Modeler Qualifications*).

STEP 3. DETERMINE BASE BUILDING SYSTEMS THAT SERVE PROJECT AND OTHER SPACES

If an HVAC or service water-heating system(s) serves both project and nonproject spaces, its energy use must be allocated to each space, on a percentage basis.

- This applies to dedicated outside air units, built-up or packaged air-handling units, ground-source or water-source heat pump loops, service water-heating systems, and central or district energy plants.
- See *Further Explanation, Contribution of Base Building HVAC and Service Water Heating Systems.*

STEP 4. COLLECT BASE BUILDING INFORMATION

Collect information on all building elements outside the project scope that must be included in the model. This may require referencing as-built drawings or surveying the existing building.

- Project teams may use the results of the core and shell model, if it is available.
- An existing base building model may be developed into a tenant-level simulation.

STEP 5: DEVELOP PRELIMINARY ENERGY MODEL

Consider creating a preliminary energy model to analyze heating and cooling load reduction strategies through changes to the systems within the tenant project scope. The preliminary model uses information about the tenant improvement design and base building parameters to create a rough projection of energy usage in various scenarios (see *Further Explanation, Developing a Preliminary Energy Model*).

- A preliminary energy model is not required; however, developing a model for the proposed design will help the design team explore the energy consequences of various design options and will provide an early estimate of energy performance.
- An analysis of various efficiency measures, which may take the form of a preliminary model, contributes toward the achievement of the related credit.
- Evaluate strategies for lighting, daylighting, and passive cooling and ventilating systems in terms of projected energy savings and capital costs. Teams pursuing the Integrated Process Credit must evaluate these parameters at a concept level early in the design phase.

STEP 6. MODEL POTENTIAL HVAC SYSTEM TYPES, IF APPLICABLE

After load reduction strategies have been assessed and implemented, use the energy model to analyze the performance of HVAC system alternatives, if HVAC system upgrades or alterations are within the tenant scope of work (see *Further Explanation, Modeling Potential HVAC Systems*).

- Reducing loads before evaluating HVAC system types allows the team to size the HVAC system appropriately. Smaller loads may make it possible for the HVAC designer to consider more effective system types, such as radiant heating and cooling or displacement ventilation.
- Evaluate whether alternative air distribution, heating, and cooling systems are compatible with the base building's HVAC system.
- Analysis of HVAC systems in early design is optional for this prerequisite but is required for achievement of the related credit.

STEP 7. DEVELOP ENERGY MODEL FOR PROPOSED DESIGN

Once the design parameters are established, build or update the model for the proposed design (see *Further Explanation, Building the Proposed Energy Model*).

- Include design conditions for systems within the tenant scope of work, including HVAC, lighting and plug loads, and existing conditions for systems that are unchanged.
- Include any modifications to existing conditions that are made in conjunction with the project.
- Update the model throughout the design process and compare energy performance with the ASHRAE 90.1 baseline to ensure that the proposed design meets this prerequisite's requirements. Doing so will also prepare the project to earn points under the related credit.

STEP 8. CREATE BASELINE ENERGY MODEL

Build a baseline model that reflects the minimum requirements according to ASHRAE 90.1–2010, Appendix G (see *Further Explanation, Building the Baseline Energy Model*).

- The baseline model for the project space must follow the Appendix G requirements whether or not the components or systems are existing or within the project scope of work.
- Consider constructing the baseline model early in design so that the design team can see the effect of design changes on the percentage savings relative to ASHRAE 90.1. This will contribute toward achieving more points under the related credit.
- As modifications are made to the proposed energy model, ensure that the baseline is updated appropriately to reflect any required revisions.
- Use the Appendix G energy modeling inputs and quality control checklists spreadsheet to help create the baseline model. This tool was designed to help project teams develop a baseline model in alignment with Appendix G requirements and avoid common issues raised during the LEED review process.

STEP 9. UPDATE PROPOSED AND BASELINE MODELS BASED ON FINAL DESIGN

Update the proposed energy model to reflect final construction details and specifications and make any corresponding updates to the baseline model (see *Further Explanation, Finalizing the Energy Models*).

- For elements or systems that cannot be readily modeled by the software, use the exceptional calculation method or COMNET modeling guidelines for unregulated loads (see *Further Explanation, Exceptional Calculation Method* and *Common Issues with Energy Modeling*).

STEP 10. DETERMINE ENERGY COST SAVINGS

Compare the proposed model with the baseline model to determine the anticipated energy cost savings (see *Further Explanation, Energy Cost Savings*).

- Ensure compliance with the prerequisite criteria for energy savings.
- Energy costs offset by on-site renewable energy systems do not count toward energy savings for compliance with the prerequisite. Renewable energy may be included in the model for achievement of points under the related credit.

Option 2. Prescriptive Compliance

STEP 1. ASSESS ASHRAE PRESCRIPTIVE REQUIREMENTS

Review the tenant scope of work with the design team to assess the prescriptive requirements of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the United States).

- Review Sections 5.5 (envelope), 6.5 (HVAC), 7.5 (water heating), 8.5 (power), and 9.2.2 (lighting) to determine which elements are applicable.
- Ensure that all parts of the building within the project scope, including base building systems that will be upgraded to meet the tenant requirements, meet the prescriptive criteria.
- Consider opportunities for the landlord to upgrade base building systems concurrent with the tenant project.
- Ensure that the lighting calculations include all task lighting except where specifically exempted by ASHRAE 90.1, and account for the total luminaire wattage for each fixture, consistent with ASHRAE 90.1 requirements. The luminaire wattage is not necessarily the sum of the lamp wattages; it accounts for the ballast factor for standard luminaires and the total circuit power or current-limited power for track lighting.

- As a best practice, develop a checklist of all the requirements needed to comply with the standard, review this list with the project team, and include these requirements in the owner's project requirements (see EA Prerequisite Fundamental Commissioning).

STEP 2. DESIGN FOR COMPLIANCE

Starting early in design, work with the project team to ensure that the tenant space will comply. Include requirements for ASHRAE 90.1–2010 compliance, reduced lighting power density, and ENERGY STAR products, as noted in the prerequisite requirements.

- Areas and systems that are not part of the tenant scope of work are exempt. However, modifications to base building systems that serve the tenant space must comply with the ASHRAE 90.1–2010 prescriptive requirements if they are completed by or on behalf of the tenant.

STEP 3. ANTICIPATE EA CREDIT OPTIMIZE ENERGY PERFORMANCE CRITERIA

If the project team is planning to achieve points under the related credit, consider the additional lighting, equipment, and ASHRAE 50% Advanced Energy Design Guide (AEDG) requirements.

- EA Credit Optimize Energy Performance has additional requirements (see EA Credit Optimize Energy Performance, Option 2).
- To earn points for the base building under the related credit, the design must meet AEDG prescriptive requirements for opaque envelope, glazing systems, and/or HVAC equipment. Retail projects have additional requirements for process equipment.
- If the project team plans to upgrade any of these systems, evaluate the potential to meet the related credit's prescriptive requirements.
- Projects are eligible to earn points for existing base building systems that already meet the criteria, without additional upgrades. For example, if the vertical glazing installed as part of the base building meets the AEDG requirements, the project can earn 2 points without needing to upgrade the glazing.

FURTHER EXPLANATION

CLIMATE ZONE DETERMINATION

Determining the right climate zone for the project is essential, since the requirements are specific to each climate zone. ASHRAE 90.1 defines eight climate zones (Miami is in climate zone 1; Anchorage is in climate zone 8) and three climate types: A (moist), B (dry), and C (marine).

To find the project's climate zone and type, consult ASHRAE 90.1–2010, Appendix B, for the appropriate state and county. If the project's county is not listed, use the climate zone listed for the state as a whole. For projects outside the U.S., see *Further Explanation, International Tips*.

SELECTING AN OPTION

Determining which option is more appropriate for the project requires knowing the extent of energy performance feedback desired during the design process.

- If detailed feedback is important during the design process, systems can be upgraded beyond the minimum prescriptive levels, and the investment in an energy simulation might lead to a reasonable return on investment, then the performance option (1) may be appropriate. Energy modeling generates information on the potential savings associated with various efficiency measures, both in isolation and in combination with other measures. Often this includes estimates of overall energy use or cost savings for the project, which can help gauge progress toward an energy savings goal or achievement of points under the related credit.
- The prescriptive option (2) may be more appropriate for projects with small budgets, limited ability to modify energy systems, or no available base building energy model. It is suitable for projects with standard systems, and it provides only limited feedback, since all energy efficiency measures must be incorporated to achieve the prescribed threshold.

Performance path

The following factors could indicate that Option 1 would be advantageous to the project:

- The project has an HVAC system that is not covered by the prescriptive option.
- The project team wants to explore the energy performance and load reduction effects of several systems.
- The project team is planning to maximize the number of points earned under EA Credit Optimize Energy Performance.
- The project team wants to achieve efficiency trade-offs between systems, offsetting the lower efficiency of one system by the improved efficiency of another.
- The owner is interested in commercial building federal tax credits or state, local, or utility incentives that require energy modeling. The modeling requirements for such incentive programs may be different from the ASHRAE 90.1–2010 requirements, however.
- The owner wants an estimate of the carbon reductions or lower operating costs (energy savings, demand charge savings) from energy strategies beyond a simple calculation for individual energy conservation measures.

Before undertaking energy modeling as part of the performance path, consider the timing of the simulation preparation and presentation, and understand the costs and benefits of energy modeling as it relates to the project. When energy modeling is conducted late in design, its value is very limited, except as a compliance tool: the model can only estimate the energy savings of the design.

In contrast, if initiated early and updated throughout the design process, energy modeling can be a decision-making tool, giving feedback as part of the larger analysis of building systems and components. The best value will be seen when energy modeling is used as a tool in an integrated design process because it enables a more informed, cost-effective selection of efficiency strategies.

Develop clear expectations for the presentations of modeling results and their integration into the project schedule. Ideally, iterations of the model will be presented to the team during each stage of design, beginning as early as possible, when the project goals are incorporated into preliminary plans. Updates should be presented as the design is developed further to incorporate engineering and architectural details, and again when the construction documents are being prepared.

Regardless of the project design phases, energy modeling can still be performed as the design progresses. However, the potential benefit of energy modeling decreases as the design becomes finalized and opportunities for incorporating changes are lost.

Identify the individual best suited to perform the modeling. If an energy modeler is already part of the design team, ask him or her to provide a schedule that integrates energy modeling into the design process, with appropriate milestones.

To develop an accurate and compliant energy model, it is important that the energy modeler read and understand ASHRAE 90.1–2010 (Appendix G in particular) in its entirety, not just the portions that apply to the project. This will enable a more complete understanding of the energy modeling protocols and methodologies required for LEED projects (see *Further Explanation, ASHRAE 90.1–2010 vs. 2007*). The energy modeler should also consider reading the ASHRAE 90.1–2010 User's Manual, which expands on the Appendix G requirements.

Tenant improvement projects have specific modeling requirements. An energy modeler who has experience with this LEED rating system can streamline the modeling process (see *Further Explanation, Common Issues with Energy Modeling*).

Prescriptive path

The following factors could indicate that Option 2 would be advantageous to the project:

- The project type is covered under the prescriptive option and incorporates conventional systems and energy efficiency strategies.
- The project budget and timeline would benefit from simplified decision making and analysis during the project design.
- The additional cost of energy modeling would not be warranted.

ENERGY MODELER QUALIFICATIONS

The energy modeler should have the following competences:

- A comprehensive understanding of all the building systems related to energy performance and the information needed to construct a model using the selected software
- The ability to understand and explain capabilities and limitations of modeling software in regards to the strategies the team would like to pursue
- Awareness of how much time the design team needs to provide information, feedback, and responses to the modeling exercise
- Experience with design phase modeling
- The ability to demonstrate how energy modeling can be used to perform cost benefit analysis
- Experience in modeling projects using ASHRAE 90.1, Appendix G, performance rating method, or a thorough understanding of this approach
- The ability to perform quality control to ensure that the modeling inputs accurately reflect the proposed design and Appendix G baseline
- The ability to evaluate the simulation results for reasonableness in relation to the energy modeling inputs, including energy consumption by end-use, cost, and the performance savings claimed
- The ability to validate the model through review of the actual utility bills during the occupancy phase
- Awareness of the nuances of modeling tenant spaces to meet the requirements of this prerequisite and, preferably, experience in modeling for LEED for Interior Design & Construction projects

DEVELOPING A PRELIMINARY ENERGY MODEL

Although not required for this prerequisite, preparation of a preliminary model can facilitate achievement of the related credit, which requires analysis of efficiency measures. Past analyses of similar buildings or published data, such as the AEDGs, may also be used to guide decision making, though the results will be less project-specific. A preliminary model includes design elements identified during schematic design and design development and generates a preliminary estimate of energy consumption and an end-use profile.

Evaluate how changes to the following parameters affect HVAC sizing, design, energy consumption, and overall energy performance:

- Programmatic and operational parameters (multifunctioning spaces, operating schedules, space allotment per person, teleworking, reduction of project area, operations and maintenance)
- Lighting levels, interior surface reflectance, daylighting
- Thermal comfort range options
- Plug loads
- Passive conditioning and natural ventilation strategies

Base building elements outside the scope of the tenant project will affect energy consumption. For example, a west facing space with extensive glazing in the northern hemisphere will experience higher cooling loads than a north facing space.

When examining alternative strategies, also consider the effect on human performance. For example, increasing daylighting may cause glare.

Typical steps in preliminary energy modeling are as follows:

1. Gather information about building and project loads and systems. Typically, a portion of a base building HVAC system serves the project's tenant space (see *Further Explanation, Contribution of Base Building HVAC and Service Water Heating Systems*).
2. Collect information from the base building's owner about operating schedule, lighting, HVAC systems and zones, size and efficiency of HVAC components, service hot water systems, area and exposure of fenestration, and thermal conductivity of all exterior walls, windows, and doors.
   If the other spaces served by the energy system have dissimilar occupancies to the project space, the

project team must allocate energy consumption using Method 2 under *Further Explanation, Contribution of Base Building HVAC and Service Water Heating Systems*. For Method 2, document the type of occupancy and operating schedule, envelope parameters, and estimated existing lighting and plug loads for those areas. If information is not available, use default ASHRAE 90.1 and ASHRAE 62.1 values.

3. Review any existing base building documents, such as operation and maintenance manuals, commissioning reports, energy audit reports, and utility bills. If utility consumption data are not available from the base building's owner, contact local utilities for energy rates and demand charges.
4. Research building energy codes, including any local variations.
5. Engage the design team early to investigate opportunities for load reduction. Focus on internal load reduction (lights, plug loads, process loads), since there are likely to be limited opportunities to affect the central HVAC system, envelope, or exterior shading. Examine energy consumption by end use and heating and cooling load distribution to identify high-impact load reduction and energy efficiency opportunities.
6. Investigate interconnected strategies. For example, energy modeling could evaluate the effect of automatic interior shades, with daylight harvesting controls, on cooling, heating and fan loads, HVAC system capacities, and total energy consumption and cost. A life-cycle cost analysis for this scenario would indicate the net increase or decrease in capital costs and the potential savings over multiple years. When evaluating the capital cost, consider trade-offs between the higher capital cost for the shading and daylight harvesting controls and the lower capital costs for a smaller HVAC system.
7. Use the model to compare potential performance with the project's energy goals.

MODELING HVAC SYSTEMS

Although not required for this prerequisite, an evaluation of HVAC system alternatives can help the design team optimize energy consumption. This exercise is a requirement for achievement of points under the related credit. Because of base building constraints, the project team's options may be limited to new or upgraded HVAC controls, terminal units, or zoning.

Typical steps for HVAC system type modeling include the following:

1. Coordinate with the mechanical engineer, since decreased loads may affect mechanical system sizing or potential system types. Compare high-efficiency HVAC systems with typical systems for reductions in operating costs (energy, maintenance). Weigh this against the higher first costs of more efficient equipment. Evaluate the potential for reducing the first cost of HVAC equipment by reducing the loads. Include not only the smaller equipment but also the infrastructure related to HVAC—ductwork, piping, and controls. Consider opportunities to improve an existing system's performance with upgraded controls or new zoning, based on the project-specific design loads.
2. For the selected system, analyze and optimize additional HVAC energy efficiency measures, including equipment efficiency, energy recovery, and demand-controlled ventilation.
3. Coordinate with the architect, since different system types may have specific space, height, or structural requirements. For example, under-floor or ceiling plenums will reduce the interior floor-to-ceiling height.
4. Ensure that HVAC zones are accurately modeled according to ASHRAE 90.1–2010 and the project space as designed.
5. Systems with chilled or hot water can be modeled as purchased energy, following the guidance in ASHRAE 90.1–2010, Appendix G, or using district energy system (DES) guidance. Alternatively, allocate a percentage of the base building's existing HVAC systems to the project area (see *Further Explanation, Contribution of Base Building HVAC and Service Water Heating Systems*).

BUILDING THE PROPOSED ENERGY MODEL

An energy model of the proposed design is required for prerequisite compliance under Option 1. A team that has already prepared a preliminary model may update it to reflect the newest design information throughout the project. If a base building model is available, modify it to incorporate tenant space systems and criteria. If an energy system serves both the project area and other spaces in the building, allocate its energy consumption on a percentage basis (see *Further Explanation, Contribution of Base Building HVAC and Service Water-Heating Systems*).

Create or update the model based on the latest information and specifications on systems, assemblies, and equipment in the current design. This can be accomplished as early as design development to estimate projected savings, and later updated when the construction documents are complete. The proposed design model must include the existing conditions along with all modifications, new components, and systems, as shown on the project design and construction documentation.

Analyze remaining efficiency strategies that the team would like to consider before the design documents are finalized. For example, the proposed energy model could be used to evaluate the performance and cost implications of value engineering decisions.

BUILDING THE BASELINE ENERGY MODEL

Developing a baseline energy model is a detailed process that requires a good working knowledge of ASHRAE 90.1–2010, Appendix G, and familiarity with the relevant sections of the standard. The baseline model represents a typical design for a project of the same size and use as the proposed project. It meets but does not exceed the performance requirements of ASHRAE 90.1–2010 and is used as a comparison to calculate the percentage energy cost savings for the project design.

In general, baseline development begins by changing the inputs for all of the components, assemblies, and systems of the proposed design energy model to minimally compliant input values, in accordance with 90.1–2010 Appendix G. Determine or update baseline values for each system, assembly, and piece of equipment for the appropriate climate zone, building type, and fuel type(s).

If the energy simulation software automates some or all of the baseline generation, review the automated baseline model inputs against the expected baseline values, and confirm consistency (see *Further Explanation, Common Issues with Energy Modeling*). This is especially critical for LEED Interior Design & Construction projects that do not have many of the project's systems or assemblies as part of the scope of work.

Preparation of the initial baseline model is best undertaken during the design development phase, after major design decisions have been made, so that modeling can evaluate whether the project is likely to meet energy savings targets (or achieve points under the related credit). The baseline model will typically need to be updated based on the final project design.

The baseline HVAC system type must be based on the building's area and number of floors (not the project's area and number of floors).

If appropriate, apply Section G3.1.1 exceptions (a–f) to the model. More specifically, if the building heating source (fossil fuel or hybrid versus electric) or building type (nonresidential versus residential) varies from the predominant conditions of the building for an area exceeding 20,000 square feet, an alternative system type should be modeled for the space where exception (a) applies. Additional systems should be modeled in any portions of the space where exceptions (b) through (f) apply.

Existing conditions must be modeled as new construction in the baseline case, following Appendix G, for all components and systems.

FINALIZING THE ENERGY MODELS

Update the proposed model based on the information and specifications for systems, assemblies, and equipment in the final construction documents. Confirm that all efficiency measures claimed have been incorporated into the design. Include all energy consumption and costs within and associated with the project.

Ensure that assumptions used in earlier versions of the model are replaced with actual data from the construction documents. For example, if proposed chiller control sequences were assumed in the preliminary model, use the actual control sequences from the construction documents for the final version. Update the baseline model as necessary based on the project's final construction documents, including changes in occupant density, required outdoor airflow, thermostat setpoints, and system or fuel types. The model will have to be updated again if any changes during construction affect efficiency measures.

Schedules must be modeled correctly for both the proposed and baseline models (see *Further Explanation*, *Schedules*).

Perform a quality control check to verify that all Appendix G and LEED modeling guidelines have been followed.

Record both the proposed and baseline values in the Appendix G energy modeling inputs and quality control checklists spreadsheet. This record of energy conservation measures is a good tool for confirming that proposed project characteristics and baseline values have been selected properly.

Document the input assumptions for receptacle and process loads. These loads should be modeled accurately to reflect the actual expected energy consumption of the building. Per ASHRAE 90.1–2010, Table G3.1-12, receptacle and process loads must be modeled identically in both the proposed and baseline models, unless there are specific efficiency requirements listed in Sections 5 through 10 that allow a less stringent baseline requirement (e.g., motor efficiency).

If the project claims savings for variations in power requirements, schedules, or control sequences, the burden of proof is on the project team to document that the design represents a significant departure from conventional practice. If an energy efficiency measure cannot be explicitly modeled, the team may use Section G2.5, Exceptional Calculation Method (see *Further Explanation, Exceptional Calculation Method*).

Verify the final energy cost savings. Evaluate the energy savings by end use for reasonableness based on the differences in the modeling inputs between the baseline and proposed models (see *Further Explanation, Energy Cost Savings*). Use Figure 1 to help verify proposed energy savings.

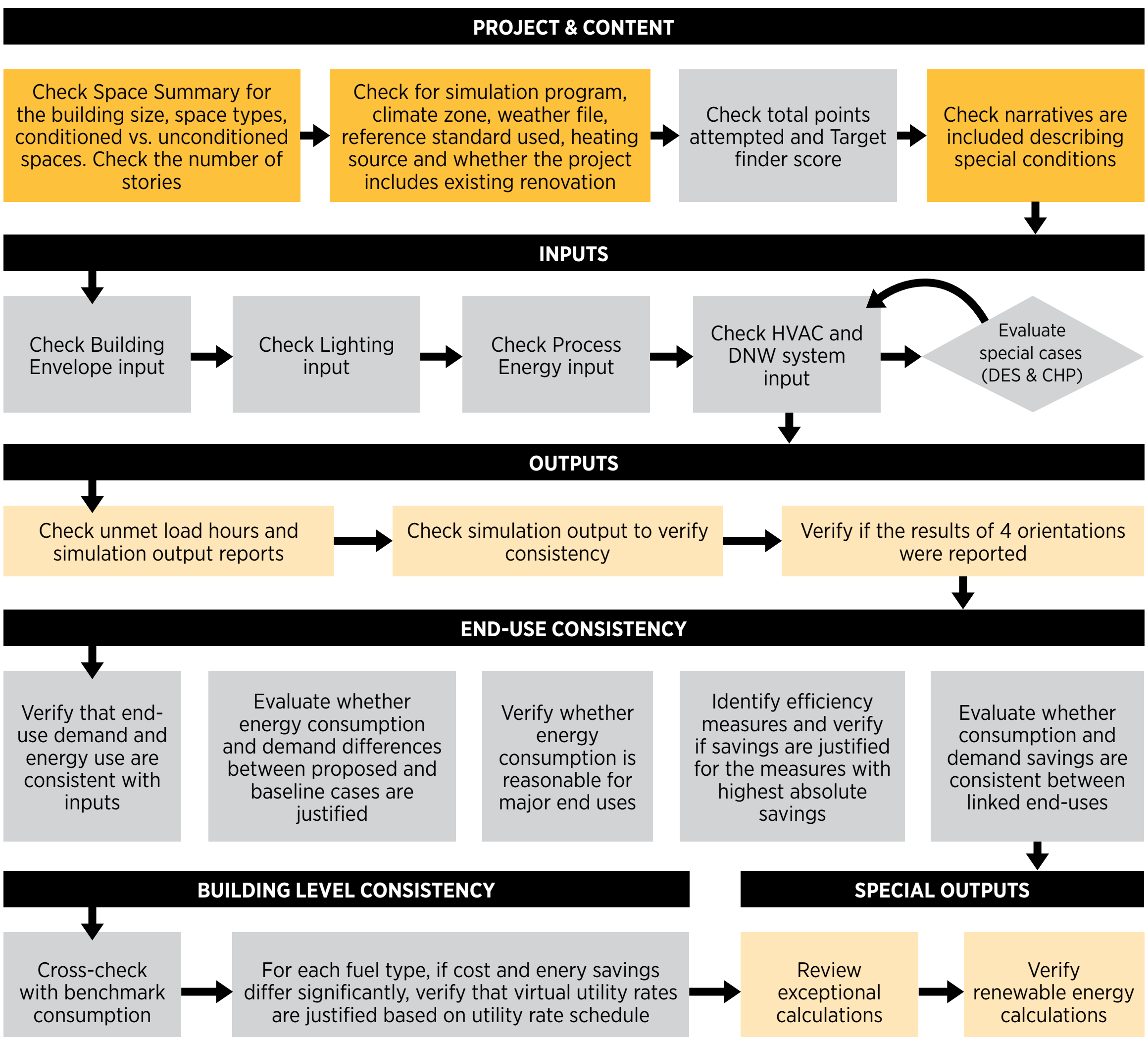


Figure 1. Steps to verify proposed energy savings

Model Inputs | Model Outputs | Consistency

CONTRIBUTION OF BASE BUILDING HVAC AND SERVICE WATER-HEATING SYSTEMS

In many projects, a portion of a base building HVAC system serves the project's tenant space. To allocate a percentage of that HVAC system to the tenant area, use whichever of the following two methods is more appropriate.

Method 1 is applicable when the additional spaces served by the HVAC or service water heating system have similar occupancies to the project space, provided the resulting unmet load hours for the proposed design do not exceed the amount allowed by ASHRAE 90.1.

- Determine the total square footage (square meters) served by the HVAC or service water-heating system.
- Determine the project floor area served by the HVAC or service water-heating system.
- For air-handling units, determine the design supply airflow, design fan power, design heating capacity, design cooling capacity, and outdoor airflow. For central service water heaters or thermal energy plants (e.g., steam, hot water, or chilled water) located in the building, determine the chiller or boiler quantities and capacities, storage tank volumes as applicable, pump design supply volume for each pump as applicable, heat rejection fan power, and any other pertinent parameters relative to HVAC system capacities.
- Determine the relative contribution of the HVAC or service water-heating system to the project floor space by applying the project floor space ratio to each design parameter (design supply airflow, design fan power, design heating capacity, design cooling capacity, outdoor airflow, chiller capacity, service water heating storage volume, or pump capacity):

$$\text{Adjusted parameter} = \frac{\text{Parameter} \times \text{Project area served by system}}{\text{Total area served by system}}$$

- Model the HVAC or service water-heating system based on the actual design conditions and sequence of operations, but use the adjusted parameters as calculated above.

Method 2 is applicable when the other spaces served by the air-handling unit have dissimilar occupancies to the project space.

- For air-handling units, determine the design supply airflow, design fan power, design heating capacity, design cooling capacity, and outdoor airflow. For central thermal energy plants or service water heaters located in the building, determine the chiller or boiler quantities and capacities, storage tank volumes as applicable, pump design supply volume for each pump as applicable, heat rejection fan power, and any other pertinent parameters relative to HVAC system capacities.
- Determine the percentage allocation of HVAC or service water heating capacity to the project space, using the following equations.

$$\%\ \text{allocation} = \frac{\text{Airflow allocated to project space}}{\text{Total design supply airflow}}$$

$$\%\ \text{allocation} = \frac{\text{Chilled water capacity allocated to project space}}{\text{Total chilled water capacity}}$$

- Example: A dedicated outside air system supplies the entire building, and VAV boxes distribute the outside air to each tenant space. The team makes the calculation as follows:

$$\%\ \text{allocation} = \left\{ \frac{\text{AHU design supply flow}}{\text{Sum of all VAV box peak design flows}} \right\} \times \text{VAV box peak design flow for project space}$$

- Provide documentation from the base building's owner identifying the airflow and/or thermal capacity allocated to the project space versus the total design supply airflow and/or thermal capacity. Justify this percentage allocation in a narrative.
- Identify the different occupancies, by type and square footage (square meters), served by the air-handling unit or thermal energy system.
- In ASHRAE 90.1 User's Manual or ASHRAE 62.1, look up default assumptions for the other occupancies' lighting loads, ventilation, occupancy, etc. Use these values to determine (per square foot or square meter) the peak heating and cooling loads, design supply air volume, and design outside air volume for the other occupancies:

$$\text{Total load} = \text{Sum}\left\{\frac{\text{Design load}}{\text{ft}^2}\right\} \times \text{Area}$$

$$\text{Adjusted parameter} = \frac{\text{Parameter} \times \text{Total project area served by AHU or thermal system}}{\text{Total area served by AHU or thermal system}}$$

- Model the air-handling unit or thermal energy system based on the actual design conditions, but use the adjusted parameters as calculated above.

SCHEDULES

For optimal results, ensure that the schedule inputs into the model accurately reflect the base building and project space operation. If anticipated operating schedules are unknown, helpful guidance for determining model inputs for occupancy, lighting, HVAC system, receptacle power, and service hot water consumption values can be found in the ASHRAE 90.1–2010 User's Manual, Appendix G.

Schedules must be identical in both the baseline and the proposed cases unless documented in an exceptional calculation or specifically allowed by ASHRAE 90.1–2010 Appendix G (see *Further Explanation, Exceptional Calculation Method*).

Certain space types may require specific schedules based on anticipated operation and may vary by space type. For example, a server room may have different temperature schedules than an occupied space.

Exceptions to Section G3.1.1 may require modeling of a different baseline HVAC system type in spaces with schedules that vary significantly from the rest of the building.

Different lighting schedules may be used for a project with both office and retail occupancy when the space-by-space method is used or when the building area method is used with multiple building type classifications. Different schedules cannot be used, however, if an average lighting power density is applied to the whole project.

Ventilation and infiltration schedules should also be adjusted to ensure the same amount of outside air delivery and infiltration between baseline and proposed cases, except for specific exceptions allowed by Appendix G.

ENERGY COST SAVINGS

For EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance, modeled energy savings must be reported on an energy cost basis using actual utility rates or the state's average energy prices.

Using energy cost savings as a metric for overall energy efficiency is important for several reasons. It aligns with the energy modeling procedures in ASHRAE 90.1–2010, Appendix G, and provides a uniform metric for all fuel types. It captures the relative effects of various efficiency measures on energy demand and long-term operating costs—valuable metrics for the owner in determining the overall cost-effectiveness of selected efficiency strategies. And finally, the energy cost savings metric can help designers understand energy consumption because in many cases, cost and carbon emissions of each fuel source are closely correlated.

Ensure that project-level rates are included in the model, and the costs are limited to the fuels used by the systems within the simulation scope.

EXCEPTIONAL CALCULATION METHOD

In ASHRAE 90.1–2010, Appendix G, Section G2.5, an exceptional calculation method (ECM) is used when the simulation program that is generating the energy model is incapable of modeling a certain design, material, or device of the proposed design. LEED has adopted and slightly expanded use of exceptional calculations to cover any savings claimed for a nonregulated load, defined as any building load, end use, or control without an Appendix G baseline modeling requirement that allows the load, end use, or control to be modeled differently in the proposed and baseline buildings.

Energy savings limitations. Section G2.5 indicates that exceptional calculation methods cannot constitute more than half of the difference (i.e., savings) between the proposed and baseline buildings. This will be enforced for the ASHRAE definition of an ECM. However, in LEED, this rule will not be applied to savings attempted on nonregulated loads unless the nonregulated load cannot be modeled in the simulation program.

Elements that cannot be simulated by modeling program. One type of ECM is creating a representation of an element that cannot be modeled directly by the chosen energy modeling software. Examples include innovative external shading devices, underfloor air systems, and the heat recovery performance of a variable refrigerant flow system. Whether a particular strategy is considered an ECM may depend on the modeling program and whether the energy modeler can simulate an approximation of the system in the software. If the methodology for approximation has not been previously published by ASHRAE or USGBC as an acceptable modeling path, it is the responsibility of the energy modeler to submit a narrative explanation describing the simulation and providing the calculations for the energy savings if necessary.

Documentation for nonregulated loads. Examples of nonregulated load savings include manufacturing equipment not regulated by 90.1–2010, a unique manufacturing process, or any refrigeration or kitchen equipment (including operation) not specifically covered in the LEED Retail Rating System Appendix 3, Tables 1–4. Energy savings for nonregulated loads require additional documentation. ASHRAE 90.1–2010, Table G3.1-12, indicates that "variations of the power requirements, schedules, or control sequences" are allowed by the "rating authority," provided the proposed design "represents a significant verifiable departure from documented conventional practice." Project teams must document the following information to prove that the savings represent a departure from conventional practice and are not required by local code:

- A narrative describing all baseline and proposed assumptions
- The calculation methodology used to determine the savings
- A document verifying that the efficiency measure is not conventional practice. This is generally accomplished either by documenting the baseline comparison system/schedule/control as standard practice, or by showing that the savings claimed for the efficiency measure are incentivized by a local utility program. Examples of documents used to verify that the efficiency measure is not conventional practice may include the following:
  - A recent study with researched tabulations or monitored data establishing standard practice for the given application in similar newly constructed facilities
  - A new-construction utility or government program that provides incentives for the measure
  - A document showing the systems used to perform the same function in similar facilities built within the past five years; these systems are treated as the baseline system in the analysis, and evidence must show how the energy use for the proposed and buildings is determined

Alternatively, the project team may use any of the prescriptive requirements from ASHRAE 90.1–2010 as the baseline requirement without further justification to substantiate conventional practice, but only for the specific component.

Additional guidance. Sources of typical efficiency measures include the COMNET manual, which has a calculation methodology for determining savings for process or receptacle loads, especially savings from ENERGY STAR equipment. These are offered in Section 6.4.5, Receptacle and Process Loads, and Appendix B.

Always provide a narrative explanation of the methodology used to calculate savings for exceptional calculation methods. Separate calculations are not necessary when the energy saving are found easily in the modeling results.

Changes from earlier versions of ASHRAE and LEED. Some efficiency measures that no longer need to be modeled using an exceptional calculation method include low-flow water fixtures, kitchen equipment, and kitchen ventilation.

- **Low-flow service water-heating fixtures.** The flow rates given in WE Prerequisite Indoor Water Use Reduction set the allowable baseline values. Provide sufficient information to justify energy savings from efficient fixtures and appliances that use hot water.
- **Kitchen equipment.** All project types may count energy savings from efficient refrigeration equipment, cooking and food preparation, clothes washing, and other major support appliances. LEED Appendix 3, Retail Tables 1–4, defines the baseline conditions. Provide sufficient information to justify all the savings. Savings for a piece of equipment (or its operation) not covered in Appendix 3 must be modeled using the ECM described above.
- **Kitchen ventilation.** ASHRAE 90.1–2010 now addresses kitchen ventilation, so it is no longer considered a nonregulated load. Section G3.1.1, exception (d) requires a kitchen with more than 5,000 cfm (2360 L/s) of total exhaust airflow to be modeled with its own separate system. Include demand ventilation on 75% of the exhaust air, and reduce exhaust and replacement air by 50% for half the kitchen occupied hours in the baseline design. Additionally, the maximum exhaust flow rates for hoods must meet the requirements of Section 6.5.7.1.3. The exhaust flow rate must be modeled identically in the baseline and proposed case at design conditions unless Appendix G indicates otherwise. Any design that goes beyond these minimum baseline requirements may be counted. Provide sufficient information to justify all kitchen ventilation savings, with consistent assumptions and operating schedules. Project teams that count kitchen ventilation savings must separate the savings from each end use (e.g., fan, heating, cooling) when reporting the energy outputs.

ASHRAE 90.1–2010 VERSUS 2007

The referenced standard for building the baseline model for this prerequisite has been updated to ASHRAE 90.1–2010, which represents a substantial increase in efficiency from the previous version, ASHRAE 90.1–2007. The major changes are described in Tables 1 and 2.

TABLE 1. Comparison of ASHRAE 90.1 mandatory requirements, 2007 and 2010

Building envelope requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Air barriers 5.4.3.1.2	NA	Continuous on entire building envelope
HVAC requirement	**ASHRAE 90.1–2007**	**ASHRAE 90.1–2010**
Chiller efficiencies 6.4.1.1	NA	Increased for all chiller types
Single-zone VAV 6.4.3.10	NA	Required to have VFD or two-speed motors for DX >9.2 tons (32.3 kW), and chilled water AHUs >5 hp (3.7 kW) fan motors
Water and evaporatively cooled unitary AC units and heat pump efficiency Table 6.8.1A and B	NA	3–5% more stringent
PTAC and PTHP efficiency increased 6.4.1.1; Table 6.8.1D	12 EER (3.52 COP)	13.8 EER (4.05 COP)
Water to water heat pump, CRAC, and VRF Table 6.8.1B; Table 6.8.1K; Table 6.8.1J respectively	Not covered	Now covered by 90.1
Power requirement	**ASHRAE 90.1–2007**	**ASHRAE 90.1–2010**
Automatic receptacle control 8.4.2	NA	At least 50% of all receptacles installed in private offices, open offices, and computer classrooms must be controlled by automatic control device

TABLE 1. (CONTINUED) Comparison of ASHRAE 90.1 mandatory requirements, 2007 and 2010

Lighting requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Threshold for retrofit compliance 9.1.2	Alterations that involve less than 50% of connected lighting load in space or area need not comply with lighting power density or auto-shutoff requirements, provided that such alterations do not increase installed LPD	Less than 10% of connected load
Lighting power density 9.4.5; 9.4.6	NA	Reduced; average 17% in space types, more for retail display lighting
Automatic shutoff 9.4.1.1	Required in buildings >5,000 ft^2 (465 m^2)	Required in all spaces
Additional control 9.4.1	All spaces to have general lighting controls, manual or automatic	All spaces are required to have vacancy sensors or occupancy sensors to 50% or less of lighting power
Space controls 9.4.1.2	Classrooms, conference rooms, and break rooms must have occupancy sensor or time switch that turns light off within 30 minutes	More space types added, including offices, restrooms, dressing rooms, and training, copy, and storage rooms
Light level reduction 9.4.1.2	None	Spaces must have controls that reduce power level by 30–70% of connected load in addition to off mode.
Lighting in daylit zones 9.4.1.4	None	Automatic, multilevel daylighting controls installed in sidelit areas >250 ft^2 (23 m^2) and toplit areas >900 ft^2 (84 m^2)
Exterior lighting 9.4.1.7	Lighting must be controlled by photosensor or time switch	At night light must either be off or operated at reduced level
Functional testing 9.4.4	None	All installed controls must be tested

TABLE 2. Comparison of ASHRAE 90.1 prescriptive requirements, 2007 and 2010

Requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Economizer exemptions Table 6.3.2	Only for unitary equipment, EER/SEER (COP/SCOP) rating	For all HVAC system types, must meet % efficiency improvement, now required in most climate zones
Lighting power density 9.2.1	NA	Reduced, average 17% in space types, more for retail display lighting

COMMON ISSUES WITH ENERGY MODELING

Thoroughly review both ASHRAE 90.1–2010 and the 90.1–2010 User's Manual. The manual presents extended explanations and also includes examples of the concepts and requirements within the standard. Table 3 addresses many of the most common issues but is not a comprehensive list.

TABLE 3. Common issues with energy modeling, by ASHRAE 90.1 section

Building envelope	
Baseline building envelope	Construction type and maximum U-factors for baseline walls, roofs, and floors are specified by Table G3.1-5 Baseline (b). The constructions for walls, roofs, and floors are specified by the standard and do not depend on the proposed design. For example, if a building has concrete masonry walls, the baseline model will still have steel-framed walls.
Existing building envelope	For existing envelopes, model the baseline case as described above. Model the existing envelope in the proposed case as described below. Table G3.1-5 Baseline (f) is not applicable.

TABLE 3. (CONTINUED) Common issues with energy modeling, by ASHRAE 90.1 section	
Proposed model U-values	The proposed model must reflect the building as designed or built. To the extent possible, construction assemblies need to match the dimension and U-value inputs in the model. If changes will be made to the envelope, apply Appendix A to the proposed envelope. Provide the assembly U-value, rather than a point U-value, by determining the overall construction assembly U-value that takes into account thermal bridging, as shown in Appendix A. Ensure that window U-values are input as the assembly U-value, which takes into account the U-value of the framing system. The center-of-glass value is not acceptable.
HVAC	
Baseline HVAC system selection	The HVAC system for the baseline model must be selected based on requirements in ASHRAE 90.1–2010, Section G3.1.1. The system selected will depend on the base building type, size, and heat source. Building type must be based on predominant conditions (i.e., those that account for the majority or plurality of the building area), and no space types can be excluded from the model. Project size is determined from conditioned area. Once the floor area of the predominant condition is known, consult Table G3.1.1A to determine the predominant baseline HVAC system. Section G3.1.1 also specifies whether HVAC systems must be modeled with a system per floor or a system per thermal block. Systems 1–4 are modeled with one system per thermal block and systems 5–10 with one system per floor, using systems 9 and 10 where applicable. When multiple floors have identical thermal blocks, those floors may be combined in the energy model. Note that a floor with a roof and a floor without a roof do not have identical thermal blocks and cannot be combined. A multistory building with identical thermal blocks would need to be modeled with no fewer than three floors: a ground floor, a middle floor with appropriate multiplier, and a top floor. When using Table G3.1.1A, check for nonpredominant conditions. The area of nonpredominant conditions can be deducted from the total area when determining the baseline HVAC system. If nonpredominant conditions apply to more than 20,000 ft^2 (1 860 m^2), project teams must use exception (a) and select an additional baseline HVAC system type to serve those spaces. If the LEED project meets the requirements for one of the exceptions outlined in G3.1.1, then the baseline HVAC system for the project must be selected as outlined in the exception.
Baseline HVAC system selection (laboratory spaces)	If laboratory spaces in the building have a total laboratory exhaust rate greater than 5,000 cfm (2 360 L/s), a single system of type 5 or 7 must be modeled to serve only those spaces. Section G3.1.2.11 requires exhaust air energy recovery in accordance with Section 6.5.6.1, which is likely to include laboratories. Refer to 90.1–2010 for details.
Baseline HVAC system selection (kitchens)	If kitchens in the project space have a total exhaust hood airflow rate greater than 5,000 cfm (2 360 L/s), system type 5 or 7 must be modeled and must include demand-controlled ventilation. Refer to 90.1–2010 for details.
Baseline HVAC system fuel type	Any project with a combination of fossil fuel and electric heat serving the same space must use the fossil-fuel baseline HVAC system (systems 1, 3, 5, and 7) unless it meets one of the exceptions to G3.1.1.
Baseline fan power	The baseline fan power is calculated according to Section G3.1.2.10, which indicates that the system fan power is based on the supply airflow and distributed to supply, return, exhaust, and relief fans. If the proposed system has additional return, exhaust, and/or relief fans, the team may not adjust the baseline model to account for the additional fan power. Section G3.1.2.10 also includes Table G3.1.2.9, whose value A is calculated according to Section 6.5.3.1.1 using pressure drop adjustments. Pressure drop adjustments may not be taken for system types 1, 2, 9, or 10. The calculations are straightforward, but a common issue involves pressure credits. Table G3.1.2.9 allows pressure drop adjustments for evaporative coolers or heat recovery devices only when they are required in the baseline building system. Also, the pressure drop adjustment is applicable only to the design airflow through each device. For example, if only the ventilation air is filtered with a MERV 13 filter, then only the ventilation airflow rate may apply the 0.9 in. w.c. (224.2 Pa) adjustment, and not the entire supply airflow rate. Pressure credit may be taken only for those filters present in the proposed project. For fully ducted return and/or exhaust air systems, the fan power allowance is based on plenum return. The credit can be applied only when the return is fully ducted; systems that have a combination of ducted and nonducted may not use this pressure credit. For return or exhaust airflow control devices (which maintain a specific pressurization relative to other spaces), a project team claiming this credit in spaces other than a laboratory, hospital, or similar space type must provide evidence of this control device. The credit may be applied only for the amount of airflow passing through the control device. A project team using the modeling software to automatically determine the baseline building fan power must ensure that the correct allowance has been calculated. Publicly available fan power calculators can be used to verify and determine the correct fan power.
Proposed HVAC system sizing	Table G3.1.1(a) requires that the proposed building be consistent with the design documents, including envelope, lighting, HVAC, and service hot water systems. Additionally, all end-use load components within and associated with the building must be modeled. Table G3.1.10(b) specifically requires that the model be consistent with the design documents. All modeled HVAC system parameters (e.g., fan volumes, fan powers, efficiencies, heating and cooling capacities) must be consistent with the mechanical schedules and drawings. The simulation should never be allowed to automatically size the HVAC system for the proposed case model when there is a complete design.

TABLE 3. (CONTINUED) Common issues with energy modeling, by ASHRAE 90.1 section	
Heat pumps (operation)	Section G3.1.3.1 describes the operation of baseline building heat pumps. The operation of the heat pump was specifically address in ASHRAE Interpretation 90.1–2007-09, which means that the heat pump and auxiliary heat should operate together at low temperature conditions, with the compressor as the lead machine. The outside air cutoff temperature for the compressor must be no greater than the temperature associated with the low-temperature heating efficiency requirements of Table 6.8.1B (17°F) (–8.3°C). The HSPF rating for packaged heat pump units smaller than 65,000 Btuh (19kW) and packaged terminal heat pumps accounts for electric auxiliary operation, and includes test conditions at 17 degrees F (–8.3°C). The heat pump efficiency curves in the model should reflect the heat pump ratings that account for simultaneous operation of the electric resistance *and* heat pump elements below 40°F (4.4°C).
Unitary heating and cooling efficiencies	Use the correct Table 6.8.1 to determine equipment efficiencies: Table 6.8.1A for system types 3, 5, and 6 Table 6.8.1B (with electric resistance heating section) for system type 4 Table 6.8.1D for system types 1 and 2 These efficiencies are based on the capacity of each system individually, not a sum of all units. It is important to correctly adjust efficiencies of each piece of equipment to separate fan power at AHRI rating conditions, per Section G3.1.2.1. Most simulation software programs can perform this step automatically.
Humidity controls	Humidification must be modeled identically in the baseline and the proposed models since it is not addressed in Appendix G. Use the exceptional calculation method if claiming savings. If the proposed project includes dehumidification controls, they must be modeled as designed. Dehumidification controls may be modeled in the baseline only if one of the exceptions to Section 6.5.2.3 applies. Exception (d) for process dehumidification does not apply to computer rooms. Table G3.1.4 requires that identical schedules be used in both models, and this includes humidity setpoints. A problem may arise if the proposed building has a dedicated outdoor air system (DOAS) that maintains proper humidity. PTAC or small DX systems in the baseline design may not be able to maintain both temperature and humidity simultaneously in the same way that the proposed system can. The project team may then incur a penalty for higher humidity levels in the baseline building. In this situation, model a DOAS in the baseline design using the same volume of outdoor air as for the proposed design, but modeled with the same efficiency and efficiency curves as the baseline HVAC systems. Additionally, the baseline fan power allowance would be separated between the DOAS and the baseline system using the same ratio as the proposed system.
Ventilation	
Ventilation rate inputs	Table G3.1.10(b) requires that the proposed building ventilation rate be consistent with the rate indicated on the mechanical schedule. Section G3.1.2.6 requires that the ventilation rate be identical between the proposed and baseline buildings, and states that reduced ventilation “is not considered an opportunity for energy savings under the Performance Rating Method; ventilation is energy neutral, per the User’s Manual. However, there are exceptions to this requirement.
Ventilation (above minimum required)	Exception (c) penalizes projects for providing more ventilation air to the space than is required by ASHRAE 62.1 or local code, whichever requires more ventilation air. If the proposed project provides outdoor air in excess of the amount required, the baseline must be modeled with the required ventilation rates, which will be lower than the proposed ventilation rate. This creates an “energy penalty” for the additional fan and conditioning energy. For various reasons, however, it is common practice to specify slightly more ventilation air than required. A project team that has specified up to 5% more total ventilation air than required may model identical ventilation flows. If exhaust requirements dictate the amount of ventilation air that must be provided to the building (as indicated in Section 5.9.2 of ASHRAE 62.1–2010), the project team should model the ventilation rate identically in both designs. Provide an explanation and documentation or calculations to show that exhaust requirements exceed the minimum ventilation flows.
Demand-control ventilation and nighttime ventilation requirements	Exception (a) allows credit for demand-control ventilation when it is not required by Sections 6.3.2(p) or 6.4.3.9. If demand-control ventilation is being modeled for credit, Table G3.1.4 (baseline) indicates that schedules may be modified and allowed to differ to take it into account, provided the schedules are approved by the rating authority. In this instance, project teams must submit both proposed and baseline ventilation schedules. ASHRAE 90.1, Section 6.4.3.4.3, requires shutoff dampers that automatically shut during unoccupied periods when the HVAC system cycles on and off to meet loads except when ventilation reduces energy costs (e.g., night purge), or when ventilation must be supplied to meet local requirements (such as minimum flow requirements for hospital or chemical storage rooms during unoccupied periods). Therefore, the demand-control ventilation schedules presented for both the baseline and proposed cases should show zero outside airflow during unoccupied periods unless the supplemental documentation supports that ventilation during unoccupied periods reduces energy cost or is required by local code, in which case the baseline and proposed ventilation rates during unoccupied periods must be modeled with identical flow rates. Additionally, the baseline ventilation flow must be modeling using minimum required rates.

TABLE 3. (CONTINUED) Common issues with energy modeling, by ASHRAE 90.1 section

Ventilation (zone air distribution effectiveness)	Exception (b) allows for lower ventilation rates in the proposed building for efficient ventilation system designs that have high zone air distribution effectiveness (E_z >1.0), as determined by ASHRAE 62.1–2010. In this case, the baseline ventilation levels can be based on the proposed calculations, only with reduced zone air distribution effectiveness (E_z = 1.0). This makes the baseline outdoor airflow rates higher than the proposed outdoor airflow rates, so ventilation calculations must be submitted to claim the exception for a higher E_z in the proposed case. If a lower ventilation flow rate is an aspect of the design, the project team must provide ventilation rate procedure calculations for both the proposed and baseline designs, with the proposed building using the actual E_z value and the baseline building using an E_z value of 1.0 in each zone where the E_z value is greater than 1.0, but equal to the proposed building for all other zones where the E_z value is not greater than 1.0. If ASHRAE 62.1, Section 6.2, Ventilation Rate Procedure, is not used for the ventilation design, then this exception may not be used. Credit may not be taken, via ventilation flows, for any other ventilation design, such as a 100% outdoor air unit. Additionally, credit may not be taken for increased system ventilation efficiency, E_v, of a proposed ventilation system compared with a baseline ventilation system; Appendix G does not allow this. The only exception would be a different E_v value due to an E_z greater than 1.0, as described above.
Natural ventilation	The ASHRAE User's Manual indicates that an exceptional calculation method is not required for natural ventilation, and gives some further examples. Perform sufficient analysis to document that loads can be met when credit is taken for passive cooling and natural ventilation using a simulation tool capable of ensuring thermal conditions are met with natural ventilation. A simple load calculation is not sufficient.
Service water heating	
Hot water demand	Hot water demand savings from low-flow fixtures must be derived from WE Prerequisite or WE Credit Indoor Water Use Reduction calculations.
Lighting	
Lighting power density, method	Lighting power must be determined using the same categorization procedure (building area or space-by-space method) in both the proposed and baseline models.
Lighting power density, luminaire wattage	Table G3.1.6 requires that the proposed lighting power include all components shown on the plans and be determined in accordance with Sections 9.1.3 and 9.1.4. Ensure that the lighting calculations include all task lighting except where specifically exempted by ASHRAE 90.1. Ensure that all power used by the luminaires, including lamps, ballasts, transformers, and controls is taken into account. For track and other flexible lighting systems, use the specified wattage of the transformer supplying the system. The sum of lamp wattages will not necessarily meet the requirements of G3.1.6.
Lighting power density, additional lighting power	ASHRAE 90.1, Section 9.6.2, addresses the use of additional lighting power for decorative lighting, in retail areas, or when additional controls have been installed. Additional lighting is allowed only when using the space-by-space method and if it is "installed and automatically controlled, separately from the general lighting, to be turned off during nonbusiness hours." Therefore, the general lighting system must be separate and capable of providing general illumination to the space, and the additional lighting must have automated controls that shut it off during nonbusiness hours even when the general lighting remains on. In retail applications, a common mistake is that the lighting may not be used for any purpose other than to highlight the merchandise. Project teams can model the additional lighting power up to what has actually been designed, and no more; the baseline building must be modeled equal to what has been designed or up to the lighting allowance from ASHRAE 90.1, Section 9.6.2, whichever is less (i.e., credit may not be taken for unclaimed additional lighting power). Note that only the sales area can be used in the lighting power allowance. For example, do not use the entire project floor area (which may include space with other purposes, such as checkout areas, corridors, or dressing rooms) to determine the allowance. ASHRAE 90.1–2010 now allows an additional lighting power allowance based on the application of additional controls and using the control factors found in Table 9.6.2. This additional allowance may be used anywhere in the building and is based on the total wattage in the given space to which the control method is being applied. Unlike the retail allowance, this allowance is earned with the application of the control methods and may be added to the baseline whether or not the project designs up to the full allowance.
Automatic lighting controls	ASHRAE 90.1, Table G3.1(g), indicates that only automatic lighting controls, such as occupancy sensors, that are in addition to the required minimum control (Section 9.4.1) may be taken for credit. One of the most common errors is taking credit for an occupancy sensor located in a conference room; this is already a requirement of the baseline building. ASHRAE 90.1–2010 lists additional spaces that must have occupant sensors or timer switches that automatically turn off lighting. ASHRAE 90.1–2010 has added requirements for the lighting system and controls for buildings. Project teams are encouraged to read the standard, the User's Manual, and the lighting compliance forms to ensure that all mandatory measures have been met; these are prerequisites to LEED certification.

TABLE 3. (CONTINUED) Common issues with energy modeling, by ASHRAE 90.1 section	
Exterior lighting	Where exterior lighting is included in the LEED project, such as for a ground floor project with exterior entrances, and for terraces, patios, and balconies, whether existing or proposed, this end use must be included in the model. Exterior lighting is divided into allowances for tradable and non-tradable surfaces. No credit may be taken for lighting reductions on non-tradable surfaces. A lighting power allowance cannot be claimed in the baseline building for surfaces that are not provided with lighting in the actual design, and lighting fixtures cannot be double counted for different exterior surfaces.
Energy rates	Project teams must consistently use either actual utility rates or their state's average energy prices, published by the U.S. Department of Energy's Energy Information Administration for commercial building customers. The sources may not be mixed.

RATING SYSTEM VARIATIONS

Retail

Option 1. For projects using tenant-level energy simulation, include all relevant process loads in the energy model and ensure that they are modeled accurately. Retail process loads can constitute a large proportion of the total energy consumption, and equipment selection can significantly affect savings.

Typical retail process loads include refrigeration equipment, cooking and food preparation, ice machines, display lighting for merchandise, clothes washing, and other major support appliances. Compare the energy consumption of each piece of equipment with the value indicated in Appendix 3, Tables 1–4. If the item is not included, use an accepted industry standard.

For hard-wired refrigeration, the modeling software may be used if the system can be modeled explicitly. Otherwise, a thermodynamically similar component model must be used, in accordance with Table G3.1.13. An example of this would be an analysis prepared using 8760 hourly weather data.

For commercial kitchen equipment and refrigeration defined in Appendix 3, Tables 1–4, no additional documentation is necessary to substantiate these predefined baseline systems as industry standard. Supporting documentation is still needed to verify that the proposed equipment includes the claimed energy-efficient features.

For other equipment not listed in the table, identify an appropriate standard, provide hourly energy use for the baseline and proposed models, estimate daily use hours, and include the total energy use in the energy model as a plug load.

For display lighting, use the space-by-space method to determine allowed lighting power under ASHRAE 90.1–2010.

Option 2. If the project team is using prescriptive compliance and intends to earn points under EA Credit Optimize Energy Performance, also comply with the prescriptive measures in Appendix 3, Tables 1–4, for 90% of total energy consumption for all process equipment.

PROJECT TYPE VARIATIONS

Central Plant or District Energy Systems

If the base building is served by a central thermal energy plant or a district thermal energy system and the project is following Option 1, the team may demonstrate compliance with EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance by using Path 1, ASHRAE 90.1–2010, Appendix G; Path 2, Full DES or central plant performance accounting; or Path 3, Streamlined DES modeling.

Scope of DES equipment inclusion. Downstream equipment (e.g., heat exchangers, steam pressure reduction stations, pumps, valves, pipes, controls) may not be located in a commercial interiors project, but when present, all such equipment must be included consistently in the scope of EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. Upstream equipment is included or excluded depending on the chosen compliance path.

The proposed design for any building air distribution systems, ground source heat pump loops, or water source heat pump loops must still be modeled consistent with Method 1 or 2 (see *Further Explanation, Contribution of Base Building HVAC and Service Water Heating Systems*).

Energy simulation versus postprocessing. Whenever possible, incorporate system and equipment performance parameters directly into the energy simulation. Potential methods include developing efficiency curves and scheduling equipment operation and curves. Postprocessing of DES performance is acceptable if reasonable simulation methods are not available or are too onerous. All postprocessing methodologies must be fully documented.

Path 1. ASHRAE 90.1–2010, Appendix G

Model the proposed and baseline designs using purchased energy according to ASHRAE 90.1–2010, Appendix G. The project may be modeled using purchased energy even if the building's central plant generates the thermal energy for the project space.

Energy rates

All virtual DES energy rates must be identical in the baseline and proposed cases. If tariffs or rates are not available from the district plant servicing the project, such as campus or military plants, or for central plants located within the building, calculate the rates based on the virtual electric and fossil fuel rates from the model.

If a flat rate structure, in which the cost per unit of energy is the same throughout the year and there are no demand charges, is being used for all energy sources, then those flat rates become the virtual energy rates for the project.

If all energy rate structures are not flat, a preliminary run of the baseline case energy model must first be completed to identify the virtual electric and fossil fuel rates for the project. For this preliminary run only, the rate for the energy supplied by the DES or central plant may be left blank or entered as any value.

Once all the virtual energy rates are identified for electricity and fossil fuel, calculate the virtual DES or central plant rates for both the baseline and proposed cases, using the values in the minimum energy performance calculator provided by USGBC.

Exception: to obtain the virtual fuel rate when the connected project does not use fossil fuel but the DES or central plant does, use a flat rate consistent with the central plant rates or the historical average local market rates. No preliminary model run is needed. Input the virtual DES or central plant rates into the modeling software for each DES or central plant source and use for the remainder of the process. Alternatively, calculate the DES or central plant energy costs directly by multiplying the DES or central plant energy consumption for each DES or central plant source by its virtual DES or central plant rate.

Path 2. Full DES or central plant performance accounting

Path 2 is available to projects connected to a central plant or DES that wish to account for average efficiency across a smaller time step. The energy model scope accounts for both downstream equipment and upstream equipment and requires calculation of the district energy average efficiencies using either modeling or monitoring.

Energy rates

All DES energy rates must be identical in both the baseline and the proposed cases. Use local rates as they would normally apply to the project for the energy sources under consideration. For energy sources used by the DES but not normally available to the building, such as diesel fuel, use the rates charged to the DES. If this information is not available, use representative market rates.

Exception: For DES plants that operate under specific and atypical rate structures and actively take advantage of those rates through strategies such as load management or energy storage, use the rate structures as they apply to the DES.

Baseline plant

Model the baseline case with a dedicated plant that is compliant with ASHRAE 90.1–2010, Appendix G, baseline requirements. Model the baseline building plant with conventional equipment using performance parameters and efficiencies per ASHRAE 90.1–2010, using energy sources corresponding to the DES or central plant.

Proposed plant

Model the proposed case with a virtual central plant or DES-equivalent plant. Model a virtual plant with the same efficiencies as the entire upstream DES heating, cooling, and combined heat and power (CHP) system, including all distribution losses and energy use. Equipment efficiencies, distribution losses, and distribution pumping energy may be determined using any of the following methods:

- Monitored data
- Engineering analysis
- Default values

Efficiencies and losses may be determined and modeled at any level of time resolution, from hourly to annual. However, the time resolution must be sufficiently granular to capture and reasonably represent any significant time- or load-dependent interactions between systems, such as thermal storage or CHP.

Monitoring data for heating, cooling, pumping, and cogeneration may be used only if the thermal loads that are monitored represent at least 90% of the load on the building, campus, or district plant predicted after occupancy of the project space.

Monitoring and analytical methods may be combined as necessary and appropriate. Whether using monitoring or an analytical method, the methodologies must be fully documented. The following specific requirements apply.

Heating and cooling plants

Efficiencies, whether determined through monitoring or analytically, must include all operational effects, such as standby, equipment cycling, partial-load operation, internal pumping, and thermal losses.

Thermal distribution losses

For central plants located inside the project building, the thermal losses are assumed to be zero. For district systems, use monitored data or an engineering analysis.

- If using monitored data, determine the distribution losses for the DES by measuring the total thermal energy leaving the plant and comparing it with the total thermal energy used by the buildings connected to the DES. De-rate the plant efficiency accordingly in the energy model:

$$\%\ \text{plant efficiency} \times \left\{ 100\% - \text{distribution loss } (\%) \right\}$$

- An engineering analysis takes into consideration all distribution losses between the DES and the building. For distribution main losses, use a prorated amount based on load. For dedicated branch losses, use the total losses of the branch that feeds the building, including heat losses and steam trap losses. Compare the total losses with the total load of the building to get a percentage distribution loss relative to load and downgrade the plant's efficiency accordingly in the energy model.

Pumping energy

Whether through monitored data or engineering analysis, determine pumping energy for the project by prorating the total pump energy of the DES or central plant by the ratio of the annual thermal load of the project space to the total annual DES thermal load. Model the pump energy as auxiliary electrical load. Pumping energy must be determined or estimated where it applies (i.e., there is no default value).

Default efficiencies and losses

Actual efficiency performance data on the DES serving the project building are preferred. If the project team cannot obtain or determine the actual performance data, use the following default values. These values are conservative and are intended to represent a DES with relatively low efficiency; a well-designed, well-operated DES generally performs better.

- DES heating plant: 70% (higher heating value, HHV) for the total boiler plant average efficiency
- DES cooling plant: coefficient of performance (COP) of 4.4 for the total cooling plant average efficiency (including cooling towers and primary pumps)
- Thermal distribution losses, including minor leaks or condensate losses:
  - Chilled water district cooling, 5%
  - Hot water district heating, 10%
  - Closed-loop steam systems, 15%
  - Open-loop steam systems, 25%

For steam systems that are partially open and partially closed, prorate between the above 15% and 25% losses in accordance with the fraction of expected or actual condensate loss.

The above guidance assumes that DES-generated heat is used for heat in the connected building, and DES-generated cooling is used for cooling in the connected building. If the DES produces heating that is then converted to cooling for the connected building using absorption chillers or other similar technology, this guidance must be modified (see *CHP Modeling Guidance*).

Path 3. Streamlined DES modeling

Path 3 is applicable for simple district energy systems. The energy model scope accounts for both downstream equipment and upstream equipment and also requires calculation of the district energy average efficiencies using either the modeling or monitoring methods.

Energy rates

Use Streamlined DES Modeling in the calculator provided by USGBC to allocate the energy costs to the results of the model for each district energy source, in lieu of the purchased energy rates, to determine the baseline energy cost.

Baseline plant

Calculate the average annual efficiency values for each district or central plant fuel source used to generate and distribute the thermal energy, based on ASHRAE 90.1–2010, Appendix G, baseline case requirements. These values depend on the ASHRAE 90.1–2010 system type that would be selected for the building if the baseline case were modeled with on-site equipment. The calculations for baseline cost per district energy source are the same as those for the proposed case model, except that the average efficiency is constant.

Proposed plant

Determine a single value for average annual efficiency, including thermal losses and distribution energy, for each district or central plant fuel source used to generate and distribute the thermal energy. For example, for chilled water:

$$COST(CHW)_{BUILDING} = CHW_{BUILDING} \times \sum_{i} (Cost_i \times \eta_i)$$

where

$COST(CHW)_{BUILDING}$ = proposed case cost of chilled water

$CHW_{BUILDING}$ = building energy model metered data for chilled water consumption

i = each fuel source used at the district plant to generate or distribute chilled water (e.g. electricity, diesel oil)

$Cost_i$ = virtual energy rate for each fuel source (in $/unit energy). This should match the proposed case virtual energy rate for fuel sources present in the building, and should be supported by local energy tariffs for fuel sources not present in the building.

η_i = average efficiency calculated for each fuel source

CHP modeling guidance

The baseline case is modeled as described in ASHRAE 90.1, Appendix G, and as summarized in the steps for each path. The baseline model assumes separate production of electricity and thermal energy. Although not modeled as CHP, the baseline case is charged with extra energy use for CHP energy accounting purposes in some situations.

The proposed case may be modeled in various ways.

- The average electricity generation, fuel input, and heat recovery of the CHP must be determined, or the defaults for electric and thermal efficiency (below) must be used in conjunction with capacity ratings of the equipment.
- Calculate annual electricity generation using one of the following methods:
  - Monitor the total annual gross electricity generation. Also monitor the total annual parasitic loads, such

as the annual electricity used for cooling the intake air for a turbine. Calculate the net annual electricity generation by subtracting all parasitic loads from the annual gross electricity generated.
    - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators. Apply measured or estimated load profiles as process loads to reflect the estimated total electric and thermal loads on the district energy CHP system. Use the total energy generated and total fuel input from this analysis. Any parasitic loads must be included in the analysis and subtracted from the annual electricity generation.
- Calculate annual fuel input using one of the following methods:
    - Monitor the total annual fuel input to the generators.
    - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators.
- Calculate waste heat recovery using one of the following methods:
    - Monitor the total waste heat recovered.
    - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators. Model the thermal equipment served by the CHP waste heat, such as boilers and absorption chillers, using the installed equipment capacities, efficiencies, and efficiency curves, and reflecting the total heating and cooling loads on the plant as a process load. Use the energy modeling outputs to identify the total heat recovered.

For baseline CHP electricity output, follow the general procedures described in this section for the proposed case, and adjust the results as follows depending on the results of the DES electricity allocation and the total modeled electricity use of the building in the Path 2 or Path 3 proposed case, including the electricity consumption of district plant equipment serving the building or project space:

- Scenario A. If the building's allocation of CHP-generated electricity is less than or equal to its modeled electricity consumption, no adjustment is necessary. The baseline project is charged with the energy used by its (non-CHP) systems at market rates using standard procedures.
- Scenario B. If the project's allocation of CHP-generated electricity exceeds its modeled electricity consumption, the amount of excess CHP electricity allocated to the building is considered process energy in the energy model. Adjust the input fuel associated with this excess CHP electricity in the baseline case as described in CHP fuel input.

For the proposed design's CHP electricity output, allocate the electricity generation to the building or project space based on the fraction of thermal loads for the DES sources that use recovered waste heat. For each DES source, determine the fraction of the recovered waste heat applied to that source as well as the amount serving the project building. For relatively simple DES systems, in which the recovered waste heat is used directly in the DES, and for which waste heat serves only heating loads in the connected buildings, use the formula for simple systems:

$$CHP\_ELEC_{BLDG}(\text{simple systems}) = (X_{HEAT} \times BLDG_{HEAT}) \times CHP\_ELEC_{TOTAL}$$

where

CHP_ELEC_{BLDG}	=	CHP electricity generation allocated to building
X_{HEAT}	=	fraction of CHP plant's total production of waste heat applied to the DES directly
$BLDG_{HEAT}$	=	fraction of total district heat provided to building
CHP_ELEC_{TOTAL}	=	total CHP electricity generated at DES plant

For CHP plants in which a portion of the recovered heat is used to drive absorption chillers that provide cooling through a DES chilled-water loop, or a portion of the recovered heat is used for a third, separate district energy source (e.g., if the building connects to both a steam loop and a hot-water loop), calculate the electricity generation assigned to each building using the formula for heat recovery-driven chillers.

$$CHP\_ELEC_{BLDG}\text{ (heat recovery-driven chillers)} = (X_{HEAT} \times BLDG_{HEAT}) + (Y_{CHW} \times BLDG_{CHW}) + (Z_{SOURCE} \times BLDG_{SOURCE}) \times CHP\_ELEC_{TOTAL}$$

where

CHP_ELEC_{BLDG} = CHP electricity generation allocated to building

X_{HEAT} = fraction of CHP plant's total production of waste heat applied to the DES directly

$BLDG_{HEAT}$ = fraction of total district heat provided to building

Y_{CHW} = fraction of CHP plant's total production of waste heat applied to producing chilled water in DES

$BLDG_{CHW}$ = fraction of total district chilled water provided to building

Z_{SOURCE} = fraction of third district energy source provided to building

$BLDG_{SOURCE}$ = fraction of third district energy source provided to building

CHP_ELEC_{TOTAL} = total CHP electricity generated at DES plant

When modeling CHP fuel input, allocate the CHP input fuel to the project building based on a proration and assignment of the total input fuel according to the results of the CHP electricity allocation described above for CHP electricity output. Use the prevailing energy rates as they apply to the project. Any additional energy used by the proposed design is also charged at market rates.

For the proposed case, calculate the CHP input fuel allocated to the building as follows:

$$\text{Proposed } BLDG_{FUEL} = \left(\frac{CHP\_ELEC_{BLDG}}{CHP\_ELEC_{TOTAL}}\right) \times CHP_{FUEL}$$

where

Proposed CHP_ELEC_{BLDG} = proposed case CHP input fuel allocated to building

CHP_ELEC_{TOTAL} = CHP electricity generation allocated to building (from previous calculations)

CHP_{FUEL} = total CHP electricity generated at DES plant

CHP_ELEC_{TOTAL} = total CHP fuel input for electricity generation at DES plant

For the baseline (scenario B in CHP electricity output only), calculate the CHP input fuel allocated to the building as follows:

$$\text{Baseline } BLDG_{FUEL} = \left(\frac{PROCESS\_ELEC_{BLDG}}{CHP\_ELEC_{TOTAL}}\right) \times CHP_{FUEL}$$

with

$$PROCESS\_ELEC_{BLDG} = CHP\_ELEC_{BLDG} - PROPOSED\_ELEC_{BLDG}$$

where

Baseline $BLDG_{FUEL}$ = baseline case CHP input fuel charged to building

$PROCESS\_ELEC_{BLDG}$ = amount of allocated CHP electricity in excess of building's modeled annual electricity consumption (treated as process energy in model)

CHP_ELEC_{TOTAL} = total CHP electricity generated at DES plant

CHP_{FUEL} = total CHP fuel input for electricity generation at DES plant

CHP_ELEC_{BLDG} = CHP electricity generation allocated to building (from previous calculations)

$PROPOSED\_ELEC_{BLDG}$ = modeled electricity consumption for building from proposed case

The model must include CHP generator default efficiencies. Actual efficiency performance data on the CHP serving the project is preferred, based on either ongoing operations (existing CHP) or design specifications (new CHP). If the project team cannot obtain the actual performance data, use the following default seasonal performance values. These values are conservative and intended to represent a CHP system with relatively low efficiency; a well-designed, well-and operated CHP system generally performs better.

- Generator electrical efficiency, 22%
- Generator thermal efficiency, 25%
- Single-effect absorption chillers, 0.60 COP
- Double-effect absorption chillers, 0.90 COP
- Absorption cooling plant electrical efficiency, including cooling towers and primary pumps, 40 COP

Special situations for DES energy models

Service water heating

If service water is heated in full or in part by a DES or central plant, consider modeling the energy source as purchased energy to hold the DES cost-neutral for service water heating. If desired, project teams using Path 2 or Path 3 may use an exceptional calculation method to document DES-related savings from service water heating. Project teams that elect to document savings must fully justify and support the annual energy consumption and cost in both the baseline and the proposed models. Use a reasonable, well-founded purchased energy rate in the models, such as the actual rate paid to the DES supplier or a virtual rate.

Heating converted to cooling

Sometimes the district or campus system heating energy supply is converted to chilled water using absorption chillers or other similar technologies to serve cooling loads. In this circumstance, the equipment that converts heating to cooling may reside within the DES itself (i.e., the DES provides cooling to the building) or within the connected buildings (i.e., DES provides heating to the building; building converts heating to cooling).

Other atypical systems.

DES also often incorporate unconventional features, such as thermal storage, ground or surface water cooling, and waste heat recovery. These features should be incorporated into the proposed virtual plant to the greatest extent practical using the general principles presented in this guidance.

INTERNATIONAL TIPS

Option 1. Tenant-Level Energy Simulation. Consult ASHRAE/ASHRAE/IESNA Standard 90.1–2010, Appendices B and D, to find the project's climate zone. Use Table B-2 (Canada) or Table B-3 (International) if the location is listed. For locations not listed in Table B-3, use Table B-4, along with the climate type definitions in Section B2, plus Appendix D to determine climate zone.

For example, a team working on a project in Beijing consults ANSI/ASHRAE/IESNA Standard 90.1–2010, Appendix B, to determine the appropriate climate zone. Table B-3 does not give a climate zone for Beijing.

The project team finds Beijing in Table D-3, which lists the values for heating degree-days to base 65°F or 18°C (HDD65 of HDD18) as 5252, and cooling degree-days to base 50°F or 10°C (CDD50 or CDD10) as 4115. The team uses these values to determine Beijing's climate zone as defined in Appendix B, Section B2 and Table B-4.

Beijing is in a "moist climate" because its warmest month has a mean temperature higher than 72°F (22.2°C) and is therefore too warm to be a "marine climate," and annual rainfall data indicate that the city is not in a "dry climate."

Finally, the project team uses the values found in Table D-2 for HDD65 (5252) and CDD50 (4115) in Table B-4 and determines that Beijing is in Zone 4A (mixed-humid) because the CDD50 value is 4500 or less, and the HDD65 value is between 3600 and 5400.

If ASHRAE 90.1–2010 is not applicable, Option 1 requirements can be met with a USGBC-approved equivalent standard.

Option 2. Prescriptive Compliance. A project outside the U.S. may install products not labeled under the ENERGY STAR program if they meet the ENERGY STAR product specifications, available on the ENERGY STAR website. All products must meet the standards of the current version of ENERGY STAR as of the date of their purchase.

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Appendix G energy modeling inputs	X	
Input and output reports from modeling software	X	
Exceptional calculations (if applicable)	X	
Energy consumption and demand for each end use and fuel type	X	
Fuels rates	X	
Target Finder results and summary	X	X
Lighting power density calculations		X
ENERGY STAR appliance percentage		X

RELATED CREDIT TIPS

Integrative Process Credit. Project teams intending to pursue the related credit must perform a preliminary energy analysis of at least two design options to understand the effects of load reduction strategies on energy use in the tenant space. This may take the form of a modeling exercise or a comparison of established measures. The analysis will inform the project team's approach to achieving this prerequisite through Option 1. The concept model should be prepared early—during predesign or schematic design, before undertaking a preliminary energy model.

EA Credit Optimize Energy Performance. Developing an early phase energy model focused on load reduction and establishing an energy savings goal for the project will ensure that the project is eligible to receive points under the related credit for any energy cost savings beyond the prerequisite's 3% minimum threshold. Consider the requirements for EA Credit Optimize Energy Performance prior to initiating the energy model, to ensure that the criteria for both the prerequisite and the credit are met. Further reduction of the connected lighting power density and the installation of ENERGY STAR appliances, office equipment, electronics, and commercial food service equipment beyond the prerequisite requirements for Option 2 may help the team earn points under the related credit.

EA Credit Renewable Energy Production. Consider renewable energy production for the project during early design. Although renewables cannot be counted toward this prerequisite, they are a viable energy cost savings measure that can achieve points for two related EA credits, Renewable Energy Production and Optimize Energy Performance.

EA Credit Green Power and Carbon Offsets. If the team is pursuing Option 1 of this prerequisite, the energy model output will be used to calculate the amount of green power required to meet the related credit requirements.

WE Prerequisite Indoor Water Use Reduction. For projects pursuing Option 1 of this prerequisite, hot water demand savings from low-flow fixtures must be derived from the related prerequisite's calculations.

EQ Prerequisite Minimum IAQ Performance. For projects pursuing Option 1 of this prerequisite, as-designed ventilation flow rates reported in the related prerequisite must correspond to the inputs in the proposed energy model.

CHANGES FROM LEED 2009

The prerequisite now includes two options: Option 1, Tenant-Level Energy Simulation, and Option 2, Prescriptive Compliance.

Option 1. Tenant-Level Energy Simulation

- Tenant-level modeling now more closely follows that for whole buildings.
- The LEED methodology for modeling shared HVAC systems has been revised to allocating a percentage of the shared systems to the LEED project. Specific guidance for this allocation is included in *Further Explanation, Contribution of Base Building HVAC and Service Water Heating Systems*.
- The baseline case must follow Appendix G requirements for all components and systems, including the building envelope. Existing conditions are not permitted to be modeled for the baseline case.

Option 2. Prescriptive Compliance. The requirements of the 2009 prerequisite were adapted to become Option 2 in LEED v4.

REFERENCED STANDARDS

ANSI/ASHRAE Standard 90.1–2010, Energy Standard for Buildings Except Low-Rise Residential Buildings: ashrae.org

Standard 90.1–2010 User's Manual: ashrae.org

ENERGY STAR: energystar.gov

COMNET Commercial Buildings Energy Modeling Guidelines: comnet.org/mgp-manual

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

combined heat and power an integrated system that captures the heat, otherwise unused, generated by a single fuel source in the production of electrical power. Also known as cogeneration. (Adapted from U.S. Environmental Protection Agency)

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

downstream equipment the heating and cooling systems, equipment, and controls located in the project building or on the project site and associated with transporting the thermal energy of the district energy system (DES) into heated and cooled spaces. Downstream equipment includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

plug load or receptacle load the electrical current drawn by all equipment that is connected to the electrical system via a wall outlet

process energy power resources consumed in support of a manufacturing, industrial, or commercial process other than conditioning spaces and maintaining comfort and amenities for building occupants of a building. It may include refrigeration equipment, cooking and food preparation, clothes washing, and other major support appliances. (ASHRAE)

process load or unregulated load the load on a building resulting from the consumption or release of process energy (ASHRAE)

regulated load any building end use that has either a mandatory or a prescriptive requirement in ANSI/ASHRAE/IES Standard 90.1–2010

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE PREREQUISITE

Fundamental Refrigerant Management

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To reduce stratospheric ozone depletion.

REQUIREMENTS

Do not use chlorofluorocarbon (CFC)-based refrigerants in new heating, ventilating, air-conditioning, and refrigeration (HVAC&R) systems. When reusing existing HVAC&R equipment, complete a comprehensive CFC phase-out conversion before project completion. Phase-out plans extending beyond the project completion date will be considered on their merits.

Existing small HVAC&R units (defined as containing less than 0.5 pound [225 grams] of refrigerant) and other equipment, such as standard refrigerators, small water coolers, and any other equipment that contains less than 0.5 pound (225 grams) of refrigerant, are exempt.

BEHIND THE INTENT

Chlorofluorocarbons (CFCs) and other refrigerants contribute to the depletion of the stratospheric ozone layer. The thinning of this ozone layer is linked to many human health problems, such as skin cancer, to ecological effects, such as reduced crop yields, and to damage to the marine food chain.[1] To address these issues, the 1987 Montreal Protocol established an international agreement to phase out use of the most harmful ozone-depleting substances, including CFCs.

Production of CFCs was phased out in industrialized nations that signed the Montreal Protocol before December 1995 and in most other countries by 2010. Accordingly, new construction projects cannot install new CFC-based refrigeration. However, CFCs may still be used in previously installed HVAC equipment.

To further progress, this prerequisite supports the elimination of CFCs. Only equipment within the project scope must meet the requirements; however, project teams are strongly encouraged to choose base buildings with systems that do not use CFCs. Though both hydrochlorofluorocarbons (HCFCs) and CFCs contribute to ozone depletion, only CFCs must be addressed to meet this prerequisite.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT NEW EQUIPMENT THAT CONTAINS NO CFC REFRIGERANTS

Identify all new HVAC&R equipment installed as part of the project that contains refrigerant and confirm that CFC refrigerants are not used.

- The mechanical engineer is typically responsible for specifying equipment that meets the prerequisite requirements.
- Older or retrofit equipment with higher efficiency ratings are the most likely to have CFCs, but it is important to check the refrigerant type for all new equipment.

Renovations

STEP 1. IDENTIFY CFCS IN EXISTING EQUIPMENT

Inventory all existing HVAC&R equipment in the project and determine whether any items use CFC refrigerants.

STEP 2. PHASE OUT CFCS IN EXISTING EQUIPMENT

Before the project's completion, replace or retrofit all existing CFC-based HVAC&R equipment currently serving the ID+C space and within the purview of the project. This includes equipment dedicated to the space, whether located in the space or not, that can be influenced by the project owner. Existing small equipment with less than 0.5 pound (225 grams) of refrigerant is exempt from the prerequisite requirements.

- Projects are not required to address CFCs contained in base building equipment for this prerequisite.
- If the CFC phaseout cannot be completed before occupancy, see *Further Explanation, Postoccupancy Phaseout*).
- Projects that retain CFCs past initial occupancy, even if a phase-out plan is in progress, are ineligible for EA Credit Enhanced Refrigerant Management. The credit calculations must account for all refrigerants present at time of occupancy, except those contained in existing small equipment with less than 0.5 pound (225 grams) of refrigerant.

1. *Questions and Answers about the Environmental Effects of the Ozone Layer Depletion and Climate Change: 2010 Update, http://ozone.unep.org/Assessment_Panels/EEAP/eeap-report2010-FAQ.pdf.*

FURTHER EXPLANATION

POSTOCCUPANCY CFC PHASEOUT

If all CFC-based equipment cannot be replaced or retrofitted before the project's completion, adopt a CFC phase-out plan with a schedule. Develop a narrative that describes the circumstances that prevent CFC phaseout before the project concludes. Consider obtaining preapproval for a postoccupancy phase-out plan before submission for certification.

PROJECT TYPE VARIATIONS

District Energy Systems (DES)
All applicable downstream equipment within the purview of the project must meet the prerequisite requirements.

CAMPUS

Group Approach
Submit separate documentation for each project space.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	All equipment	Phaseout required
Equipment type	X	X
Refrigerant type	X	X
Installation date	X	X
CFC conversion or replacement plan		X
Refrigerant leakage rate, quantity		X
Phase-out completion date		X

RELATED CREDIT TIPS

EA Credit Enhanced Refrigerant Management. Selecting equipment that has low ozone depletion potential (ODP) and global warming potential (GWP), as well as no CFCs, will help achieve the related credit.

EA Credit Optimize Energy Performance. Alternatives to CFC and HCFC refrigerants, such as HFC-410A, have lower refrigerant impacts but may require higher levels of energy use. Some energy-efficient systems, like variable refrigerant flow (VRF), may increase the overall refrigerant impact because of the relatively higher amount of refrigerants their operation requires.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

U.S. EPA Clean Air Act, Title VI, Section 608, Refrigerant Recycling Rule: epa.gov/air/caa

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

chlorofluorocarbon (**CFC**)-**based refrigerant** a fluid, containing hydrocarbons, that absorbs heat from a reservoir at low temperatures and rejects heat at higher temperatures. When emitted into the atmosphere, CFCs cause depletion of the stratospheric ozone layer.

ENERGY AND ATMOSPHERE CREDIT

Enhanced Commissioning

This credit applies to:

Commercial Interiors (4-5 points)
Retail (4-5 points)
Hospitality (4-5 points)

INTENT

To further support the design, construction, and eventual operation of a project that meets the owner's project requirements for energy, water, indoor environmental quality, and durability.

REQUIREMENTS

OPTION 1. ENHANCED COMMISSIONING (4 POINTS)

Projects must complete the following commissioning process (CxP) activities for mechanical, electrical, domestic hot water, and renewable energy systems and assemblies in accordance with ASHRAE Guideline 0–2005 and ASHRAE Guideline 1.1–2007 for HVAC&R systems, as they relate to energy, water, indoor environmental quality, and durability.

- Review contractor submittals.
- Include systems manual requirements in construction documents.
- Include operator and occupant training requirements in construction documents.
- Verify systems manual updates and delivery.
- Verify operator and occupant training delivery and effectiveness.
- Verify seasonal testing.
- Review building operations 10 months after substantial completion.
- Develop an on-going commissioning plan.

OR

OPTION 2. MONITORING-BASED COMMISSIONING (5 POINTS)

Achieve Option 1.

Develop monitoring-based procedures and identify points to be measured and evaluated to assess performance of energy- and water-consuming systems.

Include the procedures and measurement points in the commissioning plan. Address the following:

- roles and responsibilities;
- measurement requirements (meters, points, metering systems, data access);
- the points to be tracked, with frequency and duration for trend monitoring;
- the limits of acceptable values for tracked points and metered values (where appropriate, predictive algorithms may be used to compare ideal values with actual values);
- the elements used to evaluate performance, including conflict between systems, out-of-sequence operation of systems components, and energy and water usage profiles;
- an action plan for identifying and correcting operational errors and deficiencies;
- training to prevent errors;
- planning for repairs needed to maintain performance;
- the frequency of analyses in the first year of occupancy (at least quarterly);
- Update the systems manual with any modifications or new settings, and give the reason for any modifications from the original design.

BEHIND THE INTENT

Enhanced commissioning is a natural extension of the fundamental commissioning (Cx) process. It provides owners, via the commissioning authority (CxA), further oversight and verification that the building will meet their expectations and requirements beyond the first day of occupancy. Enhanced commissioning gives the CxA the power to act as the owner's advocate by conducting in-depth reviews of the basis of design, design documents, and construction submittals. Training and a postconstruction verification visit are some of the enhancements that contribute to ongoing quality control and operations.

The CxA may make additions to the Cx plan to verify that the building operators will have the proper tools to manage the project's equipment efficiently and effectively, in conjunction with the base building equipment. Monitoring-based commissioning (MBCx) gives the owner, operators, and the CxA a continual stream of information that helps them identify operational issues as they occur, thereby saving time, money, and energy consumption over the lifetime of the tenant space.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT ONE OR BOTH OPTIONS

Use input from the CxA and the project team and select one or both options. Review the space type, the assumed occupancy type, and the project goals and scope. The team should be familiar with the credit requirements so that any gaps in scope or skill can be addressed (see *Further Explanation, Planning the Cx Process* and *Choosing an Appropriate CxA*).

- Option 1 is applicable to all projects.
- Option 2 is often appropriate for projects that are energy-intensive and will benefit from real-time data and the ability to track trends. The additional initial costs may be offset by maintaining the proper energy usage over time.

STEP 2. UPDATE DOCUMENTS TO INCLUDE ENHANCED Cx ACTIVITIES

Project documents should reflect the enhanced commissioning activities included in the project scope.

- Update the owner's project requirements (OPR), basis of design (BOD), and Cx plan (see *Further Explanation, Enhanced Commissioning Plan*).
- The CxA must ensure that the OPR, the BOD, and the Cx plan include all additional commissioning activities that will be conducted throughout the design and construction phases of the project.

Option 1. Enhanced Systems Commissioning

STEP 1. DEVELOP SYSTEMS MANUAL SCOPE AND FORMAT

During the design development phase, outline the scope and format for the project systems manual in order to include all the information necessary to operate, maintain, and recommission all energy-consuming systems within or serving the space.

- The CxA is responsible for working with the owner to develop and outline the requirements of the systems manual. Include operating staff in preparing the manual if the team is in place during design.
- Information for the systems manual is generally collected during construction and after completion of a project.

The basic scope and format of a systems manual are outlined in ASHRAE Guideline 0–2005, Annex O; the manual usually includes the following:

- Executive summary
- Owner's project requirements
- Basis of design
- System single-line diagrams

- Construction record documents and specifications
  - Approved submittals
  - As-built drawings
  - As-built sequence of operation
  - Original setpoints for all systems commissioned
  - Recommended schedule for recommissioning
  - Recommended schedule for sensor recalibration
  - Equipment operations and maintenance manuals
  - Equipment preventative maintenance schedules
  - Confirmation of completed training for the owner and occupants
  - Ongoing system optimization procedures
  - Final commissioning report

STEP 2. DEVELOP TRAINING REQUIREMENTS

Create training requirements (see *Further Explanation, Examples, Table 2*). Verify that they meet the scope of the owners' requirement for the operator training.

- Training requirements must be completed before the bid documents are final.
- Integrate requirements into the commissioning specifications, to be issued as part of the bid package during the construction document phase.

Training requirements include the following:

- List of those who should receive operational training, by position or name
- List of systems that require operator training
- Level of instruction required for each system
- Determination of whether the training provided by the equipment manufacturer is acceptable
- Tracking method to ensure that all required positions or persons receive training

STEP 3. ENSURE ENHANCED Cx SCOPE ITEMS ARE INCLUDED IN CONSTRUCTION DOCUMENTS

Confirm that the following items are included in the construction documents to be issued for bid:

- System manual requirements
- Operator and occupant training requirements

STEP 4. REVIEW CONTRACTOR'S SUBMITTALS

Ensure ongoing compliance with the OPR, BOD, and Cx requirements by reviewing the HVAC&R contractor's submittals.

- Conduct a submittal review by the CxA concurrently with the design team's review or, at the latest, before final acceptance by the engineer or architect of record.
- The CxA must document all issues discovered during the review process in a log, to be distributed to the project's design and construction teams (see *Further Explanation, Examples, Table 3*).
- The CxA must also confirm that all issues recorded in the log are addressed or resolved by the owner, design, or construction teams.
- Establish the submittal review process at the commissioning kickoff meeting included in the fundamental commissioning steps.

STEP 5. VERIFY TRAINING

Confirm that the training program has been completed according to the owner's requirements for all commissioned equipment.

- Training is required in order to ensure that the operating staff is fully knowledgeable about operating the equipment and systems. Typically, it is provided by the equipment manufacturer, general contractor, or subcontractors.
- A good training program covers all new HVAC&R equipment and associated controls as well as monitoring equipment and software (if Option 2 is pursued).
- It is recommended that the training cover all operating scenarios to help the building engineering team and tenant facilities staff understand the most effective and efficient way to operate the space.

As outlined in ASHRAE Guideline 0–2005, a robust training program will address the following:

- Emergency instructions and procedures

- Operation instructions and procedures
- Troubleshooting procedures
- Maintenance and inspection procedures
- Repair procedures
- Upkeep of the systems manual and associated maintenance documentation logs

STEP 6. DELIVER POSTCONSTRUCTION DOCUMENTS

Compete and deliver the necessary operating documents and reports to the owner before tenant occupancy to ensure a smooth transition from construction to operation. The project CxA must confirm delivery, and the final package must include the following:

- Up-to-date systems manual including operations and maintenance manuals for all commissioned equipment
- Documentation of operator training on all commissioned systems
- Completed functional performance test reports
- Up-to-date issues log detailing closed and open issues
- Updated Cx plan that outlines commissioning completed to date, plan for seasonal testing, plan for 10-month operational review, and plan for addressing open issues identified after the initial round of commissioning.

STEP 7. PERFORM SEASONAL TESTING, IF REQUIRED

Determine whether seasonal testing will be necessary, based on the project schedule.

- Both projects that reach substantial completion during peak heating or cooling months and projects that are occupied and operational before all equipment has been installed must create Cx plans and complete all necessary tests.
- The project CxA must be involved in seasonal testing, even if it occurs after the project is completed.

The results of seasonal testing and the issues log must be included in the final commissioning report (preferred) or issued as an addendum to the owner.

STEP 8. REVIEW OPERATIONS 10 MONTHS AFTER SUBSTANTIAL COMPLETION

Perform the 10-month review of operations after substantial completion to ensure that the space is being operated per the owners' requirements. The 10-month review may include the following:

- Interviews with the operations and maintenance staff
- Interviews with occupants
- Status of outstanding commissioning-related issues
- Comparison of current operations with the operations and maintenance plan that was documented as part of EA Prerequisite Fundamental Commissioning
- Follow-up functional performance testing, when required
- Trends in tenant space operations, as indicated by the building automation system or system submeters

STEP 9. DEVELOP ONGOING Cx PLAN

Before or as part of the 10-month review of operations, the CxA must issue an ongoing commissioning plan. The plan should provide operating staff with procedures, blank test scripts, and a schedule for ongoing Cx activities. It may be executed either by the operators, in addition to their normal preventive maintenance activities, or by an independent CxA (see *Further Explanation, Ongoing Commissioning Basics*).

The plan must include the following:

- Definition of the ongoing commissioning process
- Defined roles and responsibilities
- Recommended schedule for recommissioning as-built systems
- Continuous documentation and updating of tenant space operating plan and current facility requirements throughout the building's lifetime
- Blank testing materials, including functional performance tests for all commissioned as-built systems in the project, as well as an issues log
- Direction for testing new and retrofitted equipment

Option 2. Enhanced and Monitoring-Based Commissioning

STEP 1. ACHIEVE OPTION 1

Ensure that the requirements for Option 1 have been met.

STEP 2. UPDATE CX PLAN TO INCLUDE MONITORING-BASED COMMISSIONING (MBCX) REQUIREMENTS

During the design development phase, incorporate the MBCx requirements and activities into the project Cx plan (see *Further Explanation, Monitoring-Based Commissioning Basics*).

- Define analysis procedures, including frequency during year one.
- Outline the evaluation process and determine the procedure for handling system conflicts, usage profiles, and out-of-sequence operations.
- Include preventive planning and maintenance procedures necessary to meet performance goals.
- Determine measurement requirements and decide whether predictive algorithms can be used in conjunction with metered points.

STEP 3. CONFIRM THAT MBCX IS FULLY INCORPORATED INTO ENHANCED CX

Ensure that requirements for MBCx are included in all commissioning documents. Items to look for may include the following:

- Owner's requirements, such as specific trends to track, reflected accurately in the engineer's BOD
- Metering and monitoring required for MBCx, included in the BOD
- Single-line or riser diagrams for location of building and system meters
- Controls sequences for specification of appropriate monitoring points
- Cx specifications for contractors and building operators
- Submittal reviews of meters, energy analysis software, and drawings of controls for compliance with the owner's MBCx metering and monitoring requirements
- Creation and completion of prefunctional tests for MBCx-related equipment, such as meters and energy analysis software programs, by the CxA and contractors
- MBCx operator education regarding measurement techniques, energy analysis software tools, fault detection and fault resolution, all incorporated into training requirements

STEP 4. IMPLEMENT MBCX PLAN

Execute, concurrently whenever possible, MBCx monitoring and analysis with the functional performance testing completed for EA Prerequisite Fundamental Commissioning.

The equipment and tools required for MBCx must be installed, and the electrical and controls contractor should submit construction checklists for review by the CxA.

The benefits of implementing MBCx functional testing after construction but before occupancy include the following:

- More robust documentation of functional performance tests
- Verification that the energy meters and monitoring points have been properly installed and programmed
- CxA oversight of monitoring procedures and energy analysis, to ensure that the owner's requirements for ongoing monitoring are executed correctly
- Verification that energy analysis software tools, if installed, are appropriately identifying faults and producing the correct reports

It is recommended that the CxA confirm execution of the MBCx commissioning plan during the 10-month review. Confirmation of execution includes the following:

- Review of metering and trend logs
- Review of the issues log showing results of the MBCx
- Confirmation of issue resolution
- Confirmation of ongoing operator training
- Updating of the systems manual with any modifications or new settings that differ from design, with explanations for the changes

FURTHER EXPLANATION

PLANNING THE COMMISSIONING PROCESS

Table 1 outlines the tasks required to meet the intent of EA Prerequisite Fundamental Commissioning and Verification and EA Credit Enhanced Commissioning, Options 1 and 2, with suggested timing.

TABLE 1. Commissioning activities

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx
Predesign	Develop OPR	Owner	X	X	X
Schematic design	Develop BOD, including envelope requirements	Design team	X	X	X
	Include general monitoring, metering, and trending requirements	Design team			X
Design documents	Engage CxA	Owner	X	X	X
	Develop initial commissioning plan	CxA	X	X	X
	Include monitoring requirements, equipment	CxA			X
	Conduct OPR, BOD, and design document review	CxA, owner, design team	X	X	X
	Prepare systems manual outline	CxA, owner		X	X
	Include monitoring requirements, equipment	CxA, owner			X
	Document training requirements	CxA, owner		X	X
	Update OPR and BOD as necessary	CxA, owner, design team	X	X	X
Construction documents	Issue Cx specifications for inclusion in bid/permit documents	CxA	X	X	X
	Include enhanced Cx requirements	CxA		X	X
	Include monitoring-based Cx requirements	CxA			X
	Update OPR and BOD as necessary	CxA, owner, design team	X	X	X
	Conduct design review (recommended)	CxA, design team	X	X	X

TABLE 1. (CONTINUED) Commissioning activities

Phase	Cx task	Responsible party	Cx	Enhanced Cx	MBCx
Construction	Update OPR and BOD as necessary	CxA, owner, design team	X	X	X
	Perform prefunctional inspections	CxA	X	X	X
	Complete submittal reviews concurrently with or before acceptance by design team	CxA		X	X
	Update OPR, BOD, Cx plan and systems manual as necessary	CxA	X	X	X
	Issue owner's training requirements	CxA to contractor		X	X
	Issue construction checklists	CxA	X	X	X
	Issue functional performance test scripts for contractor review	CxA, contractor	X	X	X
	Issue/review verified TAB report	Contractor, CxA	X	X	X
	Issue/review completed construction checklists	Contractor, CxA	X	X	X
	Execute functional performance tests	CxA, contractor	X	X	X
	Document issues in issues log	CxA	X	X	X
	Compile final systems manual	CxA		X	X
	Complete final commissioning report	CxA	X	X	X
	Verify training plan has been implemented	CxA, contractor, building operators		X	X
Occupancy and operations	Complete Cx report	CxA	X	X	X
	Compile operations and maintenance plan	CxA	X	X	X
	Compile final systems manual	CxA		X	X
	Perform seasonal testing	CxA, contractor, building operators		X	X
	Perform 10-month review	CxA, contractor, building operators		X	X
	Develop ongoing Cx plan	CxA, building operators		X	X

BOD = basis of design Cx = commissioning process CxA = commissioning authority

MBCx = monitoring-based commissioning process OPR = owner's project requirements

CHOOSING AN APPROPRIATE CxA

Review the guidance on qualifications for commissioning authorities in EA Prerequisite Fundamental Commissioning, including Table 1, Who can be the CxA? The following points also apply:

- Different CxAs can be engaged to complete the fundamental, enhanced or monitoring portions of the commissioning scope. However, one CxA must oversee and coordinate all activities and deliverables provided by the commissioning team.
- The CxAs can be employees of the same company or employees of separate firms, provided they all meet the basic requirements for the task to which they are assigned.
- Not all CxAs are qualified to perform all aspects and types of commissioning activities.

ENHANCED COMMISSIONING PLAN

The CxA develops the commissioning plan with input from the project team. Updates during the design and construction process are the primary responsibility of the CxA. A sample table of contents for the enhanced commissioning plan is provided in ASHRAE Guideline 0–2005p Informative Annex G – Commissioning Plan.

The recommended components of the commissioning plan are the following:

- Commissioning program overview
  - Goals and objectives
  - General project information
    - Scope of commissioning
    - Systems (Option 1)
    - Monitoring, which may include points, meters, and trending logs (Option 2)
- Commissioning team
  - Team members, roles, and responsibilities
  - Communication protocol, coordination, meetings, and management
- Commissioning process activities
  - Reviewing the OPR
  - Reviewing the BOD
  - Documenting the systems commissioning review process (Option 1)
  - Documenting the monitoring-based commissioning review process (Option 2)
  - Developing the systems manual
  - Developing systems functional test procedures documentation
  - Verifying system performance via functional performance testing
  - Reporting deficiencies and the resolution process: monitoring system analysis (Option 2) must be conducted at least quarterly an ongoing basis during occupancy.
  - Verifying the training of operations personnel: monitoring system training (Option 2) must be conducted on an ongoing basis during occupancy.
  - Reviewing building operation after 10 months of operations

ONGOING COMMISSIONING BASICS

Ongoing Cx, an extension of enhanced Cx process, is essentially a repetition of the functional performance testing and reporting procedures that occurred immediately after construction, during the initial occupancy and operations phase. Ongoing testing is required to ensure that the building continues to perform according to the OPR, BOD, and approved design and construction documents. The commissioning activities should occur approximately twice a year, to correspond with the summer and winter seasons. Those who conduct the Cx activities should use the functional performance tests and issues log templates provided as part of the original Cx report.

Ongoing Cx activities can be conducted either by in-house operating staff (in addition to their normal preventive maintenance activities) or by a third-party CxA who is responsible for all testing and issues reporting. Using the operating staff to perform the functional performance tests may be beneficial to their understanding of the building operations. However, as the facility requirements change or as systems are retrofitted over the lifetime of the building, a CxA may need to be retained to ensure all test scripts and procedures are up to date and properly documented.

MONITORING-BASED COMMISSIONING BASICS

Monitoring-based commissioning is the integration of three components: permanent energy monitoring systems, real-time energy analysis, and ongoing commissioning. Ongoing Cx is a component of MBCx but should not be confused with it. When executed independently or without MBCx capabilities, ongoing Cx is a process of discrete functional performance testing and reporting over the lifetime of a building. In comparison, MBCx is an ongoing performance analysis of an operational building, or subset of a building, that provides real-time equipment performance information to the building operators. In other words, MBCx allows the user to track energy consumption, detect faulty equipment operations, and identify unusual energy or power consumption patterns as they occur.

MBCx can be accomplished via systems submetering, operational points trending, and real-time analyses, such as fault-detection and sequence verification. The real-time analyses can be performed by either a service provider or an on-site energy manager who uses software to monitor data from meters and the building automation system.

Additions to the commissioning plan may include the following:

- Roles and responsibilities for maintaining an MBCx plan throughout the first year of occupancy
- Monitoring requirements
  - Meters and meter locations
  - Points to be tracked
  - Frequency and duration of trend monitoring
  - Software
  - Hardware
  - Data access
- Limits of acceptable values for tracked points and metered values
- Specification of fault diagnostics or predictive algorithms for tracked points and metered values, if appropriate
- Elements used to evaluate performance, including the following:
  - Conflict between systems, such as simultaneous heating and cooling
  - Out-of-sequence operation of systems components
  - Unexpected energy and water usage profiles
- Action plan for identifying and correcting operational errors and deficiencies, including the ongoing documentation of an issues log
- Ongoing operator and occupant training to prevent errors
- Planning ongoing monitoring device calibration to maintain performance
- Frequency of analyses in the first year of occupancy (at least quarterly)

MBCx is most cost-effective when the metering and energy analysis software are integrated into the initial design of a space.

EXAMPLES

TABLE 2. Example training plan

System, subsystem	Spec Section	Hours per class	Training date(s)	Theory of operation	Hands-on demo	Remarks
Rooftop unit	01783 - O&M	2	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain rooftop units
Makeup air unit	01783 - O&M	1	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain the makeup air unit
Kitchen exhaust fans	01783 - O&M	0.5	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain kitchen exhaust fans
General exhaust fans	01783 - O&M	0.5	4/5/2011	YES	YES	Engage factory-authorized service representative to train maintenance personnel to adjust, operate, and maintain general in-line exhaust fans

TABLE 3. Example submittal review log				
Comment	**Sheet**	**Comment**	**Design team comments, response**	**Final review comment, status**
1	M2-1	FF 1C and 2C call for 30 kBtu/h at 3 gpm with 180°F entering and 160°F leaving and 300 cfm. Transmittal 312037-0031 states 34.8 kBtu/h at 3 gpm with 180°F and 156.82 leaving, and 320 cfm. Designer to comment if slight deviation in parameters is acceptable.	Acceptable to engineer	Item closed
2	M2-1	FC 1F and CU 1F specified as 12 kBtu/h at 95°F entering air temperature to the condenser. Transmittal 312037-0026 shows 11.9 kBtu/h at ARI standard conditions. Design to comment if rating is acceptable.	Acceptable to engineer	Item closed
3	M1-1C	AV 1 minimum cfm specified as 600, heating as 4,000. Transmittal 312037-0022 lists each as 800 cfm. Designer to check cfm discrepancy.	Noted by engineer on submittal	Final approved submittal needed
4	M1-1C	AV 2 minimum cfm specified as 360, heating as 2,400. Transmittal 312037-0022 lists each as 800 cfm. Designer to check cfm discrepancy.	Noted by engineer on submittal	Final approved submittal needed
5	M1-1C	TB-CO3 minimum cooling cfm specified as 100 on M1-1c. Transmittal 312037-0022 states as 250 cfm. Designer to confirm fm discrepancy.	Noted by engineer on submittal	Final approved submittal needed

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Training outline and participation list	X	X
Verification of CxA activities	X	X
Ongoing Cx plan	X	X
Confirmation of systems manual delivery	X	X
Monitoring and trending point list and schedule		X

RELATED CREDIT TIPS

EA Prerequisite Fundamental Commissioning and Verification. Enhanced commissioning is an extension of fundamental commissioning and cannot be completed if the scope of fundamental commissioning is not fulfilled.

EA Credit Renewable Energy Production. Renewable energy systems installed on site must be commissioned under this credit.

EA Credit Advanced Energy Metering. Although not a requirement of this credit, achievement of the related credit will ease the execution of the MBCx plan. Conversely, if a project is pursuing the related credit, MBCx is a powerful tool for extracting additional value from the existing advanced metering system.

CHANGES FROM LEED 2009

A monitoring-based commissioning option is now included.

REFERENCED STANDARDS

ASHRAE Guideline 0–2005, The Commissioning Process: ashrae.org

ASHRAE Guideline 1.1–2007, HVAC&R Technical Requirements for The Commissioning Process: ashrae.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

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

commissioning (**Cx**) the process of verifying and documenting that a building and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the owner's project requirements

commissioning authority (**CxA**) the individual designated to organize, lead, and review the completion of commissioning process activities. The CxA facilitates communication among the owner, designer, and contractor to ensure that complex systems are installed and function in accordance with the owner's project requirements.

operations and maintenance (**O&M**) **plan** a plan that specifies major system operating parameters and limits, maintenance procedures and schedules, and documentation methods necessary to demonstrate proper operation and maintenance of an approved emissions control device or system

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

systems manual provides the information needed to understand, operate, and maintain the systems and assemblies within a building. It expands the scope of the traditional operating and maintenance documentation and is compiled of multiple documents developed during the commissioning process, such as the owner's project requirements, operation and maintenance manuals, and sequences of operation.

ENERGY AND ATMOSPHERE CREDIT

Optimize Energy Performance

This credit applies to:

Commercial Interiors (1–25 points)
Retail (1–25 points)
Hospitality (1–25 points)

INTENT

To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use.

REQUIREMENTS

Establish an energy performance target no later than the schematic design phase. The target must be established as KBtu per square foot-year (kW per square meter-year) of source energy use.

Select one of the options below.

OPTION 1. TENANT-LEVEL ENERGY SIMULATION (1–25 POINTS)

Analyze efficiency measures during the design process and account for the results in design decision-making. Analysis can include energy simulation of efficiency opportunities, energy simulation analyses for similar projects, or published data from energy analyses performed for similar projects (such as AEDGs).

Analyze efficiency measures focused on load reduction and HVAC-related strategies; passive measures are acceptable. Project the potential energy savings and cost implications for all affected systems.

Follow the criteria in EA Prerequisite Minimum Energy Performance to demonstrate a percentage improvement in the proposed tenant project performance rating compared with the baseline.

TABLE 1. Points for percentage improvement in energy performance

Interior construction	Points
4%	4
5%	6
6%	8
7%	10
8%	11
9%	12
10%	13
11%	14
12%	15
13%	16
14%	17
15%	18
16%	19
17%	20
18%	21
20%	22
22%	23
24%	24
28%	25

RETAIL ONLY

For all process loads, define a clear baseline to compare with proposed improvements. The baselines in Appendix 3, Tables 1–4, represent industry standards and may be used without additional documentation. Calculate the baseline and design as follows:

- **Appliances and equipment.** For appliances and equipment not covered in Appendix 3, Tables 1–4 indicate hourly energy use for proposed and budget equipment, along with estimated daily use hours. Use the total estimated appliance/equipment energy use in the energy simulation model as a plug load. Reduced use time (schedule change) is not a category of energy improvement in this credit. ENERGY STAR ratings and evaluations are a valid basis for performing this calculation.
- **Display lighting.** For display lighting, use the space by space method of determining allowed lighting power under ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), to determine the appropriate baseline for both the general building space and the display lighting.
- **Refrigeration.** For hard-wired refrigeration loads, model the effect of energy performance improvements with a simulation program designed to account for refrigeration equipment.

OPTION 2. PRESCRIPTIVE COMPLIANCE (1–16 POINTS)

Use any combination of the strategies in any or all of the categories below.

Base Building Systems (2-6 points)

For base building systems that serve the project, as well as any applicable improvements that are part of the project, document compliance with the following according to base building type and climate zone. For projects outside the U.S., consult ASHRAE/ASHRAE/IESNA Standard 90.1–2010, Appendixes B and D, to determine the appropriate climate zone.

- Building Envelope, Opaque (2 points)
  Comply with the recommendations in the appropriate ASHRAE 50% Advanced Energy Design Guide for all roofs, walls, floors, slabs, doors, vestibules, and continuous air barriers.

- Building Envelope, Glazing (2 points)
  Comply with the recommendations in the appropriate ASHRAE 50% Advanced Energy Design Guide for all vertical fenestration.
- HVAC Equipment Efficiency (2 points)
  For all base building HVAC systems that serve the project, comply with the recommendations in the appropriate ASHRAE 50% Advanced Energy Design Guide.

HVAC Systems (2 points)

- HVAC Zoning and Controls (2 points)
  For the tenant fit-out of spaces, provide a separate control zone for each solar exposure and interior space. Provide controls capable of sensing space conditions and modulating the HVAC system in response to space demand for all private offices and other enclosed spaces (e.g., conference rooms, classrooms).

Interior Lighting Power (1–4 points)

- Lighting Power Density (1–4 points)
  Reduce connected lighting power density below that allowed by ASHRAE/IESNA Standard 90.1–2010, either using the space-by-space method or applying the whole-building lighting power allowance to the entire tenant space. Points are awarded according to Table 2.

TABLE 2. Points for percentage reduction in lighting power density

Percentage below standard LPD	Points
10%	1
15%	2
20%	3
25%	4

Interior Lighting Controls (1–2 points)

- Daylighting Controls (1 point)
  Install daylight-responsive controls in all regularly occupied daylit spaces within 15 feet (4.5 meters) of windows and under skylights for at least 25% of the connected lighting load. Daylight controls must switch or dim electric lights in response to daylight illumination in the space.
- Occupancy Sensor Lighting Controls (1 point)
  Install occupancy sensors for at least 75% of the connected lighting load.

Equipment and Appliances (1–2 points)

- ENERGY STAR Equipment and Appliances (1–2 points)
  Install ENERGY STAR appliances, office equipment, electronics, and commercial food service equipment (HVAC, lighting, and building envelope products are excluded from this credit) or performance equivalent for projects outside the U.S.. Calculate their percentage of the total (by rated-power) ENERGY STAR–eligible products in the project. Points are awarded according to Table 3.

TABLE 3. Points for installing ENERGY STAR equipment and appliances

Percentage of ENERGY STAR products	Points
70%	1
90%	2

RETAIL ONLY

All projects pursuing Option 2 must also comply with the prescriptive measures in Appendix 3, Tables 1–4, for 90% of total energy consumption for all process equipment.

BEHIND THE INTENT

See EA Prerequisite Minimum Energy Performance, *Behind the Intent*.

STEP-BY-STEP GUIDANCE

STEP 1. REVIEW REQUIREMENTS FOR EA PREREQUISITE MINIMUM ENERGY PERFORMANCE

- Ensure that the related prerequisite will be achieved before pursuing the credit.
- Follow the initials steps of the prerequisite.
- The option pursued in the prerequisite must also be pursued in the credit.

STEP 2. DECIDE WHETHER TO PURSUE ADDITIONAL POINTS

Review the list prepared for the prerequisite to identify any potential upgrades to systems and components within the tenant space or to base building systems and equipment that serve the project.

- Early in design, determine mandatory and prescriptive requirements for any base building system upgrades requested by the tenant to ensure that these upgrades will meet the credit requirements and, if pursuing Option 1, to establish the baseline against which energy savings can be calculated.
- During the design process, project teams may discover that additional savings can be achieved more easily than originally expected. Revisit decisions made earlier in design to identify any additional low-effort and low-cost alternatives.

Option 1. Tenant-Level Energy Simulation

STEP 1. REVIEW CREDIT REQUIREMENTS

Read this credit's requirements and referenced standards before beginning the simulation. If pursuing the Integrative Process Credit, identify the scope of the energy analysis to determine how to coordinate the overall model development.

STEP 2. CONFIRM ENERGY USE TARGET FOR TENANT SPACE

Ensure that the energy use intensity (EUI) target developed for the prerequisite is based on all energy used within the space, whether or not it will be metered at the tenant level. For credit compliance, the target must be established as EUI in kBtu per square foot-year (kWh per square meter-year) of source energy use. The EUI should account for the following energy uses in the tenant space:

- Lighting
- Receptacle, appliance, and process loads
- HVAC and service water heating
- The tenant space's portion of fans, air-handling units, furnaces, chillers, boilers, and other components of the base building's HVAC and service water-heating energy system

STEP 3. ANALYZE EFFICIENCY MEASURES

Determine whether preliminary energy models will be prepared, as outlined in EA Prerequisite Minimum Energy Performance. A preliminary model may be prepared to satisfy the credit requirement for analysis of energy efficiency measures and can help the team estimate the energy implications of early design alternatives.

- A concept model prepared for compliance with the Integrative Process credit can form the basis for the preliminary energy model.
- Project teams must perform an analysis of efficiency measures. Past analyses of similar buildings or published data, such as the ASHRAE Advanced Energy Design Guides (AEDGs), may also be used to guide decision making in lieu of a preliminary energy model, though the results will be less project-specific.

STEP 4. MODEL POTENTIAL HVAC SYSTEM TYPES, IF APPLICABLE

Create an energy model of the proposed design, or expand the scope of the preliminary model, to analyze HVAC system alternatives early in the design process.

STEP 5. UPDATE PROPOSED ENERGY MODEL

Add details to the proposed model to reflect changes that may affect energy performance compared with the required ASHRAE 90.1–2010 baseline.

STEP 6. UPDATE PROPOSED AND BASELINE ENERGY MODELS BASED ON FINAL DESIGN DOCUMENTS

Update the proposed and baseline energy models to reflect final construction details and specifications (see *Further Explanation, Finalizing the Energy Models for Credit Compliance*) and review the table of common mistakes to avoid (see EA Prerequisite Minimum Energy Performance, *Further Explanation, Common Issues with Energy Modeling*).

STEP 7. DETERMINE ENERGY COST SAVINGS

Compare the proposed model with the baseline model to determine the anticipated energy cost savings.

- Apply any savings from on-site renewable energy systems after minimum compliance has been demonstrated.
- If taking credit for renewable systems serving the base building, provide documentation showing that the energy is not double-counted.

Option 2. Prescriptive Compliance

STEP 1. EVALUATE BASE BUILDING SYSTEMS FOR AEDG COMPLIANCE

Determine whether one of the four ASHRAE 50% Advanced Energy Design Guides is applicable to the base building.

Choose the appropriate AEDG for the base building type (office, retail, K–12 schools, and hospitals) and review the floor area requirements. AEDG criteria apply to the base building property, not the tenant space.

- Points for the base building may be achieved by a project that meets the AEDG prescriptive requirements for some or all of the following building systems: opaque envelope, glazing systems, and base building HVAC equipment serving the tenant space.
- If the project team plans to upgrade any of these systems, evaluate the possibility of meeting AEDG requirements (see *Further Explanation, Base Building AEDG Compliance*).
- Projects are eligible to earn points for existing base building systems that already meet the criteria, without additional upgrades. For example, if the vertical glazing installed as part of the base building meets the AEDG requirements, the project can earn points without needing to upgrade the glazing.

STEP 2. DECIDE WHICH TENANT-SPECIFIC STRATEGIES TO PURSUE

Use the AEDG to identify potential energy-saving measures for the tenant space. Possible targets typically include HVAC systems and controls, interior lighting and controls, and equipment and appliances. All projects are eligible to pursue these measures, regardless of whether any AEDGs apply to the base building.

- HVAC zoning and controls opportunities often depend on the base building system; however, most standard systems allow for the addition of thermostats, occupant sensors, and carbon dioxide (CO_2) sensors, which can contribute toward credit points (see *Further Explanation, Tenant HVAC Zoning and Controls*).
- ASHRAE Standard 90.1–2010 expands on the lighting controls required in previous versions; the updated mandatory requirements must be incorporated when the project team selects lighting control strategies.
- Retail projects must meet additional requirements for process equipment.

FURTHER EXPLANATION

FINALIZING THE ENERGY MODELS FOR CREDIT COMPLIANCE

Update the proposed model based on the information and specifications for systems, assemblies, and equipment in the final construction documents (see EA Prerequisite Minimum Energy Performance, *Further Explanation, Finalizing the Energy Models*). Ensure that all changes made to the design have been captured in the model. If changes occur during construction that could affect efficiency measures, the model information will have to be updated accordingly. Value engineering exercises may affect energy efficiency as well as credit achievement.

Document the energy modeling input assumptions for receptacle and process loads. These loads should be modeled accurately to reflect the actual expected energy consumption of the tenant space (see EA Prerequisite Minimum Energy Performance, *Further Explanation, Exceptional Calculation Method*).

Verify the final energy cost savings. Evaluate the energy savings by end use for reasonableness based on the differences in the modeling inputs between the baseline and proposed models. Ensure that renewable energy savings have been properly credited (see *Further Explanation, Applying Renewable Energy Savings*).

APPLYING RENEWABLE ENERGY SAVINGS

Only projects pursuing Option 1 of this credit may count savings from renewable energy systems, whether owned by the tenant or installed as part of the base building.

Calculate the renewable energy produced by the tenant space system, or ask the base building's owner about the total amount of energy generated by the system and the ownership of the environmental attributes, then determine the tenant space's share. Convert this value into the equivalent cost using either utility rates or virtual energy rates. See EA Credit Renewable Energy Production.

Apply the equivalent cost directly to the energy model through the simulation software, or subtract it from the final energy cost savings calculation.

BASE BUILDING AEDG COMPLIANCE

Use the climate type determined for prerequisite compliance to find the criteria for the project in the AEDG.

For the building envelope, confirm through contractor submittals and commissioning documents, if available, that envelope components meet AEDG requirements. Design documents are not sufficient because value engineering or other decisions may have changed what was originally specified.

For HVAC equipment, submittals and commissioning documents are good sources for confirming equipment efficiency; it may also be possible to determine efficiencies directly from equipment nameplates.

TENANT HVAC ZONING AND CONTROLS

The types of controls that can be used to meet credit requirements differ based on the dominant loads, space uses, and type of HVAC equipment installed.

Interior private offices or interior nondensely occupied specialty use spaces. A separate thermal control for each space is sufficient because the space demand is related to internal loads (lighting, occupants, and plug loads). When the occupant leaves the space, particularly if the space has lighting occupant sensors and ENERGY STAR computing equipment, the thermostat senses a change in demand and modulates the HVAC system in response.

Perimeter offices or perimeter nondensely occupied specialty use spaces. A separate thermal control for each space paired with an occupant-sensing or CO_2-sensing device is necessary. Perimeter spaces have both envelope loads and internal loads, and the HVAC system would respond minimally to changes in space occupancy without the additional controls.

Densely occupied specialty use spaces (e.g., conference rooms). A separate thermal control for each space, paired with a CO_2- or occupant-sensing device used to provide demand-controlled ventilation or to reset the temperature setpoint when the space is unoccupied, is necessary.

VAV systems. Supply air diffusers equipped with room thermostats are appropriate in lieu of a separate thermal zone for each private office or nondensely occupied specialty use space.

- The system should be capable of modulating AHU and zone minimum supply volume below 0.30 cfm/ft² (1.52 L/s/m²) of supply volume for standard VAV terminals, or below 22.5% of the peak design flow rate for fan-powered VAV boxes.
- Occupant-sensing or demand-controlled ventilation should be employed to achieve the specified minimum supply volumes in spaces where these minimum supply volumes are lower than the minimum outdoor air required for EQ Prerequisite Minimum Indoor Air Quality Performance.
- Include controls for fan static pressure reset in the control system.

VRF systems, fan coils, or packaged single-zone systems. Set the fan coil or system fan that serves the room to cycle on and off with loads or, for multispeed fans, to operate on the lowest setting when the space is unoccupied.

RATING SYSTEM VARIATIONS

Retail

Option 2, Prescriptive Compliance. Comply with the prescriptive measures in Appendix 3, Tables 1–4, for 90% of total energy consumption for all process equipment.

PROJECT TYPE VARIATIONS

District Energy Systems

See EA Prerequisite Minimum Energy Performance, *Further Explanation, Project Type Variations*.

INTERNATIONAL TIPS

Option 1. Tenant-Level Energy Simulation. If ASHRAE 90.1 is not applicable, Option 1 requirements can be met with a USGBC-approved equivalent standard.

Option 2. Prescriptive Compliance. A project outside the U.S. may install products that are not labeled under the ENERGY STAR program if they meet the ENERGY STAR product specifications, available on the ENERGY STAR website. All products must meet the standards of the current version of ENERGY STAR as of the date of their purchase.

CAMPUS

Group Approach

All project spaces in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Appendix G energy modeling inputs	X	
Input and output reports from modeling software	X	
Renewable energy (if applicable)	X	
Exceptional calculations (if applicable)	X	
Energy consumption and demand for each end use and fuel type	X	
Fuels rates	X	
Target Finder results and summary	X	
Lighting power density calculations		X
ENERGY STAR appliance percentage		X
Building envelope characteristics (if applicable)		X
Base building HVAC equipment efficiencies (if applicable)		X
HVAC control devices and locations (if applicable)		X
Lighting control devices and locations (if applicable)		X
Retail projects only: list of process equipment efficiencies		X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. See the related prerequisite for related credit tips.

CHANGES FROM LEED 2009

See EA Prerequisite Minimum Energy Performance.

REFERENCED STANDARDS

ANSI/ASHRAE Standard 90.1–2010, Energy Standard for Buildings Except Low-Rise Residential Buildings: ashrae.org

Standard 90.1–2010 User's Manual: ashrae.org

ENERGY STAR: energystar.gov

COMNET Commercial Buildings Energy Modeling Guidelines: comnet.org/mgp-manual

EXEMPLARY PERFORMANCE

Option 1. Achieve 32% savings.

DEFINITIONS

See EA Prerequisite Minimum Energy Performance.

ENERGY AND ATMOSPHERE CREDIT

Advanced Energy Metering

This credit applies to:

Commercial Interiors (1–2 points)
Retail (1–2 points)
Hospitality (1–2 points)

INTENT

To support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use.

REQUIREMENTS

OPTION 1. METERING (1 POINT)

Install new or use existing tenant-level energy meters to provide tenant-level data representing total tenant energy consumption (electricity, natural gas, chilled water, steam, fuel oil, propane, biomass, etc.). Utility-owned meters are acceptable.

Commit to sharing with USGBC the resulting energy consumption data and electrical demand data (if metered) for a five-year period beginning on the date the project accepts LEED certification. At a minimum, energy consumption must be tracked at one-month intervals.

This commitment must carry forward for five years or until the space changes ownership or lessee.

OPTION 2. ADVANCED METERING (2 POINTS)

Install advanced energy metering for the following:

- all energy sources used in the tenant space; and
- any individual energy end uses that represent 10% or more of the total annual consumption of the tenant space.

The advanced energy metering must have the following characteristics.

- Meters must be permanently installed, record at intervals of one hour or less, and transmit data to a remote location.
- Electricity meters must record both consumption and demand. Whole-building electricity meters should record the power factor, if appropriate.
- The data collection system must use a local area network, building automation system, wireless network, or comparable communication infrastructure.
- The system must be capable of storing all meter data for at least 18 months.
- The data must be remotely accessible.
- All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.

BEHIND THE INTENT

Disparities between how buildings are designed to operate and how they actually perform are common. Even green buildings exhibit this gap between projected and actual performance. Numerous factors can explain the incongruity: flaws with energy modeling, inadequate commissioning, inaccurate assumptions regarding occupants' behavior, lack of coordination during the transition from construction to operations, or the everyday operation of the building systems. To reduce such disparities, USGBC collects and analyzes performance data, comparing performance across the LEED portfolio to identify common traits among high and low performers, then shares the findings to help LEED registrants improve performance.

This credit encourages energy metering so that tenants can track consumption over time and identify and address variations in usage patterns.

STEP-BY-STEP GUIDANCE

Select one option

- Option 1 is for project teams that pursue tenant-level metering only.
- Option 2 is achievable if the project has sophisticated energy systems and/or a large tenant space with its own HVAC system; the team must first complete Option 1.

Option 1. Tenant-Level Metering

STEP 1. IDENTIFY ALL ENERGY SOURCES THAT SERVE TENANT SPACE

Identify all external sources of energy delivered to the tenant. Sources of energy that must be metered include all energy supplied by a utility provider or base building central plant, such as the following:

- Electricity
- Natural gas, synthetic natural gas, propane, fuel oil, diesel fuel, other fossil fuels
- Biofuels
- District or base building chilled water, steam, and hot water

This option does not require metering of locally generated sources of energy that are dedicated to the project space, such as the following:

- Solar photovoltaic-generated electricity
- Wind-generated electricity
- Solar hot water generation for domestic hot water or heating hot water

STEP 2. DETERMINE SCOPE OF UTILITY AND LANDLORD-PROVIDED METERING

Determine whether the energy provided to the tenant space is metered by one or more utility companies or whether the landlord has installed submetering for the tenant space, per Option 1 requirements. Ensure that the area to be served by the meters aligns with the tenant space.

A utility company's or landlord's meter is acceptable if it provides monthly energy consumption data or if staff can read its monthly cumulative energy usage directly.

STEP 3. DETERMINE NUMBER, TYPE AND LOCATION OF ADDITIONAL METERS

If the project includes energy sources that are not metered by a utility or the landlord, install submeters that will provide the required data.

- Projects may use a single meter at the energy source service entrance to the tenant space or multiple submeters that account for all tenant space energy use in aggregate.
- Select locations with easy access for reading and/or maintenance.
- There are no requirements for the type of meters except that they be permanent (see *Further Explanation, Meter Selection*).
- Meters installed by the owner must be maintained and calibrated per manufacturer's

recommendations.

STEP 4. TRACK ENERGY CONSUMPTION

Begin tracking energy use when the project achieves LEED certification or at occupancy, whichever occurs first.

- Measure and record energy consumption on at least a monthly basis.
- Consider tracking space occupancy, use and maintenance concurrently to help place energy use data in context and understand anomalies in usage patterns.

STEP 5. SHARE ENERGY CONSUMPTION DATA

The project owner must commit to sharing with USGBC the energy use data in one of the following ways:

- USGBC-approved data template
- Third-party data source

To see the most recent list of data-sharing pathways, visit USGBC's credit library, at usgbc.org/credits.

Option 2. Advanced Metering

STEP 1. IDENTIFY ENERGY SOURCES THAT REQUIRE ADVANCED METERING

Advanced metering must be installed for the following sources of energy delivered to the project:

- Whole-building energy sources delivered to the tenant space by an external provider, such as a utility company or building central plant
- Energy generated on-site and dedicated to the tenant space, including renewable sources (e.g., wind turbines, photovoltaic panels, solar thermal panels, geothermal) and nonrenewable sources (e.g., fossil fuel–burning generators, microturbines).

Both inputs and outputs of nonrenewable energy sources must be metered:

- Fuel input
- Electricity output
- Recovered heat (if applicable)

STEP 2. IDENTIFY ENERGY END USES THAT REQUIRE ADVANCED ENERGY METERING

Determine the type and quantity of advanced meters necessary to capture all individual end uses that represent 10% or more of the tenant space's total annual energy consumption (see *Further Explanation, Determining Major End Uses*).

- Projects that used modeling to achieve EA Prerequisite Minimum Energy Performance (Option 1) must use the simulation results to determine which end uses must be metered.
- Projects that followed a prescriptive pathway for EA Prerequisite Minimum Energy Performance (Option 2) should use historical data from buildings with similar design and operational characteristics.

STEP 3. IMPLEMENT ADVANCED METERING SYSTEM

Design and install an advanced metering system.

- Refer to the credit requirements for types of equipment, measurement frequency, communication protocols, and data storage requirements (see *Further Explanation, Meter Selection*).
- Locate the meters to capture the usage of major end users (see *Further Explanation, Electricity Metering Strategies*).
- Install and calibrate the meters according to the manufacturers' recommendations.

FURTHER EXPLANATION

DETERMINING MAJOR ENERGY END USES

Defining appropriate energy end uses is crucial to the success of an advanced energy metering program and energy management plan. Low data granularity, such as with whole-building energy data, will not help a building operator understand or identify sources of anomalies in energy consumption and does not meet the intent of this credit.

Extreme granularity, achieved by metering every piece of equipment in a building, may be cost prohibitive because of the quantity of equipment and the data storage capacity required. In addition, too much information may overwhelm an energy manager and may hamper the effectiveness of an energy management program.

Identifying major energy end uses is the first step in choosing what to meter. Often, in large commercial or industrial buildings, end uses are classified as systems composed of discrete pieces of equipment that can be metered together. For example,

- Chilled water system: chillers, chilled water pumps
- Condenser water system: cooling tower, condenser water pumps
- Hot water system (natural gas): boilers
- Hot water system (electricity): hot water pumps
- Air-handling system: supply fan, return fan, damper motors

Smaller buildings may not have large systems that are easily segregated by function. A common example is a rooftop unit (RTU), a single packaged piece of equipment that can provide the cooling, heating, and air handling but is cost and space prohibitive to submeter. Therefore, metering the entire RTU (or metering each fuel supplying the RTU, if there is more than one) is an acceptable way to achieve this credit. Even though metering the energy usage of each system component of a packaged system is not practical, the performance of each system component should be monitored by the building automation system.

The metering strategy for systems that serve the same basic function, such as multiple built-up air-handling units serving a 1,000,000-square-foot (92 900-square-meter) multitenant office building, or multiple RTUs serving a 25,000-square-foot (2 325-square-meter) physician's office, is left to the discretion of the project team. Examples of options for submetering these systems include the following:

- Meter all similar systems together. This strategy is appropriate for multiple systems that serve the same type of occupant and operate according to the same schedule.
- Meter all similar systems separately. This strategy is appropriate if each system serves a different type of occupancy group or has a different operating schedule.
- Meter similar systems by grouped occupancy type or operating schedule. This strategy is a combination of the above.

Choosing what equipment and components to group requires a balance between keeping the project costs on budget while ensuring that robust data are available for future decision making.

Examples of typical end uses for a commercial office building that may require advanced metering include the following:

- Receptacle equipment
- Interior lighting
- Space heating
- Space cooling
- Fans
- Pumps
- Heat rejection
- Exterior lighting
- Service water heating

Energy modeling software that is acceptable for EA Credit Minimum Energy Performance produces a report of energy consumption for a standard set of end uses. Some programs also allow the user to virtually meter additional end uses. An energy model completed in the design phase of the project will enable the metering system to be integrated into design drawings and project specifications. The engineer of record may enlist the energy modeling professional to help identify and specify the number and location of meters.

If the project team does not conduct energy modeling to comply with EA Prerequisite Minimum Energy Performance, the end uses to meter can be estimated by referencing the Commercial Building Energy Consumption Survey (2003) End-Use Consumption Tables for Non-Mall Buildings or End-Use Consumption Tables for All Buildings.

METER SELECTION

The accuracy of available commercial meters and submeters varies widely. Select meters based on the level of accuracy required for energy management purposes.

It is recommended that submeters that may be used for revenue purposes conform to the applicable revenue-grade accuracy.

When locating meters, consider any physical installation requirements for meter location (e.g., straight lengths of piping). Incorrect application or installation of a meter can reduce measurement accuracy.

Ensure that staff responsible for installing and maintaining equipment and using the data have input into the meter selection

The project owner is responsible for maintaining and calibrating meters per the manufacturers' recommendation.

ELECTRICITY METERING STRATEGIES

The number and location of electrical meters depends on the layout of a project's electrical panels.

If major energy-using systems are segregated by panel, energy consumption can be measured at the panel level and fewer sub-meters will be required (Figure 1).

Individual branch circuit meters can be avoided if over 90% of the panel's power is directed to a single end use. For example, if a panel is shared by the air-handling system and mechanical room but the lighting accounts for less than 10% of the power load of the panel, then the individual lighting branch circuits do not need to be metered.

If multiple diverse end uses are connected to the same panel, individual branch circuits must be metered in order to extract the individual energy consumption of each (Figure 2). Submetering individual branch circuits will be an additional cost.

If the majority of a panel serves one system type, subtraction metering may be used. This strategy requires metering of the entire panel as well the individual branch circuits for minority end uses. The energy consumption of the majority end use is then determined by subtracting the minority end uses from the total panel consumption (Equation 1, Figure 3).

EQUATION 1. Example subtraction metering

$$\text{Lighting energy consumption (Major panel end use)} = \text{Total panel energy (Panel meter)} - \text{Water heater energy (Branch circuit meter 1)} - \text{Conference room fan powered box (Branch circuit meter 2)}$$

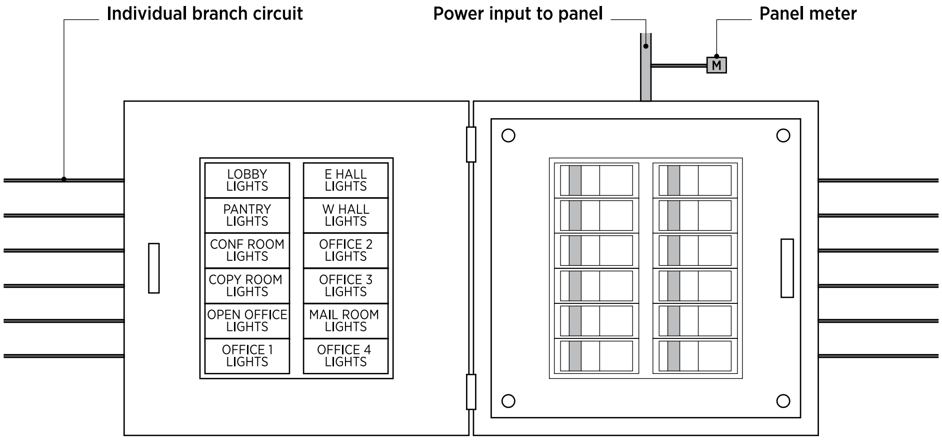


Figure 1. Power panel that serves single end use: single submeter

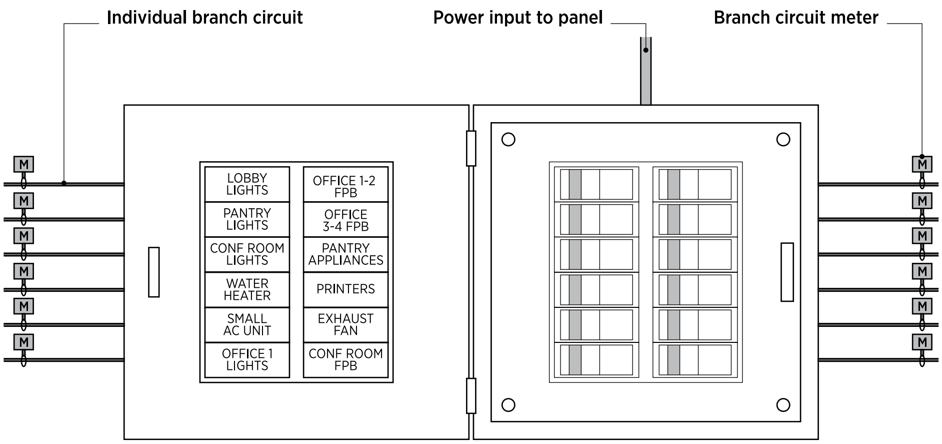


Figure 2. Panel that serves diverse end uses: one submeter for each branch circuit

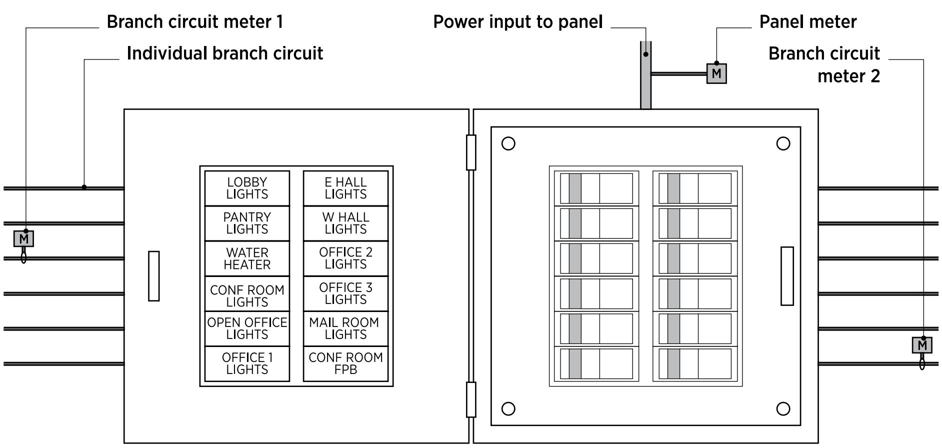


Figure 3. Panel that serves one majority use: one meter for panel and one meter for branch circuits for minority uses

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Confirmation of permanently installed meters, letter of commitment, and data sharing source	X	
Confirmation that tenant-level advanced meters have been installed for all energy sources and all end uses that represent more than 10% of total tenant energy use		X
List of all advanced meters to be installed, including type, energy source metered		X
Manufacturers' cutsheets		X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. Project teams following Option 1, Tenant-Level Energy Simulation, must use the results of the simulation to determine which end uses represent 10% or more of the total annual consumption of the tenant space. Project teams following Option 2, Prescriptive Compliance, can estimate energy consumption by referencing the Commercial Building Energy Consumption Survey (2003), End-Use Consumption Tables for Non-Mall Buildings or End-Use Consumption Tables for All Buildings.

EA Credit Renewable Energy Production. Renewable energy systems and net metering will affect the kind of energy meters installed for this credit.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

revenue-grade meter a measurement tool designed to meet strict accuracy standards required by code or law. Utility meters are often called revenue grade because their measurement directly results in a charge to the customer.

ENERGY AND ATMOSPHERE CREDIT

Renewable Energy Production

This credit applies to:

Commercial Interiors (1–3 points)
Retail (1–3 points)
Hospitality (1–3 points)

INTENT

To reduce the environmental and economic harms associated with fossil fuel energy by increasing self-supply of renewable energy.

REQUIREMENTS

Use tenant renewable energy systems to offset the project's energy cost. Calculate the project's percentage of renewable energy by the following equation:

$$\%\text{ renewable energy} = \frac{\text{Equivalent cost of usable energy produced by renewable energy system}}{\text{Total building annual energy cost}}$$

Use the project's annual energy cost, calculated in EA Prerequisite Minimum Energy Performance, if Option 1 was pursued; otherwise use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) database to estimate energy use and cost.

The use of solar gardens or community renewable energy systems is allowed if both of the following requirements are met.

- The project owns the system or has signed a lease agreement for a period of at least 10 years.
- The system is located with the same utility service area as the facility claiming the use.

Credit is based on the percentage of ownership or percentage use assigned in the lease agreement. Points are awarded according to Table 1.

TABLE 1. Points for renewable energy

Percentage renewable energy	Points
1%	1
3%	2
5%	3

BEHIND THE INTENT

Renewable energy generation can reduce carbon emissions and offer local environmental benefits by reducing air pollution. Some renewable energy systems capture wind or sunlight; others usefully employ materials that might otherwise be wasted. Renewable energy produced on site protects projects from energy price volatility and reliance on the grid while reducing wasted energy lost in transmission. Ultimately, renewable energy production contributes to reducing a country's demand for imported energy.

STEP-BY-STEP GUIDANCE

STEP 1. EXPLORE OPPORTUNITIES FOR RENEWABLES

Determine the most abundant renewable resources on site, such as sunlight, wind, or water, and explore opportunities for using renewable fuels, such as waste wood or biomass (see *Further Explanation, Renewable Resource Considerations*).

STEP 2. COMPARE REQUIREMENTS FOR RENEWABLE ENERGY SYSTEMS

Carefully evaluate the space requirements, costs, financial incentives, and efficiencies for each potential technology.

- Local funding, financing, and incentives for renewable generation projects may be available for certain technologies and may be a significant factor.
- Excess energy, beyond the project's energy demand at a given point, can be sold to the utility company (net metering). The owner receives the market rate, however, and cannot charge a premium for the renewable energy. In effect, the grid serves as a storage system and frees the project from hosting a storage system on site.
- Tying into an existing community system or creating a community system may lower cost barriers through economies of scale, because unit costs may decrease as system sizes increase. Community systems can also take advantage of time-shifted demand: one space that is occupied during the day and another space that is occupied at night could both take advantage of the same biofuel-fired heating system.
- Renewable energy may be available from a third-party system, or the project team may enter an arrangement in which a third party owns a system that serves the project. In such cases, project teams must take additional steps to ensure that the arrangement continues for a set period of time and that the renewable energy credits (RECs) are retained (see *Further Explanation, Renewable Energy Systems and Third Parties*).
- Some systems that are commonly considered renewable do not qualify for this credit (see *Further Explanation, Eligible Renewable Energy Systems*).

STEP 3. SET RENEWABLE ENERGY TARGET

To establish the target renewable energy system size for the project, estimate the annual energy cost for the project.

- Projects that used modeling to achieve EA Prerequisite Minimum Energy Performance (Option 1) must base annual energy cost on the simulation results (see *Further Explanation, Example 1*).
- Projects that used the prescriptive path to achieve EA Prerequisite Minimum Energy Performance (Option 2) must use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) data to estimate annual energy use and cost (see *Further Explanation, Example 2*).
- Use either the maximum system size that can be accommodated in the project or the available budget as the starting point to estimate the maximum number of points for this credit, or evaluate the energy available from the existing base building system.
- To qualify toward credit points, the environmental benefits associated with generated renewable energy must be retained or, if sold, purchased in an equivalent amount (see *Further Explanation, Renewable Energy Certificates [RECs] and Carbon Offsets*).

STEP 4. DESIGN AND SPECIFY SYSTEM CRITERIA

Many resources are available, some for no or little cost, for planning and designing a renewable energy system. Given basic information for the project, many manufacturers can complete the necessary calculations for the project team. Teams will also find software tools that help in sizing. If pursuing EA Credit Enhanced Commissioning, address commissioning of the system at this step.

STEP 5. CALCULATE RENEWABLE ENERGY COST CONTRIBUTION

Use Equation 1 to estimate the annual energy cost of the usable energy produced by the renewable energy system and calculate the points available. Teams that used simulation to comply with EA Prerequisite Minimum Energy Performance must use the results of the model in this calculation.

EQUATION 1. Percentage renewable energy cost contribution

$$\text{\% renewable energy cost} = \frac{\text{Equivalent cost usable energy produced by renewable energy system}}{\text{Total estimated project annual energy cost}}$$

- Usable energy is defined as the output energy from the system less any transmission and conversion losses, such as standby heat loss or losses when converting electricity from DC to AC.
- The project may use the virtual energy rate or the actual utility rates (see *Further Explanation, Equivalent Cost for Renewable Energy*).

Projects whose base building uses renewable energy are eligible to receive credit for the percentage of its contribution. Use Equation 2 to determine this amount.

EQUATION 2. Equivalent cost of renewable energy from base building system

$$\text{Equivalent cost of base building renewable energy} = \text{\$ value of renewable energy used in base building} \times \text{\% of base building energy delivered to project}$$

Similarly, projects whose base building is served by a district energy system (DES) using renewable energy are eligible to receive credit for the percentage of its contribution. Use Equation 3 to determine this amount (see *Further Explanation, Example 3*).

EQUATION 3. Equivalent cost of renewable energy with DES serving base building

$$\text{Equivalent cost of DES renewable energy} = \text{\$ value of renewable energy used at DES} \times \text{\% of DES energy delivered to building} \times \text{\% of base building energy delivered to project}$$

Projects generating renewable energy through a community or off-site facility have additional documentation requirements for the criteria noted in the credit requirements.

FURTHER EXPLANATION

CALCULATIONS

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

RENEWABLE RESOURCE CONSIDERATIONS

Project teams may want to look for a building that already has a renewable energy system or whose owner may be amenable to adding one. Possible cost-sharing opportunities may make the investment attractive to both parties.

A project team should use web resources and other tools available to determine the feasibility of renewable systems, given the project site's climate, context, and infrastructure (see *Further Explanation, Renewable Energy Tools*). Consider the features of the site, such as solar availability, wind patterns, and other renewable energy sources, and any seasonal or daily variations in its supply. Certain project types may have special opportunities: office or university campuses typically have available land, for example, and warehouse projects may have large roof areas.

Match the project's energy needs with renewable energy output when selecting a renewable system. For example, a sunny site is a good candidate for solar thermal hot water, but this type of renewable resource is most cost-effective if the project has a constant demand for hot water.

Daily and seasonal variations in loads may also factor into the investigation of renewable energy. For example, a residential project with low day-time electricity demand may require battery storage to benefit from a photovoltaic (PV) array; an office building with high daytime demand may not.

Existing energy systems may be able to switch to renewable fuels, such as natural gas instead of methane gas in a boiler. In such cases, additional restrictions may apply (see *Further Explanation, Renewable Energy Systems and Third Parties*).

RENEWABLE ENERGY SYSTEMS AND THIRD PARTIES

Some renewable energy systems that use fuels produced off-site (e.g., landfill gas) can still be eligible to receive points under this credit. In such a case, the project team must provide documentation showing the following:

- The project has a minimum 10-year contract with the fuel provider.
- The contract with the fuel provider includes both the fuel and all associated RECs.
- If the fuel provider does not also provide RECs, the project must purchase offsets for 100% of the renewable energy produced in the form of RECs every year for at least 10 years.

In some cases, renewable energy may be available from equipment, such as a PV array or wind turbine, owned by a third party, whether on- or off-site. Project teams wishing to receive credit for such an arrangement must submit documentation, including the agreement between the project owner and the power producer. The power purchase agreement must last for at least 10 years, and the project owner must retain all environmental benefits from the renewable energy.

For example, if a PV array owner sells electricity to the project and then sells RECs to a different party, the project is not eligible for this credit unless RECs are purchased by the project in a sum equal to the electricity being purchased, for a period of 10 years.

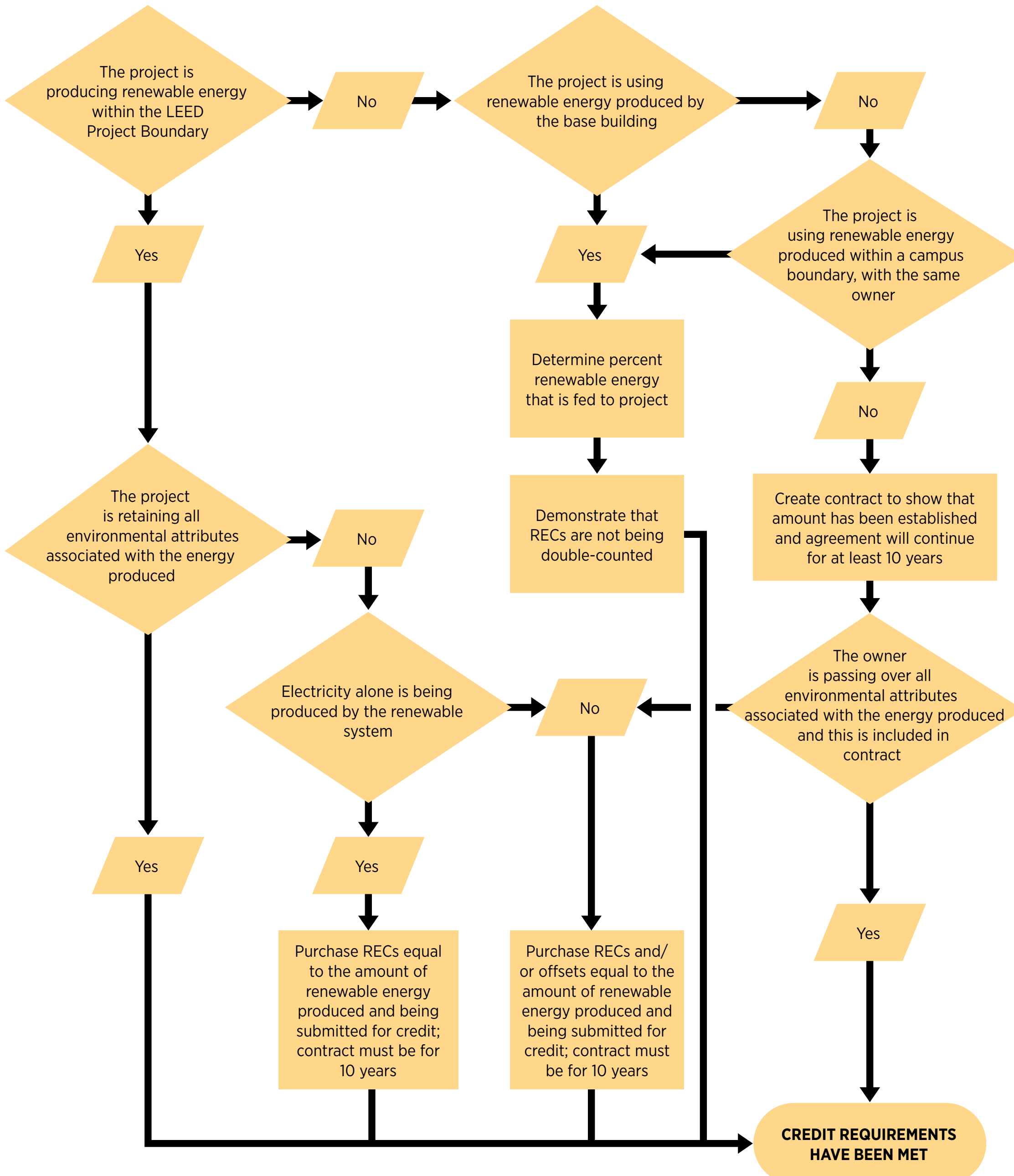


Figure 1. Renewable energy scenarios and requirements

ELIGIBLE RENEWABLE ENERGY SYSTEMS

Allowable sources for renewable energy include the following:

- Photovoltaic
- Solar thermal
- Wind
- Biofuel (in some cases)
- Low-impact hydroelectricity
- Wave and tidal energy
- Geothermal energy (in some cases)

Some renewable energy systems do not meet the intent of the credit and are not eligible. Strategies like architectural features, passive solar, and daylighting, for example, reduce energy consumption but are not eligible renewable energy systems.

Geothermal energy, such as electricity generated from subterranean steam or heat generated from subterranean steam or hot water, is eligible. However, geothermal energy used in conjunction with vapor compression cycles, as in a ground-source heat pump, is not.

If a biofuel is used in a cogeneration plant that produces both electricity and heat, both of these energy uses count as renewable energy. A biofuel used in a boiler to produce heat also qualifies. However, not all biofuels will meet the intent of this credit. The following biofuels are ineligible:

- Combustion of municipal solid waste
- Forest biomass waste other than mill residue
- Wood coated with paints, plastics, or laminate
- Wood treated for preservation with materials containing halogens, chlorine compounds, halide compounds, chromated copper arsenate, or arsenic; if more than 1% of the wood fuel has been treated with these compounds, the energy system is ineligible.

RENEWABLE ENERGY CERTIFICATES (RECS) AND CARBON OFFSETS

The environmental benefits from renewable energy generation are certified and tracked through renewable energy certificates (RECs). A third party ensures that a specific amount of power was generated by a renewable source. By purchasing RECs, a project that is using nonrenewable energy can still stimulate demand for green power.

Carbon offsets allow buildings or companies to fund activities that decrease carbon emissions or remove carbon from the atmosphere. Carbon offset projects include reforestation, carbon sequestration, energy efficiency projects, and land-use changes.

Generating renewable energy has both environmental and financial benefits, and projects must retain both benefits to be eligible for this credit. Projects with ownership of renewable energy generation have the option to sell the RECs associated with their renewable energy generation. Some utilities may grant a rebate to projects that generate their own renewable energy and also require that they give up the rights to the RECs associated with the generation. A project can still claim this credit by purchasing enough RECs or offsets to make up for the RECs that were sold. In such cases, projects that are generating electricity are required to purchase Green-e–certified RECs; projects that are generating heat or other nonelectric energy are required to purchase Green-e Climate–certified carbon offsets.

Both RECs and carbon offsets are addressed in EA Credit Green Power and Carbon Offsets.

EQUIVALENT COST OF RENEWABLE ENERGY

The equivalent cost of the usable energy system can be calculated in two ways, virtual rate or actual utility tariff plus demand rates.

Virtual rate. The project team may use the virtual energy rate determined by the proposed energy model used for EA Credit Optimize Energy Performance. The virtual rate accounts for both consumption and demand charges. Project teams that use the Energy Information Administration's average energy prices must use the virtual rates to determine the renewable energy system cost.

Actual rate plus demand. Calculate the expected savings in both consumption and demand charges, based on the rates charged by the utility that serves the project. If a project is served by a utility that uses time-dependent valuation to set rates, the team may use those rates but must provide hourly calculations for the value of generated energy. Some energy modeling software may calculate the savings from renewable energy systems if the utility rates include consumption, demand, time-dependent valuation, time-of-use, ratchets, and other factors.

For renewable energy sources priced on a basis other than per unit of energy, the project team must account for all the costs associated with the source, such as delivery costs and annual fees. For example, a project that uses heat generated from geothermal steam needs to account for all the equipment, maintenance, and labor costs associated with the geothermal system throughout the year.

In addition to calculating the equivalent cost of the energy generated, project teams must also provide calculations that show how much energy the renewable energy system will produce. With some technologies, like a biofuel-fired boiler, energy modeling software can determine the amount of energy generated. In other cases, such as PV or wind systems, the amount of energy generated may be determined by using an external calculation program (see *Further Explanation, Renewable Energy Tools*). In either case, provide all assumptions and outputs associated with the renewable energy calculations.

EXAMPLES

Example 1. Project with complete energy modeling data

A proposed tenant retail project has completed its energy model for EA Credit Optimize Energy Performance, and is working with the building owner to install a PV array on the roof. The project anticipates using 562,457 kWh of electricity, with a virtual energy rate of $0.082 per kWh. Gas consumption is calculated as 29,650 therms, at a utility rate of $0.675 per therm of natural gas. The total project annual energy cost is as follows:

Total cost = (Gas consumption x Gas rate) + (Electricity consumption x Electricity rate)

Total cost = (29,650 therms x $0.675/therm) + (562,457 kWh x $0.082/kWh)

Total cost = $20,013 + $46,121 = $66,134

The project has space on site for a 150-kW PV array. Based on calculations provided by the solar array installer, the system will produce 218,789 kWh of electricity per year, after transmission and conversion losses. The project team calculates the equivalent cost of the renewable energy generated:

Equivalent cost = (Units of renewable energy generated x Project utility or virtual rate for type of energy generated)

Equivalent cost = (218,789 kWh x $0.082/kWh) = $17,941

The project can now calculate its percentage of renewable energy:

$$\text{\% renewable energy} = \frac{\text{Equivalent cost usable energy produced by renewable energy system}}{\text{Total project annual energy cost}}$$

$$\text{\% renewable energy} = \frac{\$17{,}941}{\$66{,}134}$$

$$\text{\% renewable energy} = 27\%$$

Example 2. Project without energy modeling data

A proposed 75,000-square-foot office project is complying with EA Prerequisite Minimum Energy Performance through the prescriptive path but is also installing an on-site renewable energy system. In order to achieve this credit, the team must determine its total annual energy cost. The project will have gas and electric service. Local utility rates are $1.10 per therm of natural gas and $0.09 per kWh of electricity. Using data from CBECS (Table 1), the project can estimate its annual energy consumption by fuel type.

Projects with multiple space types should calculate energy consumptions for each space type separately based on Table 2.

TABLE 2. CBECS building energy intensity data

Building type	Total energy consumption (CBECS Table C3)		Total electric energy consumption (CBECS Table C14)		Total nonelectric energy consumption	
	kBtu/ft²	kWh/m²	kWh/ft²	kWh/ft²	kBtu/ft²	kWh/m²
Education	83.1	262.2	11	118.4	45.5	143.6
Food sales	199.7	630.1	49.4	531.8	194.6	614
Food service	258.3	814.9	38.4	413.3	127.4	401.9
Health care inpatient	249.2	786.2	27.5	296.0	155.5	490.6
Health care outpatient	94.6	298.5	16.1	173.3	39.6	124.9
Lodging	100	315.5	13.5	145.3	53.9	170.1
Retail (nonmall)	73.9	233.2	14.3	153.9	25.1	79.2
Enclosed and strip malls	102.2	322.4	22.3	240.0	26.2	82.7
Office	92.9	293.1	17.3	186.2	34	107.3
Public Assembly	93.9	296.3	12.5	134.6	51.3	161.9
Public order and safety	115.8	365.3	15.3	164.7	63.5	200.3
Religious worship	43.5	137.2	4.9	52.7	26.9	84.9
Service	77	242.9	11	118.4	39.5	124.6
Warehouse and storage	45.2	142.6	7.6	81.8	19.3	60.9
Other	164.4	518.7	22.5	242.2	87.6	276.4

Electricity cost is estimated as follows:

Electricity cost = (Electricity kWh/ft² for space type x Project area x Project electricity rate)

Electricity cost = (17.3 kWh/ft² x 75,000 ft² x $0.09/kWh)

Electricity cost = $116,775

The project gas cost can be estimated in the same manner:

Gas cost = (Nonelectric kBtu/ft² for space type x Project area x (1 Therm / 100 kBtu) x Project gas rate)

Gas cost = (34 kBtu/ft² x 75,000 ft² x (1 Therm / 100 kBtu) x $1.10 / Therm)

Gas cost = $28,050

The project's total annual energy cost is the sum of the electricity and gas costs, or $144,573. The building site has space for a 70-kW solar array, which is estimated to produce 92,254 kWh of electricity per year, after transmission and conversion losses. The project's equivalent cost of usable energy is calculated as follows:

Equivalent cost = (Units of renewable energy generated x Project utility rate for type of energy generated)

Equivalent cost = (92,254 kWh x $0.09/kWh) = $8,303

The project can now calculate its percentage of renewable energy:

$$\% \text{ renewable energy} = \frac{\text{Equivalent cost usable energy produced by renewable energy system}}{\text{Total project annual energy cost}}$$

$$\% \text{ renewable energy} = \frac{\$8{,}303}{\$144{,}825}$$

$$\% \text{ renewable energy} = 5.7\%$$

Example 3. Project connected to a base building with renewables
A commercial office building contains a central chilled water plant that serves multiple tenant spaces. The central plant has a dedicated photovoltaic array that provides a portion of the energy to the chilled water plant. The central plant uses the equivalent of $100,000 of electricity generated from PV, and the project receives 25% of the chilled water output of the chiller plant. The project team calculates the equivalent cost of renewable energy:

Equivalent cost = ($ value of renewable energy used at chiller plant x % of chiller plant energy delivered to tenant space)

Equivalent cost = ($100,000 x 25%)

Equivalent cost = $25,000

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	On-site system	Third-party system ownership	Community systems
Renewable system rated capacity	X	X	X
Calculations to determine energy generated	X	X	X
Documentation of annual energy costs	X	X	X
Equivalent cost of renewable energy produced	X	X	X
Contract indicating duration		X	X
Documentation indicating percentage owned or leased in community system			X

RELATED CREDIT TIPS

EA Prerequisite Fundamental Commissioning and Verification and EA Credit Enhanced Commissioning. All renewable energy systems dedicated to the project space must be commissioned to comply with the related prerequisite and credit.

EA Credit Optimize Energy Performance. Renewable energy systems will contribute to achievement of the related credit.

EA Credit Advanced Energy Metering. All whole-building energy sources, including renewable energy sources, must be submetered to comply with the related credit.

EA Credit Green Power and Carbon Offsets. Renewable energy certificates, green power, and carbon offsets purchased from outside vendors are addressed in the related credit; additional points are available for projects that purchase them.

CHANGES FROM LEED 2009

Solar gardens and community systems are eligible under certain conditions.

REFERENCED STANDARDS

Center for Resource Solutions Green-e Program: green-e.org

Commercial Building Energy Consumption Survey (CBECS): eia.gov/consumption/commercial

EXEMPLARY PERFORMANCE

Meet 10% renewable energy generation.

DEFINITIONS

renewable energy energy sources that are not depleted by use. Examples include energy from the sun, wind, and small (low-impact) hydropower, plus geothermal energy and wave and tidal systems.

renewable energy credit (REC) a tradable commodity representing proof that a unit of electricity was generated from a renewable resource. RECs are sold separately from electricity itself and thus allow the purchase of green power by a user of conventionally generated electricity.

solar garden a shared solar array or other renewable energy system with grid-connected subscribers who receive credit for the use of renewables using virtual net metering. Also known as a community renewable energy system. (Adapted from solargardens.org)

ENERGY AND ATMOSPHERE CREDIT

Enhanced Refrigerant Management

This credit applies to:

Commercial Interiors (1 point)
Retail (1 point)
Hospitality (1 point)

INTENT

To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.

REQUIREMENTS

COMMERCIAL INTERIORS, HOSPITALITY

OPTION 1. NO REFRIGERANTS OR LOW-IMPACT REFRIGERANTS (1 POINT)

Do not use refrigerants, or use only refrigerants (naturally occurring or synthetic) that have an ozone depletion potential (ODP) of zero and a global warming potential (GWP) of less than 50.

OR

OPTION 2. CALCULATION OF REFRIGERANT IMPACT (1 POINT)

Select refrigerants that are used in heating, ventilating, air-conditioning, and refrigeration (HVAC&R) equipment to minimize or eliminate the emission of compounds that contribute to ozone depletion and climate change. The combination of all new and existing base building and tenant HVAC&R equipment that serve the project must comply with the following formula:

IP Units	SI Units
LCGWP + LCODP × 10^5 ≤ 100	LCGWP + LCODP × 10^5 ≤ 13
Calculation definitions for LCGWP + LCODP × 105 ≤ 100 (IP units)	Calculation definitions for LCGWP + LCODP x 105 ≤ 13 (SI units)
LCODP = [ODPr × (Lr × Life + Mr) × Rc] / Life	LCODP = [ODPr × (Lr × Life + Mr) × Rc] / Life
LCGWP = [GWPr × (Lr × Life + Mr) × Rc] / Life	LCGWP = [GWPr × (Lr × Life + Mr) × Rc] / Life
LCODP: Lifecycle Ozone Depletion Potential (lb CFC 11/Ton-Year)	LCODP: Lifecycle Ozone Depletion Potential (lb CFC 11/Ton-Year)
LCGWP: Lifecycle Direct Global Warming Potential (lb CO_2/Ton-Year)	LCGWP: Lifecycle Direct Global Warming Potential (kg CO_2/kW-year)
GWPr: Global Warming Potential of Refrigerant (0 to 12,000 lb CO_2/lbr)	GWPr: Global Warming Potential of Refrigerant (0 to 12,000 kg CO_2/kg r)
ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 lb CFC 11/lbr)	ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 kg CFC 11/kg r)
Lr: Refrigerant Leakage Rate (2.0%)	Lr: Refrigerant Leakage Rate (2.0%)
Mr: End-of-life Refrigerant Loss (10%)	Mr: End-of-life Refrigerant Loss (10%)
Rc: Refrigerant Charge (0.5 to 5.0 lbs of refrigerant per ton of gross AHRI rated cooling capacity)	Rc: Refrigerant Charge (0.065 to 0.65 kg of refrigerant per kW of AHRI rated or Eurovent Certified cooling capacity)
Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)	Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)

For multiple types of equipment, calculate a weighted average of all base building HVAC&R equipment, using the following formula:

IP UNITS

$$\frac{\sum \left(LCGWP + LCODP \times 10^5 \right) \times Qunit}{Qtotal} \leq 100$$

SI UNITS

$$\frac{\sum \left(LCGWP + LCODP \times 10^5 \right) \times Qunit}{Qtotal} \leq 13$$

CALCLULATION DEFINITIONS FOR (IP UNITS)

$$\frac{\sum \left[\left(LCGWP + LCODP \times 10^5 \right) \times Qunit \right]}{Qtotal} \leq 100$$

Qunit = Gross AHRI rated cooling capacity of an individual HVAC or refrigeration unit (Tons)

Qtotal = Total gross AHRI rated cooling capacity of all HVAC or refrigeration

CALCULATION DEFINITIONS FOR (SI UNITS)

$$\frac{\sum \left[\left(LCGWP + LCODP \times 10^5 \right) \times Qunit \right]}{Qtotal} \leq 13$$

Qunit = Eurovent Certified cooling capacity of an individual HVAC or refrigeration unit (kW)

Qtotal = Total Eurovent Certified cooling capacity of all HVAC or refrigeration (kW)

RETAIL

Meet Option 1 or 2 for all HVAC systems.

Stores with commercial refrigeration systems must comply with the following.

- Use only non-ozone-depleting refrigerants.
- Select equipment with an average HFC refrigerant charge of no more than 1.75 pounds of refrigerant per 1,000 Btu/h (2.72 kg of refrigerant per kW) total evaporator cooling load.
- Demonstrate a predicted store-wide annual refrigerant emissions rate of no more than 15%. Conduct leak testing using the procedures in GreenChill's best practices guideline for leak tightness at installation.

Alternatively, stores with commercial refrigeration systems may provide proof of attainment of EPA GreenChill's silver-level store certification for newly constructed stores.

BEHIND THE INTENT

This credit addresses the two main threats to the environment posed by refrigerants: their ozone depletion potential (ODP) and global warming potential (GWP).

As is well known, chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and other ozone-depleting substances commonly used in refrigerants contribute to the depletion of the stratospheric ozone layer. Yet refrigerants released into the atmosphere also contribute to global climate change, having a disproportionately large effect compared with other greenhouse gases. For example, HCFC-22 contributes to warming at 1,780 times the potency of an equal amount of carbon dioxide.

However, trade-offs also exist between the above concerns and energy use. Alternatives to CFC and HCFC refrigerants, such as HFC-410A, have a lower GWP when directly released, but their use may require more energy—which also affects climate. Conversely, variable refrigerant flow (VRF) systems may improve energy efficiency but have a higher refrigerant charge.

Careful consideration of the refrigerant requirements of energy systems and appliances can improve performance and reduce operating cost. Refrigerants vary in operating pressure, material compatibility, flammability, and toxicity. Operating pressure and material compatibility are particularly critical factors to take into account when refrigerants in existing equipment are replaced.

The refrigerant impact calculation addresses the overall effect of each refrigerant's ODP and GWP combined by accounting for these interrelated factors.

STEP-BY-STEP GUIDANCE

STEP 1. GATHER INFORMATION ON SYSTEMS AND REFRIGERANTS IN PROJECT

All refrigerant-using equipment part of systems serving the project space, including those that are part of the base building systems, must be included in the credit calculations. Identify all HVAC&R equipment that contains refrigerant and record the refrigerant charge and type for existing and new units. Projects that retain CFCs past initial occupancy, even if using a phase-out plan to meet the requirements of EA Prerequisite Fundamental Refrigerant management, are ineligible for this credit.

- Small systems with less than 0.5 pound (225 grams) of refrigerants, such as individual water fountains or stand-alone refrigerators, do not need to be included in credit calculations.
- Unit charge information is often not available for new equipment until contractor submittals are provided (particularly for split systems) because the charge depends on the length of refrigerant piping runs.
- If a district energy system (DES) serves the project, data for the refrigerant-using equipment in the DES must be collected.
- Consider incorporating the credit requirements and equations into project specifications.

STEP 2. SELECT ONE OPTION

- Option 1 is for projects that have no refrigerants and projects with refrigerants that have an ODP of zero and a GWP of less than 50 (see *Further Explanation Designing for No Refrigerants or Low-Impact Refrigerant Use*). These projects achieve the credit; no additional steps are required.
- Option 2 is for projects whose refrigerants exceed the Option 1 limit.

Option 2. Refrigerant Impact Calculation

STEP 1. CALCULATE REFRIGERANT IMPACT OF PROPOSED SYSTEMS

To determine the environmental effects of HVAC&R systems containing refrigerants, apply the following assumptions.

Assume the ODP and GWP values listed in Table 1.

TABLE 1. Ozone depletion and global warming potentials of common refrigerants			
Refrigerant	**ODPr**	**GWPr**	**Common building applications**
Chlorofluorocarbons			
CFC-11	1.0	4,680	Centrifugal chiller
CFC-12	1.0	10,720	Refrigerators, chiller
CFC-114	0.94	9,800	Centrifugal chiller
CFC-500	0.605	7,900	Centrifugal chiller, humidifier
CFC-502	0.221	4,600	Low-temperature refrigeration
Hydrochlorofluorocarbons			
HCFC-22	0.04	1,780	Air-conditioning, chiller
HCFC-123	0.02	76	CFC-11 replacement
Hydrofluorocarbons			
HFC-23	~0	12,240	Ultra-low-temperature refrigeration
HFC-134a	~0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	~0	1,020	Insulation agent, centrifugal chiller
HFC-404A	~0	3,900	Low-temperature refrigeration
HFC-407C	~0	1,700	HCFC-22 replacement
HFC-410A	~0	1,890	Air-conditioning
HFC-507A	~0	3,900	Low-temperature refrigeration
Natural refrigerants			
Carbon dioxide (CO_2)	0	1.0	
Ammonia (NH_3)	0	0	
Propane	0	3	

Assume equipment life according to Table 2. For any HVAC&R equipment not listed, assume an equipment life of 10 years. Different values for equipment life may be substituted, with manufacturers' documentation.

For existing equipment, apply the default equipment life according to Table 2. The equation is based on refrigerant impact spread over the life of the equipment; estimated remaining equipment life should not be substituted because it would provide inaccurate results.

TABLE 2. Default equipment life	
Equipment	**Default equipment life**
Window air-conditioner, heat pump	10 years
Unitary, split, packaged air-conditioner, package heat pump	15 years
Reciprocating and scroll compressor, reciprocating chiller	20 years
Absorption chiller	23 years
Water-cooled packaged air-conditioner	24 years
Centrifugal chiller	25 years

Assume that refrigerant leakage rate (Lr) is 2% per year and end-of-life refrigerant loss (Mr) is 10%, for all equipment types. No alternative values may be substituted for these percentages (see *Further Explanation, Calculations* and *Examples*).

Refrigerant charge (Rc) is the ratio of the total refrigerant used in a piece of equipment to the total cooling capacity of that equipment, expressed in pounds per ton or kilograms per kW. For example, if a packaged air-conditioning unit uses 7 pounds of refrigerant and its cooling capacity is 5 tons, the refrigerant charge is 1.4.

STEP 2. INCORPORATE DESIGN CRITERIA INTO PROJECT PLANS AND SPECIFICATIONS

If calculations were performed during design, use the results to specify the maximum refrigerant charge for the HVAC equipment. When the project is under construction, review equipment submittals from the mechanical contractor to verify that the equipment and refrigerant charge meet the design specifications.

FURTHER EXPLANATION

CALCULATIONS

Weighted Average Refrigerant Impact for the Project Building:
The project team must develop a weighted average calculation based on both downstream and upstream equipment. The weighted average is based on the entire downstream equipment capacity, but only the designed capacity of the equipment being served by the base building central plant, not the entire capacity of the central plant.

EQUATION 1. Weighted average refrigerant impact

$$\left\{\frac{\left(\text{Project building design chilled water cooling load in tons} \times \text{Chilled water central plant refrigerant impact score}\right) + \left(\text{Project building refrigerant systems' total capacity in tons} \times \text{Project building refrigerant impact score}\right)}{\text{Total combined capacity (tons): Project building refrigerant systems' total capacity in tons} + \text{Project building design chilled water cooling load in tons}}\right\}$$

For example, a project has 50 tons of packaged equipment with a refrigerant impact value of 100 per ton. The base building central plant has a refrigerant impact value of 70 per ton and a total capacity of 1,000 tons. The project also has a designed 50 tons of equipment served by the central plant. The weighted average impact is calculated as follows:

$$\left\{\frac{\left(50 \text{ tons} \times 70\right) + \left(50 \text{ tons} \times 100\right)}{\left(50 \text{ tons} + 50 \text{ tons}\right)}\right\} = \text{85 weighted average refrigerant impact}$$

OPTIMIZING HVAC SYSTEMS TO MINIMIZE REFRIGERANT IMPACT

Avoiding equipment with a high refrigerant charge, such as multiple small packaged units or split systems, can make this credit easier to achieve. Systems that use chillers or a central plant are more likely to meet the credit requirements. If possible, incorporate indirect or direct evaporative cooling.

For renovations, consider retrofitting or replacing existing HVAC systems to minimize ODP and GWP contributions. Assess whether equipment replacement or refrigerant conversion is economical. Equipment that is easily accessible and has a high run time may be a candidate for refrigerant swap with a reasonable return on investment.

EXAMPLES

Sample Calculation 1. Interior Office Space (SI)
The cooling equipment for a commercial office consists of the following systems:

- Twelve 17.57-kW packaged HVAC units with HFC-410A for the open office
- One 7.03-kW split system HVAC unit with HCFC-22 for a data room
- One-3.51 kW window HVAC unit with HCFC-22 for a private office

SAMPLE CALCULATION. Interior Office Space (SI)													
Inputs									Calculations				
Units	Qunit (kW)	Refrigerant	GWPr	ODPr	Rc (kg/kW)	Life (yrs.)	Lr (%)	Mr (%)	Tr Total Leakage (Lr x Life +Mr)	LCGWP (GWPr x Tr x Rc) / Life	LCODP x 10^5 100,000 x (ODPr x Tr x Rc) / Life	Refrigerant atmospheric impact = LCGWP + LCODP x10^5	(LCGWP + LCODP x 10^5 x N x Qunit
12	17.57	R-410A	1 890	0	0.23	15	2	10	40%	11.59	0	11.59	2 443.64
1	7.03	R-22	1 780	0.04	0.43	15	2	10	40%	20.41	45.87	66.28	465.95
1	3.51	R-22	1 780	0.04	0.27	10	2	10	30%	14.42	32.4	46.82	164.34
Qtotal	221.38											Subtotal	3 073.93
Average refrigerant atmospheric impact = Σ (LCGWP + LCODP x 10^5) x Qunit) / Qtotal 13.89													

Lr = leakage rate Mr = refrigerant loss Qunit = cooling capacity of equipment Rc = refrigerant charge

Because the average refrigerant impact is greater than 13, the project does not earn the credit.

Sample Calculation 2. Interior Office Space with Variable Refrigerant Flow
The cooling equipment in an office building consists of four 8-ton outdoor VRF units. Each unit has a base refrigerant amount of 16.5 pounds and an additional refrigerant amount of 2.7 pounds for distribution, which must be included. The Rc for each unit is (16.5 pounds + 2.7 pounds) / 8 tons = 2.4 pounds/ton.

SAMPLE CALCULATION 2. Interior Office Space with Variable Refrigerant Flow													
Inputs									Calculations				
Units	Qunit (tons)	Refrigerant	GWPr	ODPr	Rc (lb/ton)	Life (yrs.)	Lr (%)	Mr (%)	Tr Total Leakage (Lr x Life +Mr)	LCGWP (GWPr x Tr x Rc) / Life	LCODP x 10^5 x 100,000 (ODPr x Tr x Rc) / Life	Refrigerant atmospheric impact = LCGWP + LCODP x10^5	(LCGWP + LCODP x 10^5 x N x Qunit
4	8	R-410A	1,890	0	2.4	15	2	10	40%	120.96	0	120.96	3,871
Qtotal	32											Subtotal	3,871
Average refrigerant atmospheric impact = Σ (LCGWP + LCODP x 10^5) x Qunit) / Qtotal 120.96													

Lr = leakage rate Mr = refrigerant loss Qunit = cooling capacity of equipment Rc = refrigerant charge

Becauseecause the average refrigerant impact is greater than 100, the project does not earn the credit.

DESIGNING FOR NO REFRIGERANTS OR LOW-IMPACT REFRIGERANT USE

In some cases, cooling needs can be met without vapor compression HVAC equipment. This can be possible in buildings that are designed for natural ventilation and have very low cooling loads. Optimizing the following non-HVAC design elements can help reduce the project's cooling load:

- Glazing properties
- Shading
- Insulation
- Lighting and equipment power density

Determine whether natural refrigerants like carbon dioxide, ammonia, or water can be used to meet cooling needs or other project goals. Absorption chillers, for example, are compatible with refrigerants like ammonia, and carbon dioxide is popular for low-temperature cooling applications.

Heat from the refrigeration process can be recovered for other uses, like service hot water heating. To reduce peak cooling requirements for ventilation air, use air-side energy recovery.

EVAPORATIVE COOLING

Another strategy for minimizing refrigerant charge is to incorporate direct or indirect evaporative cooling. Table 3 outlines the most favorable circumstances for this approach to refrigerant impact reduction.

TABLE 3. Evaporative cooling scenarios

Direct evaporative cooling	Indirect evaporative cooling
Hot and dry climates with design wet-bulb temperatures 68°F (20°C) or lower	Hot and dry climates with design wet-bulb temperatures 68°F (20°C) or lower
Residential, light commercial, industrial or other spaces with low latent heat gain	Pretreatment of outside air for systems with higher latent loads, such as densely occupied office spaces, and need to control humidity

Indirect and direct evaporative cooling can be combined for greater efficiency. An indirect cooler lowers the temperature of air and reduces the air's moisture content; a direct cooler then cools the air further and restores humidity to the air.

RATING SYSTEM VARIATIONS

Retail

For Retail HVAC systems, use the calculation methodology and assumptions listed for all projects.

Retail projects with commercial refrigeration systems may either follow the prescriptive criteria or pursue certification through U.S. EPA GreenChill's certification program for newly constructed stores. If pursuing EPA certification, follow the certification steps outlined on the program website.

If following prescriptive requirements, have the commercial refrigeration equipment tested for leaks according to the procedures outlined in GreenChill's Best Practices Guideline for Leak Tightness at Installation. The leak testing is required for GreenChill certification but the guidelines are applicable to any retail project, including non-U.S. projects, regardless of whether the project is pursuing GreenChill certification. The installer is typically responsible for conducting leak testing after installation. Include requirements in the contract with the commercial refrigerant installer. The commissioning scope may also include verification of proper leak testing, but this is not required.

Non-Retail projects that have commercial refrigeration systems may follow the prescriptive criteria available to retail projects for commercial refrigeration systems. Both these prescriptive criteria for the commercial refrigeration systems and the credit requirements for the HVAC refrigerant-using systems must be met to achieve credit compliance in this case.

PROJECT TYPE VARIATIONS

District Energy Systems and Central Plants

If a project has only downstream refrigeration equipment, only that equipment must be included in the refrigerant impact calculation. If a project has only upstream refrigeration equipment, only that equipment must be included in the refrigerant impact calculation. If a project has both downstream and upstream refrigeration equipment, use the following procedure to show credit compliance.

Complete two separate refrigerant impact calculations: one to calculate the refrigerant impact using only the downstream equipment and another using only the upstream equipment.

If both calculations meet the credit requirements, the project team has demonstrated credit compliance. If neither calculation meets the credit requirements, the project cannot achieve this credit. If one calculation fails but the other passes, the project team may demonstrate compliance using the weighted average refrigerant impact (see *Further Explanation, Calculations*).

CAMPUS

Group Approach
Submit separate documentation for each project space.

Campus Approach
Option 1. Eligible.

Option 2. Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Confirmation that only no or low-impact refrigerants are used	X	
Equipment type		X
Equipment cooling capacity		X
Equipment quantity		X
Refrigerant type		X
Refrigerant charge (plus supporting documentation, if applicable)		X
Equipment life (plus supporting documentation, if applicable)		X
Refrigerant charge calculations (for VRF systems only)		X
Provide Refrigerant equipment schedule or GreenChill certification (commercial refrigeration systems only)		X
Provide Leak Test Results (commercial refrigeration systems only)		X

CHANGES FROM LEED 2009

Sector-specific requirements have been added for commercial refrigeration equipment.

REFERENCED STANDARDS

None.

RELATED CREDIT TIPS

EA Credit Optimize Energy Performance. Alternatives to CFC and HCFC refrigerants, such as HFC-410A, have lower refrigerant impacts but may require higher levels of energy use. Variable refrigerant flow (VRF) and some split systems rarely meet the requirements of this credit because of the long refrigerant piping runs and the high quantity of refrigerant needed.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

downstream equipment the heating and cooling systems, equipment, and controls located in the project building or on the project site and associated with transporting the thermal energy of the district energy system (DES) into heated and cooled spaces. Downstream equipment includes the thermal connection or interface with the DES, secondary distribution systems in the building, and terminal units.

natural refrigerant a compound that is not manmade and is used for cooling. Such substances generally have much lower potential for atmospheric damage than manufactured chemical refrigerants. Examples include water, carbon dioxide, and ammonia.

upstream equipment a heating or cooling system or control associated with the district energy system (DES) but not part of the thermal connection or interface with the DES. Upstream equipment includes the thermal energy conversion plant and all the transmission and distribution equipment associated with transporting the thermal energy to the project building or site.

ENERGY AND ATMOSPHERE CREDIT

Green Power and Carbon Offsets

This credit applies to:

Commercial Interiors (1–2 points)
Retail (1–2 points)
Hospitality (1–2 points)

INTENT

To encourage the reduction of greenhouse gas emissions through the use of grid-source, renewable energy technologies and carbon mitigation projects.

REQUIREMENTS

Engage in a contract for qualified resources that have come online since January 1, 2005, for a minimum of five years, to be delivered at least annually. The contract must specify the provision of at least 50% or 100% of the project's energy from green power, carbon offsets, or renewable energy certificates (RECs).

Green power and RECs must be Green-e Energy certified or the equivalent. RECs can only be used to mitigate the effects of Scope 2, electricity use.

Carbon offsets may be used to mitigate Scope 1 or Scope 2 emissions on a metric ton of carbon dioxide–equivalent basis and must be Green-e Climate certified, or the equivalent.

For U.S. projects, the offsets must be from greenhouse gas emissions reduction projects within the U.S.

Determine the percentage of green power or offsets based on the quantity of energy consumed, not the cost. Points are awarded according to Table 1.

TABLE 1. Points for energy from green power or carbon offsets

Percentage of total energy addressed by green power, RECs and/or offsets	Points
50%	1
100%	2

Use the project's annual energy consumption, calculated in EA Prerequisite Minimum Energy Performance, if Option 1 was pursued; otherwise use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) database to estimate energy use.

BEHIND THE INTENT

The voluntary market can be an effective catalyst for encouraging energy generators and utility companies to develop clean energy sources and help address climate change. Purchasing renewable energy certificates (RECs) allows projects that use nonrenewable power to create market demand for renewable energy. Carbon offsets allow projects or companies to fund activities that seek to decrease carbon emissions or remove carbon from the atmosphere, such as methane abatement, energy efficiency projects, and reforestation or land-use changes.

STEP-BY-STEP GUIDANCE

STEP 1. INVESTIGATE AVAILABLE OPTIONS

The possibilities for purchasing green power, RECs, and offsets will vary with the project's location and energy types. Consider the costs of various options.

- Green power and RECs must be Green-e Energy certified or the equivalent. Direct or local green power may be available through local utility providers; review their websites for green power cost premiums.
- Green power and RECs can be used only toward the electric energy use portion of the project's annual energy use (Scope 2, electricity). They cannot be applied toward nonelectric energy uses (see *Further Explanation, Scope 1 and Scope 2 Emissions*).
- Carbon offsets must be Green-e Climate certified or the equivalent. Unlike RECs and purchased green power, carbon offsets can be used toward both electric and nonelectric energy use.

STEP 2. CONDUCT COST-BENEFIT ANALYSIS

Undertake a cost-benefit analysis to understand the financial and environmental payback for the available options. All carbon offsets are not the same. Some are associated with land-use development, others with energy efficiency projects. Teams are encouraged to purchase carbon offsets that align with their environmental interests and values.

STEP 3. SET PROJECT GOAL FOR GREEN POWER OR CARBON OFFSETS

Review the credit point thresholds and establish the green power or carbon offset purchase goal for the project. The offset goal is not a one-time purchase—it must be met for multiple consecutive years, as indicated in the credit requirements.

STEP 4. CALCULATE ENERGY USE ASSOCIATED WITH SCOPE 1 AND SCOPE 2 EMISSION CATEGORIES

Determine the total grid-generated annual energy use, based on the option selected in EA Prerequisite Minimum Energy Performance.

- Projects that used modeling to comply with EA Prerequisite Minimum Energy Performance (Option 1) must use the simulation results to determine the total annual electricity and nonelectricity energy use.
  - Exclude any site-generated electricity (e.g., wind turbines, photovotaics) and fuel (e.g., biogas) from the total consumption amount, provided the project does not sell the on-site energy generated as RECs.
  - Include as nonelectric energy any steam and chilled water purchased from the utility provider or a third party and any fuel purchased for on-site electricity generation in the building (e.g., diesel for gensets).
- Projects that used the prescriptive pathway to achieve EA Prerequisite Minimum Energy Performance (Option 2) must use the U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS) database to estimate annual energy use (see EA Credit Renewable Energy Production, *Further Explanation, Table 2*).
  - Exclude any site-generated electricity from the total annual electric energy use.
  - Use the total project area and appropriate energy use intensity (EUI) from the CBECS database to calculate the projected electric and nonelectric annual energy use.
- Net-zero tenant spaces—those anticipated to consume zero net energy on an annual basis— are eligible to achieve 2 points under this credit without purchasing any additional renewable energy,

RECs, or carbon offsets, provided the project does not sell any RECs associated with the on-site renewable energy production.

STEP 5. CALCULATE REQUIRED GREEN POWER AND CARBON OFFSETS

Use the project's electricity and nonelectricity energy use totals to determine the required amount of green power and/or carbon offsets to be purchased.

- Projects that use green power or RECs must convert their annual grid-generated electricity use to MWh.
- Projects that use carbon offsets must convert their annual grid-generated electricity use to metric tons of CO_2e. For conversion factors and GHG emissions factors, see *Further Explanation, Calculating Greenhouse Gas Emissions*.
- All projects must convert their annual nonelectricity energy use to metric tons of CO_2e.
- Any combination of the above can be used to achieve either the 50% or the 100% threshold. If the project goal is less than the 100% threshold, prorate the required amount accordingly.

STEP 6. OBTAIN PROPOSALS FROM GREEN-E PROVIDER OR EQUIVALENT AND MAKE PURCHASE

Solicit proposals for green power, RECs, and/or carbon offsets from qualified Green-e providers, as specified in the credit requirements and select a vendor.

- The provider must provide confirmation of the date on which the qualified resources came online.
- The contract must specify the purchasing goals and is valid for the duration indicated in the credit requirements.
- For U.S. projects, the offsets must come from greenhouse gas (GHG) emissions reduction projects within the U.S.
- If Green-e certified products are not available, equivalency of other products must be demonstrated (see *Further Explanation, Establishing Green-e Equivalency*). Projects outside the U.S. that cannot find local products that meet the Green-e standard or equivalent can still achieve this credit by purchasing Green-e certified products from the U.S.

FURTHER EXPLANATION

CALCULATIONS

EQUATION 1. Total qualifying energy use

$$\text{Total qualifying annual energy use} = \left\{ \left(\text{Total annual grid-based electricity use} - \text{Total annual site-generated electricity} \right) + \left(\text{Total annual fossil fuel use} - \text{Total annual renewable fuels use} \right) \right\}$$

EQUATION 2. Percentage of energy purchased or offset

$$\text{\% Energy purchased or offset} = \left\{ \frac{\left(\text{Quantity of RECs in kWh}\right)}{\left(\text{Annual building energy use in kWh}\right)} + \frac{\left(\text{Purchased green power}\right)}{\left(\text{Annual building energy use in kWh}\right)} + \frac{\left(\text{Purchased carbon offsets}\right)}{\left(\text{GHG emissions associated with project's annual energy use}\right)} \right\}$$

EQUATION 3. Metric tons of CO_2 equivalent, Fuel A

$$\text{Metric tons of } CO_2 \text{ equivalent, Fuel A} = \text{Annual use, Fuel A (kBtu)} \times \text{Direct GHG emissions factor, Fuel A (mt } CO_2e/\text{kBtu)}$$

EQUATION 4. Metric tons of CO_2 equivalent, electricity

$$\text{Metric tons of } CO_2 \text{ equivalent, electricity} = \text{Annual electricity use (kWh)} \times 3.412\ (\text{kBtu/kWh}) \times \text{Indirect GHG emissions factor, electricity (mt } CO_2e/\text{kBtu)}$$

SCOPE 1 AND SCOPE 2 EMISSIONS

Scope 1 emissions are greenhouse gases emitted directly—that is, from sources owned or controlled by the entity (e.g., emissions from fossil fuels burned on site). Electricity produced on site through the burning of fossil fuels is measured by the Scope 1 emissions associated with that fossil fuel.

Scope 2 emissions are an entity's greenhouse gases associated with purchased electricity - and also with high temperature hot water, chilled water, or steam - that comes from a utility provider. Scope 2 emissions include transmission and distribution losses related to hot water, chilled water, and steam. Transmission and distribution losses associated with electricity are not included in Scope 2.

ESTABLISHING GREEN-E EQUIVALENCY

Projects not using Green-e certified products must demonstrate the alternative's equivalency to the quality standards established for Green-e Energy and Green-e Climate products:

- Green-e Energy National Standard v2.1, Sections II, III (excluding G), IV (excluding A), and V
- Green-e Climate National Standard v2.0, Sections 4, 5, 6.1, 6.3, 6.4, and 7

The accounting process and standards must be equivalent to Green-e products and address the following:

- Verifiable chain of custody
- Verifiable age of renewable energy
- Tracking of GHG reductions from eligible projects
- Mechanism to prevent double-counting
- Third party–verified retail transaction

For carbon offsets, retirement of an eligible credit alone is not equivalent to Green-e Climate certification.

CALCULATING GREENHOUSE GAS EMISSIONS

When calculating offsets, project teams must use the default emissions factors established by ENERGY STAR Portfolio Manager for the appropriate fuel types (Tables 2 and 3). Using Equation 1, apply the default emissions factor to the project's annual fuel consumption to determine the project's greenhouse gas footprint, expressed in metric tons of CO_2 equivalent (CO_2e).

EQUATION 5. Project greenhouse gas emissions

$$\text{GHG emissions } (CO_2e) = \text{Consumption} \times CO_2 \text{ emissions factor}$$

where emissions factor = mass CO_2 per mass or volume unit of fuel

TABLE 2. Direct GHG emissions factors		
Fuel type	**Mt CO_2e/kBtu**	**Mt CO_2e/kWh**
Natural gas	5.32×10^{-5}	1.82×10^{-4}
Fuel oil (No. 2)	7.36×10^{-5}	2.51×10^{-4}
Wood	1.02×10^{-4}	3.47×10^{-4}
Propane	6.35×10^{-5}	2.17×10^{-4}
Liquid propane	6.36×10^{-5}	2.17×10^{-4}
Kerosene	7.27×10^{-5}	2.48×10^{-4}
Fuel oil (No. 1)	7.36×10^{-5}	2.51×10^{-4}
Fuel oil (Nos. 5 and 6)	7.92×10^{-5}	2.70×10^{-4}
Coal (anthracite)	1.04×10^{-4}	3.56×10^{-4}
Coal (bituminous)	9.42×10^{-5}	3.21×10^{-4}
Coke	1.14×10^{-4}	3.90×10^{-4}
Fuel oil (No. 4)	7.36×10^{-5}	2.51×10^{-4}
Diesel	7.36×10^{-5}	2.51×10^{-4}

TABLE 3. Indirect GHG emissions factors		
Fuel type	**Mt CO_2e/kBtu**	**Mt CO_2e/kWh**
Purchased electricity (national average)	1.73×10^{-4}	5.90×10^{-4}
District steam	7.90×10^{-5}	2.69×10^{-4}
District hot water	7.90×10^{-5}	2.69×10^{-4}
District chilled water, electric-driven chiller (0.238095*purchased electricity national average)	4.11×10^{-5}	1.40×10^{-4}
District chilled water, absorption chiller using natural gas	6.65×10^{-5}	2.27×10^{-4}
District chilled water, engine-driven chiller using natural gas	4.43×10^{-5}	1.51×10^{-4}

EXAMPLES

Example 1. Determining compliance based on modeled energy use

A project team has used modeling to comply with EA Prerequisite Minimum Energy Performance (Option 1). According to the simulation results, the project's annual electricity use is 5,077,667 kWh plus 5,750,000 kBtu of natural gas use. To earn 1 point under this credit, the project team has two choices.

1. The project can purchase RECs for electricity consumption and carbon offsets for natural gas consumption. For RECs, the team uses the following calculation:

   5,077,667 kWh/yr x 50% = 2,538,834 kWh/yr

   For carbon offsets, the team uses this calculation:

   5,775,000 kBtu/yr x (5.32×10^{-5} mtCO_2e/kBtu) x 50% = 153.6 mtCO_2e/yr

   Projects are not required to cover 50% of its electricity use and 50% of its natural gas use, only 50% of total energy use.

2. Alternatively, the project can purchase carbon offsets for all consumption (Scope 1 and Scope 2 emissions). For the carbon offsets to cover electricity use (Scope 2), the team performs the following calculation:

   5,077,667 kWh/yr x (5.90×10^{-4} mtCO_2e/kWh) = 2995.8 mtCO_2e/yr

For carbon offsets to cover natural gas use (Scope 1), the team uses this calculation:

$$5{,}775{,}000 \text{ kBtu/yr} \times (5.32 \times 10^{-5} \text{ mtCO}_2\text{e/kBtu}) = 307.2 \text{ mtCO}_2\text{e/yr}$$

2995.8 + 307.2 = 3303 metric tons of CO_2 equivalent. Thus, the project's total carbon offsets are as follows:

$$3303 \text{ mtCO}_2\text{e/yr} \times 50\% = 1651.5 \text{ mtCO}_2\text{e/yr}$$

Example 2. Determining compliance using CBECS data

A project team has achieved EA Prerequisite Minimum Energy Performance through the prescriptive pathway (Option 2) and will therefore use CBECS data to estimate electricity and gas consumption. The project is a 10,000–square-foot ground-floor retail space that uses both electricity (for cooling and equipment) and natural gas (for heating and domestic hot water). The team is attempting to earn 2 points by covering 100% of the project's energy usage through RECs and offsets.

The team must estimate total electricity and natural gas use based on CBECS data for the retail space type, as follows:

$$\text{Electricity: } 10{,}000 \text{ ft}^2 \times 14.3 \text{ kWh/ft}^2 = 143{,}000 \text{ kWh}$$

$$\text{Natural gas: } 10{,}000 \text{ sf} \times 25.1 \text{ kBtu/ft}^2 = 251{,}000 \text{ kBtu}$$

The emissions factor is applied as follows:

$$251{,}000 \text{ kBtu} \times 5.32 \times 10^{-5} = 13.35 \text{ mtCO}_2\text{e}$$

To earn 2 points, the project must purchase Green-e certified green power equal to 143,000 kWh and must also purchase carbon offsets for 13.35 metric tons of CO_2 equivalent.

PROJECT TYPE VARIATIONS

District Energy Systems and Central Plants

For projects using energy model Path 2 or 3, green power and offsets used in a DES or base building central plant may contribute toward this credit for a connected space. For any projects using energy model Path 1, green power and offsets used in a DES or central plant do not contribute.

Performance is based on the fraction of the project's annual energy consumption that is supplied by green power or made up for by carbon offsets. In the DES or central plant setting, this fraction depends in turn on the fraction of plant energy that is supplied by the green power or offset, and the fraction of the model's annual energy consumption associated with the plant. For each thermal energy source provided to the project by the plant, calculate the green power or offset contribution as follows:

1. Find the fraction of the annual DES or central plant energy use supplied by qualifying green power sources or covered by offsets:

$$\text{Fraction of Thermal Energy Source } i \text{ from Green Power or covered by RECs/offsets (GS)} = \frac{\left\{\dfrac{\text{Quantity RECs or Green Power purchased}}{\text{Electricity used to generate source, } i}\right\} + \left\{\dfrac{\text{Quantity Carbon Offsets purchased}}{\text{Carbon equivalent of fuel used to generate source, } i}\right\}}{\text{Total energy used to generate source, } i}$$

2. Find the fraction of the project's annual energy consumption that is supplied by the DES or central plant's thermal energy source.

$$\text{Fraction of building annual energy consumption supplied by source (BS), } i = \frac{\text{Project energy supplied by Source, } i}{\text{Total project energy consumed}}$$

3. Multiply the two.

$$\text{Total Green Power or offset contribution from DES} = \sum_i GS_i \times BS_i$$

4. Derive the project's total annual energy consumption reported for EA Credit Green Power and Carbon Offsets credit compliance from the proposed case modeling run of EA Prerequisite Minimum Energy Performance.

If green energy contributions from the DES/central plant are applied to the project, submit a letter from the plant or base building owner or operator verifying that the renewable energy is allocated specifically to the DES generation or distribution equipment, and confirming that no renewable energy allocated specifically to the DES or central plant building, if any (in a separate LEED application), is being counted toward the renewable energy contribution of the satellite project building or space. The letter must also confirm that no renewable energy is being double-counted among any satellite projects (in separate LEED applications).

Projects without a Path 2 or 3 energy model may not take credit for renewable energy sources used for the DES upstream of the project. However, credit may be taken for green power associated with the project itself. In this case, project teams should follow the standard guidance provided.

INTERNATIONAL TIPS

Projects must use Green-e qualified products or demonstrate Green-e equivalency to achieve this credit.

Projects that wish to use a local benchmark based on source energy from their country's national or regional energy agency must submit proof that the local benchmark contains a statistically significant sample of the project type being referenced and that the benchmarking process is repeatable. The benchmark should include at least 30 buildings of the project building type and the data should be weather normalized and account for internal and external loads.

- Additional information on the regressions and models used in CBECS can be found at eia.gov/emeu/cbecs/tech_end_use.html to help determine whether a local baseline is equivalent to CBECS.
- Projects outside the U.S. are not required to purchase products from the country in which the project is located. Projects in Canada can either buy Green-e certified products or use RECs from Canadian facilities that meet the eligible renewable definition and are generated at facilities certified by the EcoLogo Program (ecologo.org).
- Projects can use the WRI-WBCSD Greenhouse Gas Protocol Standards to calculate GHG emissions based on GHG inventories for the project location.

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	All projects
Annual electricity and nonelectricity energy use calculation	X
Calculations showing required REC, green power, carbon offsets for targeted point	X
Purchase contract or letter of commitment showing REC, green power, or carbon offsets for targeted point threshold	X
Green-e equivalent documentation, if not Green-e certified	X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. The amount of the project's proposed energy use, as determined in Option 1 of the related prerequisite, can be used to calculate the green power, RECs, or offsets that will be contracted.

EA Credit Optimize Energy Performance. Implementing energy efficiency measures that reduce total annual energy use will reduce the amount of RECs and carbon offset purchases required to meet this credit's requirements.

EA Credit Renewable Energy Production. Renewable energy production will reduce the project's total energy use and therefore the amount of green power, RECs, or carbon offsets required.

CHANGES FROM LEED 2009

- In addition to including electricity, the credit now requires nonelectric use to be offset using carbon offsets.
- The credit now requires a five-year contract and specifies that resources must have come online after January 1, 2005, and be delivered at least annually.
- The percentage thresholds have been increased to 50% for 1 point and 100% for 2 points.

REFERENCED STANDARDS

Green-e Energy and Green-e Climate: green-e.org

U.S. Department of Energy's Commercial Buildings Energy Consumption Survey (CBECS): eia.gov/consumption/commercial/index.cfm

ENERGY STAR Portfolio Manager: Methodology for Greenhouse Gas Inventory and Tracking Calculations: energystar.gov/ia/business/.../Emissions_Supporting_Doc.pdf

Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2010. Annex 2 Methodology and Data for Estimating CO_2 Emissions from Fossil Fuel Combustion: epa.gov/climatechange/ghgemissions/usinventoryreport/archive.html

2006 IPCC Guidelines for National Greenhouse Gas Inventories, Intergovernmental Panel on Climate Change, Geneva, Switzerland: ipcc-nggip.iges.or.jp/public/2006gl/index.html.

eGRID2012 Version 1.0, U.S. Environmental Protection Agency: epa.gov/cleanenergy/energy-resources/egrid/index.html

WRI-WBCSD Greenhouse Gas Protocol: ghgprotocol.org/standards

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

carbon offset a unit of carbon dioxide equivalent that is reduced, avoided, or sequestered to compensate for emissions occurring elsewhere (World Resources Institute)

district energy system (**DES**) a central energy conversion plant and transmission and distribution system that provides thermal energy to a group of buildings (e.g., a central cooling plant on a university campus). It does not include central energy systems that provide only electricity.

green power a subset of renewable energy composed of grid-based electricity produced from renewable energy sources

renewable energy credit (**REC**) a tradable commodity representing proof that a unit of electricity was generated from a renewable resource. RECs are sold separately from electricity itself and thus allow the purchase of green power by a user of conventionally generated electricity.

Scope 1 emissions direct greenhouse gas emissions from sources owned or controlled by the entity, such as emissions from fossil fuels burned on site

Scope 2 emissions indirect greenhouse gas emissions associated with the generation of purchased electricity, heating/cooling, or steam off site, through a utility provider for the entity's consumption

Materials and Resources (MR)

OVERVIEW

The Materials and Resources (MR) credit category focuses on minimizing the embodied energy and impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials. The requirements are designed to support a life-cycle approach that improves performance and promotes resource efficiency. Each requirement identifies a specific action that fits into the larger context of a life-cycle approach to embodied impact reduction.

THE WASTE HIERARCHY

Construction and demolition waste constitutes about 40% of the total solid waste stream in the United States[1] and about 25% of the total waste stream in the European Union.[2] In its solid waste management hierarchy, the U.S. Environmental Protection Agency (EPA) ranks source reduction, reuse, recycling, and waste to energy as the four preferred strategies for reducing waste. The MR section directly addresses each of these recommended strategies.

Source reduction appears at the top of the hierarchy because it avoids environmental harms throughout a material's life cycle, from supply chain and use to recycling and waste disposal. Source reduction encourages the use of innovative construction strategies, such as prefabrication and designing to dimensional construction materials, thereby minimizing material cutoffs and inefficiencies.

Building and material reuse is the next most effective strategy because reusing existing materials avoids the environmental burden of the manufacturing process. Replacing existing materials with new ones would entail production and transportation of new materials, and it would take many years to offset the associated greenhouse gases through increased efficiency of the building. LEED has consistently rewarded the reuse of materials. LEED v4 now offers more flexibility and rewards all material reuse achieved by a project—both in situ, as part of a building reuse strategy, and from off site, as part of a salvaging strategy.

1. *U.S. Environmental Protection Agency, epa.gov/osw/conserve/rrr/imr/cdm/pubs/cd-meas.pdf.*
2. *European Commission Service Contract on Management of Construction and Demolition Waste, Final Report, http://www.eu-smr.eu/cdw/docs/BIO_Construction%20and%20Demolition%20Waste_Final%20report_09022011.pdf (accessed April 9, 2013).*

Recycling is the most common way to divert waste from landfills. In conventional practice, most waste is landfilled—an increasingly unsustainable solution. In urban areas landfill space is reaching capacity, requiring the conversion of more land elsewhere and raising the transportation costs of waste. Innovations in recycling technology improve sorting and processing to supply raw material to secondary markets, keeping those materials in the production stream longer.

Because secondary markets do not exist for every material, the next most beneficial use of waste materials is conversion to energy. Many countries are lessening the burden on landfills through a waste-to-energy solution. In countries such as Sweden and Saudi Arabia, waste-to-energy facilities are far more common than landfills. When strict air quality control measures are enforced, waste-to-energy can be a viable alternative to extracting fossil fuels to produce energy.

In aggregate, LEED projects are responsible for diverting more than 80 million tons (72.6 million tonnes) of waste from landfills, and this volume is expected to grow to 540 million tons (489.9 million tonnes) by 2030.[3] From 2000 to 2011, LEED projects in Seattle diverted an average of 90% of their construction waste from the landfill, resulting in 175,000 tons (158 757.3 tonnes) of waste diverted.[4] If all newly constructed buildings achieved the 90% diversion rate demonstrated by Seattle's 102 LEED projects, the result would be staggering. Construction debris is no longer waste, it is a resource.

LIFE-CYCLE ASSESSMENT IN LEED

Through credits in the MR category, LEED has instigated market transformation of building products by creating a cycle of consumer demand and industry delivery of environmentally preferable products. LEED project teams have created demand for increasingly sustainable products; in turn, suppliers, designers, and manufacturers are responding. From responsibly harvested wood to recycled content to biobased materials, the increased supply of sustainable materials has been measurable over the history of LEED. Several MR credits reward use of products that perform well on specific criteria. It is difficult, however, to compare two products that have different sustainable attributes—for example, cabinets made of wheat husks sourced from all over the country and bound together in resin versus solid wood cabinets made from local timber. Life-cycle assessment (LCA) provides a more comprehensive picture of materials and products, enabling project teams to make more informed decisions that will have greater overall benefit for the environmental, human health, and communities, while encouraging manufacturers to improve their products through innovation.

LCA is a "compilation and evaluation of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle."[5] The entire life cycle of a product (or building) is examined, the processes and constituents identified, and their environmental effects assessed—both upstream, from the point of manufacture or raw materials extraction, and downstream, including transportation, use, maintenance, and end of life. This approach is sometimes called "cradle to grave." Going even further, "cradle to cradle" emphasizes recycling and reuse at the end of life rather than disposal.

Life-cycle approaches to materials assessment began in the 1960s with carbon accounting models. Since then, LCA standards and practices have been developed and refined. In Europe and a few other parts of the world, manufacturers, regulators, specifiers, and consumers in many fields have been using life-cycle information to improve their product selections and product environmental profiles. Until relatively recently, however, the data and tools that support LCA were lacking in the U.S. Now a growing number of manufacturers are ready to document and publicly disclose the environmental profiles of their products, and programs that assist this effort and help users understand the results are available.

LEED aims to accelerate the use of LCA tools and LCA-based decision making, thereby spurring market transformation and improving the quality of databases. Recognizing the limitations of the life-cycle approach for addressing human health and the ecosystem consequences of raw material extraction, LEED uses alternative, complementary approaches to LCA in the credits that address those topics.

3. *USGBC, Green Building Facts, USGBC, usgbc.org/ShowFile.aspx?DocumentID=18693 (accessed September 13, 2012).*
4. *City of Seattle, LEED Projects Analysis, seattle.gov/dpd/greenbuilding/docs/dpdp022009.pdf (accessed March 26, 2013).*
5. *ISO 14040 International Standard, Environmental management, Life cycle assessment, principles and framework (Geneva, Switzerland: International Organization for Standardization, 2006).*

CROSS-CUTTING ISSUES

Required Products and Materials

The scope of the MR credit category includes the building or portions of the building that are being constructed or renovated. Portions of an existing building that are not part of the construction contract are excluded from MR documentation unless otherwise noted. For guidance on the treatment of additions, see the minimum program requirements.

Qualifying Products and Exclusions

The MR section for interior design and construction includes permanently installed building products as well as furniture. "Permanently installed building products" is defined by LEED as the products and materials that create the building or are attached to it. Examples include structure and enclosure elements, installed finishes, framing, interior walls, cabinets and casework, doors, and roofs. Most of these materials fall into Construction Specifications Institute (CSI) 2012 MasterFormat Divisions 3-10, 31, and 32. Some products addressed by MR credits fall outside these divisions. Furniture items within the project's scope of work are also required to be included in credit calculations.

In past versions of LEED, all mechanical, electrical, and plumbing (MEP) equipment, categorized as CSI MasterFormat divisions 11, 21-28, and other specialty divisions, was excluded from MR credits. In this version of LEED, some specific products that are part of these systems but are "passive" (meaning not part of the active portions of the system) may be included in credit calculations. This allows flexibility for the optional assessment of piping, pipe insulation, ducts, duct insulation, conduit, plumbing fixtures, faucets, showerheads, and lamp housings. If they are included in credit calculations, they must be included consistently across relevant MR credits. However, if some of these products are included in credit calculations, not all products of that type must be included. For example, if the cost of ducts is included in the MR calculations for recycled content, the cost of ducts that do not meet the credit requirement does not need to be included in the numerator or denominator of credit calculations. However, the denominator for cost-based credits (all Building Product Disclosure and Optimization credits) calculations must be the same.

Special equipment, such as elevators, escalators, process equipment, and fire suppression systems, are excluded from the credit calculations. Also exclude products purchased for temporary use on the project, like formwork for concrete.

Defining a Product

Several credits in this category calculate achievement on the basis of number of products instead of product cost. For these credits, a "product" or a "permanently installed building product" is defined by its function in the project. A product includes the physical components and services needed to serve the intended function. If there are similar products within a specification, each contributes as a separate product. Here are a few scenarios.

Products that arrive at the project site ready for installation:

- Metal studs, wallboard, and concrete masonry units are all separate products.
- For wallboard, the gypsum, binder, and backing are all required for the product to function, so each ingredient does not count as a separate product.

Products that arrive as an ingredient or component used in a site-assembled product:

- Concrete admixtures are considered separate products because each component (admixture, aggregate, and cement) serves a different function; each component is therefore a separate product.

Similar products from the same manufacturer with distinct formulations versus similar products from the same manufacturer with aesthetic variations or reconfigurations:

- Paints of different gloss levels are separate products because each paint type is specified to serve a different function, such as water resistance. Different colors of the same paint are not separate products because they serve the same function.
- Carpets of different pile heights are separate products because they are used for different kinds of foot traffic. The same carpet in a different color is not a separate product.
- Desk chairs and side chairs in the same product line are different products because they serve different functions. Two side chairs differing only in aesthetic aspects, such as the presence of arms, are not different products.

Determining Product Cost

Product and materials cost includes all expenses to deliver the material to the project site. Materials cost should include all taxes and delivery costs incurred by the contractor but exclude any cost for labor and equipment after the material is delivered to the site.

The Building Design and Construction (BD+C) rating systems use a default materials cost calculation. This approach is not applicable to Interior Design and Construction (ID+C) rating systems.

Location Valuation Factor

Several credits in the MR section include a location valuation factor, which adds value to locally produced products and materials. The intent is to incentivize the purchase of products that support the local economy. Products and materials that are extracted, manufactured, and purchased within 100 miles (160 kilometers) of the project are valued at 200% of their cost (i.e., the valuation factor is 2).

For a product to qualify for the location valuation factor, it must meet two conditions: all extraction, manufacture, and purchase (including distribution) of the product and its materials must occur within that radius (Figure 1), and the product (or portion of an assembled product) must meet at least one of the sustainable criteria (e.g., FSC certification, recycled content) specified in the credit. Products and materials that do not meet the location radius but do meet at least one of the sustainability criteria are valued 100% of their cost (i.e., the valuation factor is 1).

Figure 1. Example material radius

The distance is measured as the crow flies, not by actual travel distance. The point of purchase is considered the location of the purchase transaction. For online or other transactions that do not occur in person, the point of purchase is considered the location of product distribution.

For the location valuation factor of salvaged and reused materials, see MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, *Further Explanation, Material Reuse Considerations*.

Determining Material Contributions of an Assembly

Many sustainability criteria in the MR category apply to the entire product, as is the case for product certifications and programs. However, some criteria apply to only a portion of the product. The portion of the product that contributes to the credit could be either a percentage of a homogeneous material or the percentage of qualifying components that are mechanically or permanently fastened together. In either case, the contributing value is based on weight. Examples of homogeneous materials include composite flooring, ceiling tiles, and rubber wall base. Examples of assemblies (parts mechanically or permanently fastened together) include office chairs, demountable partition walls, premade window assemblies, and doors.

Calculate the value that contributes toward credit compliance as the percentage, by weight, of the material or component that meets the criteria, multiplied by the total product cost (Figure 2, Table 1).

Product value (\$) = Total product cost (\$) x (%) product component by weight x (%) meeting sustainable criteria

Figure 2. Sustainably produced components of \$500 office chair

TABLE 1. Example calculation for $500 office chair

Chair component	Percentage of product, by weight	Value of component	Percentage of component meeting sustainability criteria	Value of sustainability criteria
Fastening hardware	2%	$10	25% preconsumer recycled content	$2.50
Cotton fabric	5%	$25	100% certified by Rainforest Alliance	$25.00
Plastic component	25%	$125	10% postconsumer recycled content	$12.50
Armrest	5%	$25	10% postconsumer recycled content	$2.50
Metal base	20%	$100	25% preconsumer recycled content	$25.00
Steel post	8%	$40	40% preconsumer recycled content	$16.00
Wheels	5%	$25	5% postconsumer recycled content	$1.25
Total value contributing to credit				**$84.75**

MATERIALS AND RESOURCES PREREQUISITE

Storage and Collection of Recyclables

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To reduce the waste that is generated by building occupants and hauled to and disposed of in landfills.

REQUIREMENTS

COMMERCIAL INTERIORS, HOSPITALITY

Provide dedicated areas accessible to waste haulers and building occupants for the collection and storage of recyclable materials for the entire building. Collection and storage areas may be separate locations. Recyclable materials must include mixed paper, corrugated cardboard, glass, plastics, and metals. Take appropriate measures for the safe collection, storage, and disposal of two of the following: batteries, mercury-containing lamps, and electronic waste.

RETAIL

Conduct a waste stream study to identify the retail project's top five recyclable waste streams, by either weight or volume, using consistent metrics. Based on the waste stream study, list the top four waste streams for which collection and storage space will be provided. If no information is available on waste streams for the project, use data from similar operations to make projections. Retailers with existing stores of similar size and function can use historical information from their other locations.

Provide dedicated areas accessible to waste haulers and building occupants for the separation, collection, and storage of recyclable materials for at least the top four recyclable waste streams identified by the waste study. Locate the collection and storage bins close the source of recyclable waste. If any of the top four waste streams are batteries, mercury-containing lamps, or electronic waste, take appropriate measures for safe collection, storage, and disposal.

BEHIND THE INTENT

Waste disposal continues to be a significant environmental burden on communities and ecosystems. In the U.S., paper, food, glass, metals, and plastics—all recyclable—make up approximately 69% of total municipal solid waste[1] (Figure 1). Diverting such recyclable waste from landfills can not only reduce hauling costs but also help convert recyclables into new products, reducing demand for virgin materials.

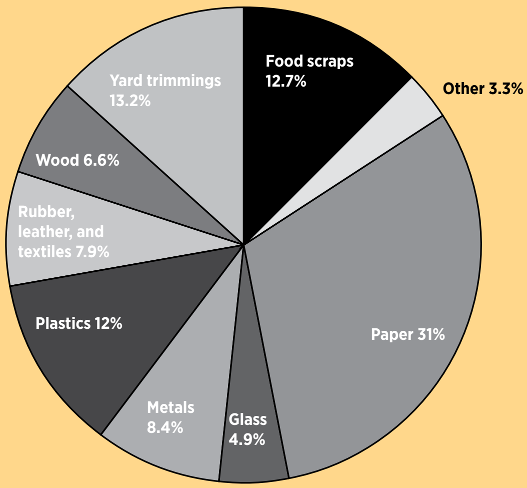


Figure 1. Total municipal solid waste generation. Adapted from the US Environmental Protection Agency.

A factor that commonly thwarts recycling efforts within buildings is a lack of convenient, physical spaces for doing so. Incorporating recycling infrastructure early in the design process encourages successful recycling once operations begin. Well-designed and accessible waste management infrastructure that anticipates how and where waste will be discarded helps occupants make recycling their default behavior.

The increasing volume of electronic waste (e-waste)—computers, cameras, printers, keyboards—has become a growing environmental concern. Therefore, identifying storage areas, recycling facilities, and haulers that can process e-waste is important. The disposal procedure for batteries, fluorescent lamps, and other e-waste is more hazardous than for cardboard, glass, plastic, metals, and paper. Because safety in handling and diversion of these materials is often overlooked by many recycling programs, this prerequisite requires developing waste management infrastructure for at least two hazardous waste streams.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY THE WASTE DISPOSAL NEEDS FOR THE PROJECT

Identify the possible waste types and quantities that may be generated by different occupants and spaces. For example, an office may need a large area devoted to paper recycling, whereas a café may require more space for plastics, glass, and metals.

- Even if a recycling service is not available, all required recyclable waste streams must have dedicated storage in anticipation of future service (see *Further Explanation, Projects without Available Recycling Infrastructure*).
- Retail projects only. Conduct a waste stream audit for the project in an existing location, or make projections based on historical data for similar establishments. Identify the top-five recyclable waste streams. List the top-four waste streams for which collection and storage space will be provided. See *Further Explanation, Rating System Variations*.

1. *epa.gov/osw/nonhaz/municipal/pubs/msw2009rpt.pdf* (accessed July 3, 2013).

STEP 2. DESIGN APPROPRIATELY SIZED STORAGE AREAS

Provide sufficient collection and storage space for all required recyclables. Indicate recycling storage and collection areas on a floor plan, and be prepared to describe the dedicated recycling storage areas, their accessibility, and how these spaces will serve their functional needs (see *Further Explanation, Infrastructure Considerations*).

- Storage areas should be easily accessible to building occupants, including visitors, full time occupants, operations staff, and waste haulers.
- For any of the collected hazardous waste streams (batteries, mercury-containing lamps, e-waste), take appropriate measures for safe collection, storage, and disposal.
- Locate and highlight central collection and storage areas for recyclables, including paper, cardboard, glass, plastic, metal, and e-waste, on submitted floor plans.

FURTHER EXPLANATION

PROJECTS WITHOUT AVAILABLE RECYCLING INFRASTRUCTURE

Projects where there is no access to haulers or external facilities must still comply with this prerequisite by establishing accessible recycling areas. As an interim measure, until a recycling service becomes available, consider alternative means of recycling, such as reuse or donation.

The requirements of this prerequisite help establish a recycling infrastructure in the building, and encourage waste separation behavior by occupants.

INFRASTRUCTURE CONSIDERATIONS

Consider the following factors for the setup, size, and accessibility of storage and collection of recyclables.

Recycling approach. Research local recycling programs. Some project teams may need to coordinate multiple services. Determine which materials will be stored separately on site and which may be commingled into a single stream and separated off site. The number and size of bins will affect storage requirements. Consider any special equipment that might be needed (e.g., tanks for fryer oil, compactors, and bailers).

Frequency of collection. Occupants may generate more of one type of waste than another, necessitating different schedules for collection or different space requirements. Haulers may operate on a calendar schedule, use sensing technology to retrieve waste only when the compactor is full, or negotiate pick-up patterns for specialized waste, such as e-waste.

Specialized waste streams. Some waste streams may require particular handling or disposal requirements. For example, health care, retail, and some office projects may require secure areas for shredding sensitive or proprietary documents. Electronic waste and mercury-containing lamps may require extra precautions to prevent breakage or exposure to toxins. To set up safe storage and recycling programs, refer to the U.S. Environmental Protection Agency's universal wastes page, at epa.gov/wastes/hazard/wastetypes/universal/index.htm.

Access for waste haulers. Ensuring that waste haulers have access to the recyclable materials is particularly important when planning and building loading docks and roads or when special equipment is required. Waste hauling for the building is typically outside the scope of a commercial interiors project, but dedicated storage within the project space is required to support recycling for the building.

RATING SYSTEM VARIATIONS

Retail

Retail projects must identify the project's top-five recyclable waste streams by conducting a waste stream study.

The waste stream study must include, at a minimum, a 24-hour period. In some cases the representative time period may be longer. Project teams will be asked how the time period chosen is representative.

The required measurement of each waste stream may be by weight or volume but must be consistent. Visual estimation is not considered an effective metric. Project teams must describe the method of conducting the waste stream study, including location, time period, separation method, safety precautions, and measurement method.

Waste streams comprise two major substreams: waste disposed of via landfills or incinerators and waste diverted from disposal through recycling, reuse, or composting. The results of the waste stream study must divide the waste into at least these two substreams.

Use the findings of the study to evaluate how each type of waste can be reduced and set goals for minimizing waste and disposal costs. This may include source reduction, reuse, and recycling. In addition, check local waste haulers, buyers, and other recycling service providers to investigate the potential disposal and diversion options. For example, a local nursery may be able to use coffee grounds for compost.

If a waste stream study is not feasible, the project team may make an informed estimate using one of the following approaches:

- Make projections based on a waste stream study of a similar retail operation in close proximity to the project.
- Use historical data from existing stores in other locations of the same retailer or of similar size and function.

CAMPUS

Group Approach

All project spaces in the group may be documented as one. For campuses, a shared central recycling facility for haulers is acceptable, provided the space accommodates recycling produced by all spaces being served.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	All Projects	Retail Only
Verification of recycled material types	X	X
Narrative describing recycling storage and collection strategies	X	X
Floor plans indicating recycling storage and collection areas	X	X
Methodology and results of waste stream study		X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

Materials that require dedicated storage now include batteries, mercury-containing lamps, and e-waste; project teams may choose two of the three. For retail projects, the required number of waste streams with dedicated storage has increased from three to four.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

commingled waste building waste streams that are combined on the project site and hauled away for sorting into recyclable streams. Also known as single-stream recycling.

dedicated storage a designated area in a building space or a central facility that is sized and allocated for a specific task, such as the collection of recyclable waste. Signage often indicates the type of recyclable waste stored there. Some waste streams, such as mercury-based light bulbs, sensitive paper documents, biomedical waste, or batteries, may require particular handling or disposal methods. Consult the municipality's safe storage and disposal procedures or use

electronic waste discarded office equipment (computers, monitors, copiers, printers, scanners, fax machines), appliances (refrigerators, dishwashers, water coolers), external power adapters, and televisions and other audiovisual equipment

mixed paper white and colored paper, envelopes, forms, file folders, tablets, flyers, cereal boxes, wrapping paper, catalogs, magazines, phone books, and photos

MATERIALS AND RESOURCES PREREQUISITE

Construction and Demolition Waste Management Planning

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.

REQUIREMENTS

Develop and implement a construction and demolition waste management plan:

- Establish waste diversion goals for the project by identifying at least five materials (both structural and nonstructural) targeted for diversion. Approximate a percentage of the overall project waste that these materials represent.
- Specify whether materials will be separated or commingled and describe the diversion strategies planned for the project. Describe where the material will be taken and how the recycling facility will process the material.

Provide a final report detailing all major waste streams generated, including disposal and diversion rates.

Alternative daily cover (ADC) does not qualify as material diverted from disposal. Land-clearing debris is not considered construction, demolition, or renovation waste that can contribute to waste diversion.

BEHIND THE INTENT

Construction waste is a significant portion of the waste produced in the world. The U.S. Environmental Protection Agency (EPA) estimated that in the U.S. in 2003, 170 million tons of construction and demolition waste were generated and, of that, 61% from nonresidential construction projects.[1] The European Commission estimates that 510 million metric tonnes of construction waste is generated annually by European Union member nations.[2] Keeping these materials out of landfills prevents ground and water pollution, promotes recycling, and keeps materials in active use longer.

Waste management services vary widely from one location to another; therefore, teams should begin by identifying the technologies, haulers, and facilities in the project's area. Planning for construction waste management (CWM) before construction allows time to identify the most effective waste diversion strategies available. Such strategies typically include reuse, recycling, donation, and salvage; however, source reduction and source separation are also viable and effective. Source reduction eliminates project waste through prefabrication, modular construction, or incorporating standard material lengths or sizes into construction documents. Source separation sorts waste on site into recycling streams, ensuring delivery to the correct facility.

Developing a CWM plan early in the design process allows more time for planning and coordination, identifying appropriate strategies, and developing contractual agreements. Educating project team members, site workers, and waste haulers helps ensure that the plan is followed and material is actually diverted from landfills and incinerators. A well-devised CWM plan can also minimize cost and maximize return by decreasing tipping fees, selling high-valued scrap materials, or identifying materials for reuse.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY WASTE DIVERSION GOALS

Identify at least five construction or demolition material streams for diversion from landfill. It may be easiest to focus on determining the heaviest waste or the waste that generates the most volume.

- Common materials that may be simple to divert include drywall, wood, scrap metals, brick, and concrete.
- Finish materials, such as flooring and ceiling tiles, can often be recycled through the major manufacturers.
- Consider incorporating reuse of finish materials, furniture, or framing into the design early. Reusing existing materials may require design modifications. Some materials must remain intact to be reused (e.g., drywall) or may require additional preparation (e.g., de-nailing).

Source reduction strategies should be incorporated into the design of the project and outlined in the CWM plan. These strategies include modular construction, reduced packaging, using industry-standard measurements, and prefabrication.

STEP 2. SELECT COLLECTION AND DIVERSION METHODS

Explore on-site and off-site waste collection and sorting opportunities and consider the infrastructure needed for implementation (see *Further Explanation, Effective Construction Waste Management Strategies*).

- Projects may use a combination of on-site separation and commingled collection, depending on what is appropriate for the project location, material stream, and available facilities and haulers.
- For on-site separation, common CWM strategies include donation, resale, on-site reuse, recycling, or refurbishment. Crushing asphalt, concrete, and masonry for infill or aggregate is also considered on-site waste diversion.
- The most common off-site strategies are incineration, combustion of wood, and sending commingled waste to a sorting facility.

1. *epa.gov/osw/nonhaz/municipal/pubs/msw2009rpt.pdf (accessed July 3, 2013).*
2. *ec.europa.eu/environment/waste/pdf/story_book.pdf (accessed May 28, 2013).*

- Identify diversion options for materials.
- Incineration may be considered diversion if reuse and recycling methods are not readily available in the project's location; this must be included in the CWM plan. Wood-derived fuel, or wood combustion, is considered diversion and not subject to the additional requirements for incineration (see *Further Explanation, Waste-to-Energy*).
- Using a recycling facility for which recycling rates have been independently certified by a third party, such as the Recycling Certification Institute (recyclingcertification.org), provides assurance that diversion rates are accurate, but it is not required for compliance. Some haulers work with local municipalities to certify their average diversion rates.
- Consider how CWM plan requirements, or the requirement to write a plan, can be included in specification documents under Division 1, General Requirements.

STEP 3. DRAFT CONSTRUCTION WASTE MANAGEMENT PLAN

The CWM plan must be customized for each project. The plan must include an overall project waste diversion goal and identify at least five kinds of materials that will be diverted from landfills or incinerators.

- There is no minimum threshold for diversion, though project teams may earn points for meeting the thresholds set in the corresponding credit (see MR Credit Construction and Demolition Waste Management).
- All projects must comply with this prerequisite, including projects located in areas without recycling services and those not intending to pursue the corresponding credit.
- The plan must account for all materials, including land-clearing debris, materials to be used for alternative daily cover (ADC), and other materials not contributing to diversion but not included in the diverted waste total.
- The safe removal and disposal of hazardous materials must also be covered in the CWM plan. Hazardous materials must be tracked separately and not be included in the project's total waste.
- Specify the means and methods of diversion for each of the five selected material streams and the approximate amount of waste of each.
- If possible, provide contracts or sample contract language that describes the waste-sorting strategies and technologies used by the waste hauler and facility. Successful CWM plans start with early establishment of contractual obligations.
- When developing the waste hauler contract, consider including the waste reporting structure, a schedule that identifies the responsible parties and their contact information, and a clear chain and method of communication. Consider involving waste haulers in regular construction meetings.

STEP 4. DECIDE WHETHER TO PURSUE CREDIT

Determine whether the project team will seek to achieve the corresponding credit, which awards points for implementing the plan developed in this prerequisite and meeting diversion thresholds (see MR Credit Construction and Demolition Waste Management). A project team that does not pursue the credit must nevertheless develop the plan and produce a final waste report.

STEP 5. PRODUCE WASTE REPORT

Create a final report on the total construction and demolition waste produced by the project and the total waste diverted, using the following equation.

EQUATION 1. Diversion rate

$$\text{Diversion rate} = (\text{Total waste diverted from landfill} / \text{Total waste produced by project}) \times 100$$

- Units may be in weight or volume but must be consistent throughout.
- If the project team is pursuing the corresponding credit, see MR Credit Construction and Demolition Waste Management for additional requirements for the final waste report.

FURTHER EXPLANATION

CALCULATIONS

See calculations in *Step-by-Step Guidance*. This prerequisite has no performance requirement, but the corresponding credit does (see MR Credit Construction and Demolition Waste Management).

EFFECTIVE CONSTRUCTION WASTE MANAGEMENT STRATEGIES

On-site separation (also known as source separation) is most viable if multiple bins are conveniently located and the general contractor and subcontractors enforce careful separation. A best practice for source separation is to target waste materials that are easily separated and have established recycling markets, such as steel, wood, and concrete.

On-site separation is preferable to commingling because separated wastes are more likely to actually be diverted from the landfill. Using easy-to-understand multilingual or symbol-based signage helps prevent contamination of on-site source separation areas.

Commingled collection (or single-stream recycling) may be more appropriate for sites with limited storage area for waste containers. Recyclable materials are mixed in one container but sorted and processed at an off-site recycling facility, which separates them from the waste going to a landfill. Commingled waste may be considered only one material stream unless the facility can provide diversion rates for specific materials.

To count toward the corresponding credit (MR Credit Construction and Demolition Waste Management), commingled recycling facilities must be able to provide diversion rates either specific to the project, or an average diversion rate for the facility that is regulated by the local or state authority. The average recycling rate for the facility must exclude ADC.

Donating surplus or architectural salvage or community donation is permissible, provided the organization can verify and track the material, including how much is received and where it is going. Habitat for Humanity Restore is a commonly used donation facility in the U.S and Canada.

Use of construction waste to infill mining pits is permissible only if the waste is “clean” and the work is overseen by the state or local government or a government-sponsored organization.

Leaving items on the curb for people to pick up is not acceptable. Dumping in the ocean is never permissible as a diversion strategy.

WASTE-TO-ENERGY

Waste-to-energy may be considered a viable diversion strategy if the project team follows European Commission Waste Framework Directive 2008/98/EC and the European Commission Waste Incineration Directive 200/76/EC are followed. In addition, the facility must meet the applicable European standards based on the fuel type. See *Referenced Standards* for more information on these directives:

- EN 303-1—1999/A1—2003, Heating boilers with forced draught burners
- EN 303-2—1998/A1—2003, Heating boilers with forced draught burners
- EN 303-3—1998/AC—2006, Gas-fired central heating boilers
- EN 303-4—1999, Heating boilers with forced draught burners
- EN 303-5—2012, Heating boilers for solid fuels
- EN 303-6—2000, Heating boilers with forced draught burners
- EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner

The combustion of wood or “wood-derived fuel” is not considered waste-to-energy and is exempt from the above criteria.

Project teams must demonstrate that reuse and recycling strategies were exhausted before sending waste material to energy facilities.

CAMPUS

Group Approach
All project spaces in the group may be documented as one. Campus spaces may develop one comprehensive plan for construction waste.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects
Construction waste management plan	X
Total construction waste	X

RELATED CREDIT TIPS

MR Credit Construction and Demolition Waste Management. See the related credit for additional considerations and waste diversion requirements.

CHANGES FROM LEED 2009

The creation of a CWM plan is a new prerequisite requirement.

REFERENCED STANDARDS

European Commission Waste Framework Directive 2008/98/EC:

- ec.europa.eu/environment/waste/framework/index.htm
- eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

European Commission Waste Incineration Directive 200/76/EC:

- europa.eu/legislation_summaries/environment/waste_management/l28072_en.htm
- central2013.eu/fileadmin/user_upload/Downloads/Document_Centre/OP_Resources/Incineration_Directive_2000_76.pdf

EN 303-1—1999/A1—2003, Heating boilers with forced draught burners, Terminology, general requirements, testing and marking: http://www.cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-2—1998/A1—2003, Heating boilers with forced draught burners, Special requirements for boilers with atomizing oil burners: http://www.cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-3—1998/AC—2006, Gas-fired central heating boilers, Assembly comprising a boiler body and a forced draught burner: http://www.cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-4—1999, Heating boilers with forced draught burners, Special requirements for boilers with forced draught oil burners with outputs up to 70 kW and a maximum operating pressure of 3 bar, Terminology, special requirements, testing and marking: http://www.cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-5—2012, Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW: http://www.cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-6—2000, Heating boilers with forced draught burners, Specific requirements for the domestic hot water operation of combination boilers with atomizing oil burners of nominal heat input not exceeding 70 kW: http://www.cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner of nominal heat output not exceeding 1000 kW: http://www.cen.eu/cen/Products/Search/Pages/default.aspx

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

alternative daily cover (**ADC**) material other than earthen material placed on the surface of the active face of a municipal solid waste landfill at the end of each operating day to control vectors, fires, odors, blowing litter, and scavenging. Generally these materials must be processed so they do not allow gaps in the exposed landfill face. (CalRecycle)

clean waste nonhazardous materials left over from construction and demolition. Clean waste excludes lead and asbestos.

commingled waste building waste streams that are combined on the project site and hauled away for sorting into recyclable streams. Also known as single-stream recycling.

land-clearing debris and soil materials that are natural (e.g., rock, soil, stone, vegetation). Materials that are man-made (e.g., concrete, brick, cement) are considered construction waste even if they were on site.

waste-to-energy the conversion of nonrecyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery.

MATERIALS AND RESOURCES CREDIT

Long-Term Commitment

This credit applies to:

Commercial Interiors (1 point)
Retail (1 point)
Hospitality (1 point)

INTENT

To encourage choices that will conserve resources and reduce environmental harm from materials manufacturing and transport for tenants' relocation.

REQUIREMENTS

The occupant or tenant must commit to remain in the same location for at least 10 years.

BEHIND THE INTENT

Frequent tenant turnover often entails major remodeling projects that replace materials and equipment before the end of their useful life. Less demolition and renovation reduce construction and demolition waste and avoid the use of virgin resources in products, materials, and equipment required to fit out the tenant space.

Long-term leases and commitments also bring social benefits, such as stronger relationships with service providers in the building and surrounding community. Tenants realize economic savings by using materials and equipment for longer periods and by avoiding the costs and productivity losses of a move. Longer lease terms encourage tenants to implement improvements, such as energy-efficiency technologies, that may have a longer payback period but generate more savings over time.

STEP-BY-STEP GUIDANCE

STEP 1. SELECT LOCATION

When reviewing potential locations, investigate and identify a space that will serve the project's needs for at least 10 years.

Owners

- Consider how ownership of the project space will help achieve sustainability goals. Often, upgrades to building systems are easier to facilitate when negotiations with third-party owners are avoided.
- When purchasing office space, recognize potential growth or contraction over time and design flexible spaces so that relocation does not become necessary.

Tenants

- To the extent feasible, anticipate how much space is needed for future growth when selecting a long-term tenant space.
- Consider the investment opportunities that longer-term location planning allows, such as the value of energy-efficient technologies and durable materials.

STEP 2. COMMIT TO AT LEAST 10-YEAR LEASE

Owners

- Express commitment to remain in space for 10-year period (see *Further Explanation, Owner-Occupied Spaces*).

Tenants

- Commit to remaining in space for at least a 10-year lease through lease terms (see *Further Explanation, Tenant-Occupied Spaces*).

FURTHER EXPLANATION

OWNER-OCCUPIED SPACES

In the case of owner-occupied spaces, the owner of the property must also be the occupant of the project space. To demonstrate these requirements, the address of owned property must be the same as, or include, the project space. Ownership must be effective as of certification submission at a minimum. In addition, a commitment letter must be provided by the owner indicating a commitment to remain in the project space for at least 10 years. The letter must be on the owner's letterhead and be signed and dated by the project owner, and must state the address of the property and the effective dates of the commitment.

TENANT-OCCUPIED SPACES

Submit a copy of the portions of the tenant lease that indicate compliance and contain the required information. Sensitive information may be redacted.

Agreements for less than 10 years with an option to renew do not satisfy the credit requirement. The lease does not need to start at the beginning of construction or major renovation. As long as the minimum 10-year lease is in effect when the project is registered and achieves certification, the project is eligible for this credit. Tenants are not expected to occupy the space until construction or renovation is complete.

INTERNATIONAL TIPS

Even if the regional market does not typically engage in leases for as long as 10 years, it is up to the tenant to negotiate terms that meet the credit requirements. A commitment letter is insufficient for tenants seeking this credit.

CAMPUS

Group Approach
All project spaces in the group may be documented as one. One document for all tenant spaces is acceptable, provided all tenant spaces covered in this document comply with the minimum lease duration of 10 years. Ensure that this document clearly identifies each property covered by the lease.

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects
Verification of intent to remain in project space for 10 years, either as an owner or tenant.	X

RELATED CREDIT TIPS

MR Credit Interiors Life-Cycle Impact Reduction. Designing the project space to be flexible (Option 3, Design for Flexibility) can make it easier for a tenant to adapt and grow without relocating.

EA Credit Advanced Energy Metering. When negotiating lease terms for this credit, consider including provisions regarding metering and payment of utilities to earn the related credit.

CHANGES FROM LEED 2009

None.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

MATERIALS AND RESOURCES CREDIT

Interiors Life-Cycle Impact Reduction

This credit applies to:

Commercial Interiors (1-4 points)
Retail (1-5 points)
Hospitality (1-4 points)

INTENT

To encourage adaptive reuse and optimize the environmental performance of products and materials.

REQUIREMENTS

OPTION 1. INTERIOR REUSE (2 POINTS)

Reuse or salvage interior nonstructural elements for at least 50% of the surface area. Hazardous materials that are remediated as a part of the project must be excluded from the calculation.

AND/OR

OPTION 2. FURNITURE REUSE (1 POINT)

Reuse, salvage, or refurbish furniture and furnishings for at least 30% of the total furniture and furnishings cost.

AND/OR

OPTION 3. DESIGN FOR FLEXIBILITY (1 POINT COMMERCIAL INTERIORS AND HOSPITALITY, 2 POINTS RETAIL)

Conduct an integrative planning process to increase the useful life of the project space. Increase project space flexibility, ease of adaptive use, and recycling of building materials while considering differential durability and premature obsolescence over building design life and individual component service lives. Use at least three of the following strategies.

- Install accessible systems (floor or ceiling) for at least 50% of the project floor area to allow for flexible use of space and access to systems (under floor distribution systems) not entangled with other building systems.

- Design at least 50% of interior nonstructural walls, ceilings, and floors to be movable or demountable.
- Ensure that at least 50%, by cost, of nonstructural materials have integral labels (radio frequency identification, engraving, embossing, or other permanent marking) containing information on material origin, properties, date of manufacture, in compliance with Canadian Standards Association CSA Z782-06 Guideline for Design for Disassembly and Adaptability in Buildings.
- Include in at least one major component or systems purchase contract a clause specifying sub-contractor, vendor, or on site take back system.
- Ensure that at least 50% of nonstructural materials, by cost, are reusable or recyclable, as defined by the Federal Trade Commission Guide for Use of Environmental Marketing Claims, 260.7(d).
- Implement flexible power distribution (i.e., plug-and-play) systems for at least 50% of the project floor area so that lighting, data, voice, and other systems can be easily reconfigured and repurposed.

Implement a flexible lighting control system with plug and play components such as wall controls, sensors, and dimming ballasts for a minimum of 50% of the lighting load. The system shall allow for reconfiguring and repurposing of luminaires and controls without rewiring such as having the capability to group and assign luminaires into zones and change those zones as needed. Also, the system shall be flexible so that as a space changes functions, the lighting levels can change to suit the needs of the space without rewiring or removing or adding luminaires.

BEHIND THE INTENT

Reusing materials and designing for flexibility are effective ways to lessen the overall environmental consequences of an interior space over its lifetime. These strategies reduce costs, energy use, and construction waste and avoid the environmental burdens associated with raw material extraction, manufacturing, transportation, embodied energy, and greenhouse gas emissions.

Office spaces and other commercial interiors undergo alterations numerous times over a building's life cycle. Spaces designed for flexibility and adaptive use are more easily renovated, mitigating many of the harms caused by construction activities. Material reuse avoids the costs associated with the purchase of new materials and their transportation and installation. The payback is more pronounced in the case of furniture and furnishings, which are often the largest single purchase for commercial interiors projects.

This credit encourages integrated design solutions, such as plug–and-play lighting and accessible floor systems, so that offices can be moved and reconfigured without alterations to building systems. It also encourages purchasing solutions, such as integral labeling and take-back programs, that reduce the volume of durable goods to be thrown away at the end of their useful life.

STEP-BY-STEP GUIDANCE

Determine which option is most appropriate for your project. A combination of the three options may be used to cumulatively achieve the points indicated in the credit requirements. The decision to pursue this credit should occur early in the design process.

- Option 1 is appropriate for projects that can reuse existing nonstructural wall, ceiling, and flooring systems.
- Option 2 is suitable if existing furniture and furnishings are in good condition and could be refurbished and reused in the project.
- Option 3 is for projects whose clients want flexible spaces to accommodate their future plans.

Option 1. Interior Reuse

STEP 1. SURVEY EXISTING INTERIOR NONSTRUCTURAL ELEMENTS

Develop drawings showing the location of existing nonstructural interior elements.

- Elements could include existing and finished ceilings, flooring, interior wall partitions, doors for interior walls, exterior and party walls, and built-in case goods.
- Take into account excluded items, such as reused, salvaged, and refurbished interior elements that qualify for MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials; these items may not be double-counted under this credit (see *Further Explanation, Determining Area of Interior Nonstructural Elements*).

STEP 2. DEVELOP REUSE STRATEGY

Identify the surface areas that are in good condition and could be reused, salvaged, or refurbished for the project. Maximize reused area by working through several design iterations. Casework has considerable surface area and can therefore contribute significantly to the credit.

Develop a tracking table that lists all surveyed elements, with columns that record the total area and reused area for each interior element (see *Further Explanation, Example 1*). The following items are considered reused:

- Items that will be reused in place, as-is, for the same function
- Existing items that will be reused to serve a new function (e.g., a wood counter repurposed to serve as stair treads)

Products and materials reused from off-site, whether to serve either their original function or a new function, may be included in the credit calculations.

STEP 3. COMPLETE PRELIMINARY CALCULATIONS

Quantify the existing and reused interior nonstructural elements in terms of surface area (see *Further Explanation, Determining Area of Interior Nonstructural Elements*).

- Keep separate lists of items included and excluded.
- Using the information from the tracking table, calculate the percentage of eligible reused interior elements using Equation 1.

EQUATION 1. Area of reused interior elements

$$\text{Reused interior} = \left\{ \frac{\text{Reused nonstructural interior elements area (ft}^2\text{ or m}^2\text{)}}{\text{Total existing interior nonstructural elements area (ft}^2\text{ or m}^2\text{)}} \right\} \times 100$$

STEP 4. INCORPORATE REUSED ELEMENTS INTO CONSTRUCTION DOCUMENTS

Once the scope of desired reuse is determined, ensure that the areas intended for reuse are well defined, incorporated into the project scope, and specified in construction documents.

- In the demolition drawings, clearly identify areas to be protected for reuse in-place.
- In the design drawings and project specifications, clearly identify any items that will be reused for a different purpose.

STEP 5. CONFIRM FINAL PERCENTAGE OF REUSED ELEMENTS

Once the project is complete, calculate the percentage of reused elements using Equation 1. Record the details and the final results in the tracking table.

Option 2. Furniture Reuse

STEP 1. INVENTORY REUSED, SALVAGED, OR REFURBISHED FURNITURE AND FURNISHINGS

Early in the design process, inventory existing furniture and furnishings that could be incorporated into the project design. Develop a tracking table that lists all potentially reusable furniture and furnishings, in order of their suitability for reuse.

- Furniture and furnishings may be sourced on-site or off-site, from such sources as existing client furniture inventories, furniture resellers, and reused furniture and material exchanges.
- Take into consideration any storage requirements for reused furniture during construction and any necessary repairs or refurbishment.
- To qualify as reused, salvaged furniture taken from the owner's previous facility or location must have been purchased at least two years before the date of project registration. Alternatively, furniture that is leased must have been in service for at least two years before being installed in the current project. Document this claim.
- Reused, salvaged, and refurbished furniture that qualifies for MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials may be double-counted with this credit.

STEP 2. ESTIMATE TOTAL FURNITURE COSTS

Determine the total cost of the project's furniture and furnishings (both new and reused, refurbished, or salvaged). For the reused, salvaged, and refurbished items, use replacement values; enlist the help of a construction cost estimator or furniture representative if needed (see *MR Overview, Determining Product Cost*).

STEP 3. ESTIMATE PERCENTAGE OF REUSED ITEMS

Calculate the percentage, by cost, of reused, salvaged and refurbished items using Equation 2.

EQUATION 2. Percentage of reused furniture

$$\text{Reused furniture} = \left\{ \frac{\text{Cost of reused furniture and furnishings}}{\text{Total cost of furniture and furnishings}} \right\} \times 100$$

STEP 4. INCORPORATE REUSED ITEMS INTO CONSTRUCTION DOCUMENTS

Once list of reused, salvaged, and refurbished furniture and furnishings has been finalized, specify these items in the furniture plan and construction documents.

STEP 5: CONFIRM FINAL PERCENTAGE OF REUSED FURNITURE AND FURNISHINGS

Once the project is complete, calculate the percentage of reused, salvaged, and refurbished items used, with Equation 2. Record the details and the results in the tracking table.

Option 3. Design for Flexibility

STEP 1. DEVELOP FLEXIBILITY GOALS

Early in design, define the desired flexibility needs and establish flexibility goals and metrics for the project.

- Obtain early commitment from the entire team to ensure flexible strategies are not value-engineered out.
- In the predesign and schematic design phases, identify possible scenarios for future renovation and expansion and discuss how a flexible design could help to accommodate those potential changes.

STEP 2. IDENTIFY AT LEAST THREE STRATEGIES THAT MEET CREDIT REQUIREMENTS

Determine which design strategies outlined in the credit requirements will best help achieve the goals. Some strategies provide flexibility for future architectural, mechanical, and electrical changes; others prioritize materials and products that can be reused or recycled.

- Incorporate strategies that allow for disassembly, reuse, and recycling of building materials and systems (see *Further Explanation, Strategies for Designing for Flexibility*).
- Consider differential durability and premature obsolescence when designing and specifying products and materials.

STEP 3. COMPLETE PRELIMINARY CALCULATIONS TO DETERMINE STRATEGY SCOPE

Before design is finalized, determine whether the minimum threshold will be achievable for each applicable strategy. Calculation methodologies to determine percentage of compliance vary by strategy (see *Further Explanation, Calculations* and *Examples*).

STEP 4. INCORPORATE SELECTED STRATEGIES INTO CONSTRUCTION DOCUMENTS

Once the selected flexibility strategies have been finalized, incorporate them into the furniture plan and construction documents.

STEP 5. CONFIRM STRATEGY IMPLEMENTATION

Track performance through construction to ensure that the reuse and flexibility requirements specified in the project documents are implemented.

- During construction, some strategies may have to be scrapped. Tracking performance and allows the project team to come up with replacement strategies.
- Ensure that the completed project will achieve the reuse and flexibility strategy thresholds (see *Further Explanation, Calculations*).
- Record the details and the final results in the tracking table.

FURTHER EXPLANATION

CALCULATIONS

For Options 1 and 2, see *Step-by-Step Guidance*, Equations 1 and 2. The following equations are applicable to Option 3 only.

EQUATION 3. Design for flexibility: Accessible floor and ceiling systems

$$\text{Accessible floor and ceiling systems} = \left\{ \frac{\text{Total area of accessible floor and ceiling systems}}{\text{Total interior floor area}} \right\} \times 100$$

EQUATION 4. Design for flexibility: Movable walls, ceilings, and floors

$$\text{Movable walls, ceilings, and floors} = \left\{ \frac{\text{Total area of movable or demountable walls, ceilings, and floors}}{\text{Total area of all interior walls, ceilings, and floors}} \right\} \times 100$$

For Equation 4, exclude exterior walls, partial-height walls (considered furniture), and walls, ceiling, and floors required for fire separation by code.

EQUATION 5. Design for flexibility: Integrated materials labels

$$\text{Integrated materials labels} = \left\{ \frac{\text{Total cost of materials with compliant integral labels}}{\text{Total cost of all nonstructural materials}} \right\} \times 100$$

EQUATION 6. Design for flexibility: Reusable and recyclable materials

$$\text{Reusable and recyclable materials} = \left\{ \frac{\text{Total cost of reusable and recyclable nonstructural materials}}{\text{Total cost of all nonstructural materials}} \right\} \times 100$$

EQUATION 7. Design for flexibility: Plug-and-play power systems

$$\text{Plug-and-play power systems} = \left\{ \frac{\text{Total area with plug-and-play power systems}}{\text{Total interior floor area}} \right\} \times 100$$

EQUATION 8. Design for flexibility: Plug-and-play lighting systems

$$\text{Plug-and-play lighting systems} = \left\{ \frac{\text{Total area with plug-and-play lighting systems}}{\text{Total interior floor area}} \right\} \times 100$$

DETERMINING AREA OF INTERIOR NONSTRUCTURAL ELEMENTS

Include all finish ceilings, flooring, interior wall partitions, doors within interior walls, , exterior or party walls that are within the scop of work, and built-in case goods and determine the surface area (square feet or square meters) as follows.

Built-in case goods. Calculate the visible surface area of the assembly after installation.

Structural support elements. Columns, beams, and studs are considered part of the larger surfaces they support. Calculate the surface area of these elements as the surface area of the wall, ceiling, or floor.

Wall, ceiling, and floor assemblies. Each assembly (vertical or horizontal) may be calculated as up to three layers of surface area (see *Further Explanation, Example 2, Figure 2*). For vertical building elements, the layers are categorized as enclosure, structure, and interior finish. For horizontal building elements, the layers are categorized as ceiling finish, structure, and floor finish.

Not all layers may be present at the beginning of construction, depending on the state of the building. If a layer that existed before construction or demolition is removed and replaced with new material, it must be included in the calculation. If an existing layer was removed and not replaced, it is excluded.

- Example: A floor assembly consisting of ceiling tiles, structural slab, and carpeting has reused ceiling tiles and structural slab, but the carpet was removed and not replaced; instead, the exposed structural concrete is the finish material. The project team excludes the carpeting from the calculation but counts the slab as reused.
- Example: A building has an existing brick enclosure and steel structure but the drywall has been replaced. The team includes all three layers in the denominator but only the reused portions (enclosure and structure) in the numerator.
- Example: A building has an existing brick enclosure and steel structure with no drywall or interior finish. The team counts only those two layers in the reuse calculations.

Exclude the following items from the calculations:

- Exterior windows and doors
- Elements of the assembly that are outside the scope of work (e.g., the exterior of a wall)
- Items that are demolished and not replaced (e.g., the area of removed finish ceiling if the project has an exposed structural ceiling)
- Hazardous materials that are remediated as part of the project

Reused, salvaged and refurbished interior elements included in Option 1 of this credit that qualify for MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials cannot be double-counted with this credit.

STRATEGIES FOR DESIGNING FOR FLEXIBILITY

A variety of design strategies can provide flexibility for future architectural, mechanical, and electrical changes or make it easier to reuse or recycle materials and products.

Consider the following approaches to flexible design.

Accessible floor and ceiling systems. Accessible ceiling systems include typical t–bar and other movable ceiling assemblies that allow access to plenum spaces and building systems. The Owens Corning World Headquarters in Toledo, Ohio, for example, was built with access floors throughout. In the first year of occupancy, employees moved an average of 1.3 times. The access flooring system enabled those moves to be made very inexpensively.[1]

Demountable partitions. The entire wall, ceiling, or floor system is designed to be moved without deconstruction or demolition. Space needs in commercial interior spaces can change frequently, so incorporating demountable partitions allows tenants to meet their changing needs more easily, quickly, and cost-effectively.

Plug-and-play power and lighting systems. These systems allow for quick adjustments to meet changing power and lighting demands. When combined with flexible wall, ceiling, and floor strategies, they give building managers a high degree of interior space flexibility.

1. *Access Floors: A Step Up for Commercial Buildings, Environmental Building News.*

Integral labels. Reuse and recycling extend the use of materials, but during deconstruction it can be difficult to identify reusable and recyclable products. Specifying products with integral labels (radio frequency identification, engraving, embossing, or other permanent marking) containing information on material origin, properties, and date of manufacture will allow easier identification and reuse of these materials in the future. Refer to the Canadian Standards Association CSA Z782-06 Guideline for Design for Disassembly and Adaptability in Buildings for further information on integral labeling.

Take-back programs. In these programs, the manufacturer or another party collects used materials for recycling. More and more carpet and ceiling system manufacturers are taking back their products after use.

Leasing arrangements. Systems such as furniture can be leased, and the vendor takes the items back when the contract is up or the furniture is no longer needed. Leasing systems increase the likelihood that items will be used more than one before they reach their end of life. They also remove the burden of disposal from the project and can create an incentive to provide durable, reusable, and recyclable products.

To earn the project credit for a take-back or leasing program, the arrangement must cover a "major system or component," defined as any product or group of items used in the majority (more than 50%) of the project spaces where that item is relevant. Examples of qualifying systems include ceilings, carpeting, furniture, partitions, and casework. An example that may not qualify is built-in casework, which is typically not installed in more than half of a project's spaces.

EXAMPLES

Example 1. Calculating reused interior surfaces (Option 1)
The project is an interior refit. Figure 1 highlights the reused elements, including the interior walls. In this example, the interior side of exterior walls and the floors are not part of the scope of work and are therefore excluded from credit calculations (Table 1).

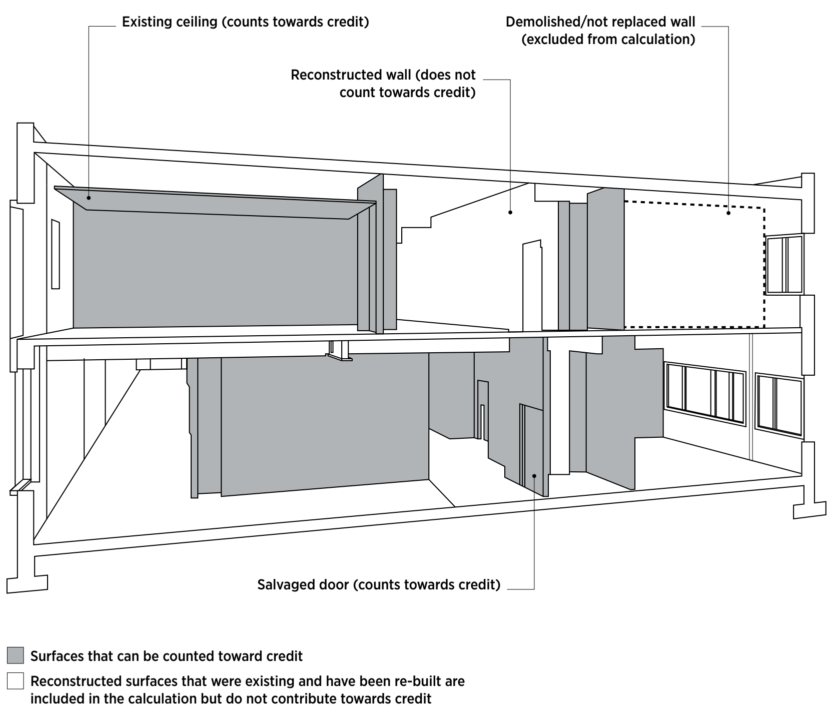


Figure 1. Example existing interior surface area reuse contribution

TABLE 1. Example tracking of reused elements (Option 1, Interior Reuse)			
Interior elements	**Existing area (m²)**	**Reused area (m²)**	**Percentage reused**
Reconstructed wall: 2nd-floor hallway	100	0	0%
Demolished wall (not replaced): 2nd-floor office partition	0	0	0%
Reused wall: 1st-floor office partitions	500	350	70%
Reused wall: 1st-floor hallway	100	100	100%
Ceiling: 1st-floor asbestos tiles, removed (hazardous material)	—	—	—
Ceiling: 2nd-floor ceiling, reused	1 200	1 000	83%
Total	**1 900**	**1 450**	**76.3%**

Example 2. Three layers of reuse

The project team must account for partial reuse of a wall assembly. The entire wall, including the exterior, is part of the project's scope of work. The project is reusing the exterior layers but replacing interior layers.

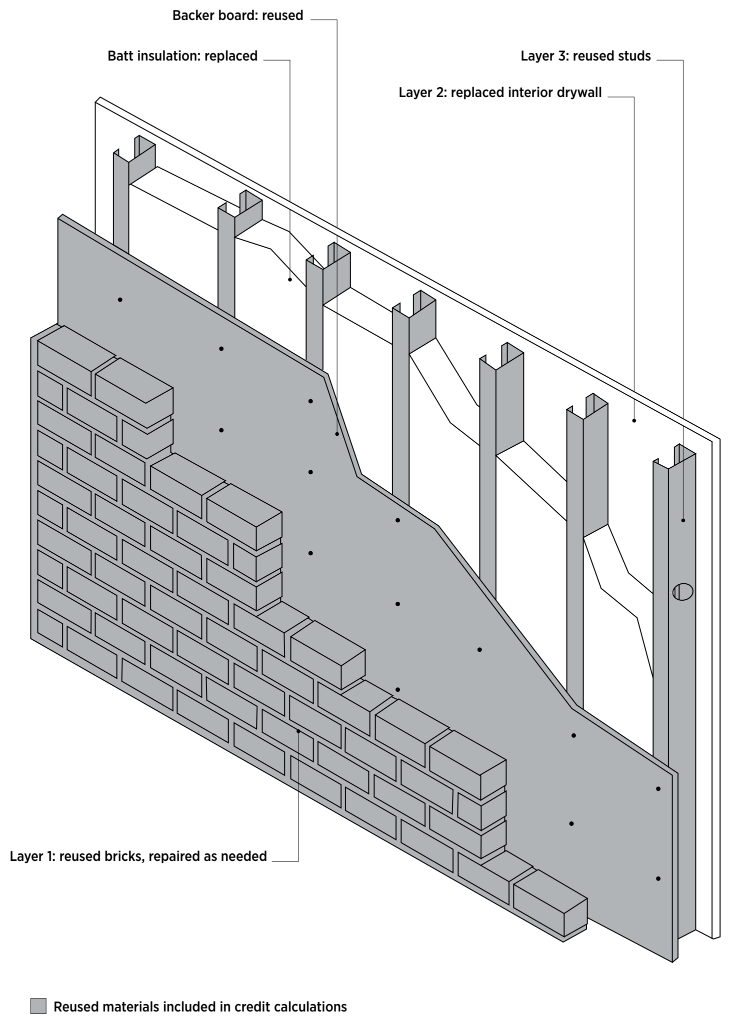


Figure 2. Example surface area reuse calculations using wall assembly layers

TABLE 2. Wall assembly layers			
Wall assembly layers	**Existing area (ft^2)**	**Reused area (ft^2)**	**Percentage reused**
Layer 1. Exterior enclosure, brick and backer board	1,000	1,000	100%
Layer 2. Interior surface, wallboard	1,000	800	80%
Layer 3. Structural framing, aluminum studs	1,000	800	80%
Total (transfer to tracking table)	**3,000**	**2,600**	**86.6%**

CAMPUS

Group Approach
Option 1. All project spaces in the group may be documented as one.

Option 2. All project spaces in the group may be documented as one.

Option 3. Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3
Drawings indicating locations of interior elements	X		
Tracking table showing total area of all interior elements, reused interior elements, percentage of reused elements, and cost of each element	X		
Tracking table for furniture and furnishings, listing all items and showing total cost, costs for reused, salvaged, and refurbished items, and percentage of reused, salvaged, and refurbished items		X	
Site drawings, floor plans, and sections (as applicable) showing compliance with flexibility strategies			X
Cutsheets and product information showing compliance with flexibility strategies (as applicable)			X

RELATED CREDIT TIPS

MR Credit Construction and Demolition Waste Management. For interior renovation projects, materials and products that are not reused on-site but are sold or donated for reuse can contribute to the diversion requirements for the related credit.

MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials. Reused or salvaged interior nonstructural materials (found on-site or off-site) may contribute toward Option 1 or Option 2 of this credit, depending on which credit(s) the project is pursuing and which calculation makes more sense (surface area versus cost). However, materials may not be double-counted under both credits.

MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials, Option 2, Leadership Extraction Practices. Salvaged, reused, and refurbished furniture contributing toward Option 2 of this credit may also contribute toward the related credit. If furniture is included in this credit, it must be included consistently across all Building Product Disclosure and Optimization credits.

CHANGES FROM LEED 2009

- Two former MR credits, Building Reuse—Maintain Interior Nonstructural Components and Materials Reuse—Furniture and Furnishings, have been combined into this credit.
- The reuse threshold for interior nonstructural elements has been changed from a tiered approach (40% and 60%) to a single 50% threshold.
- Credit is given both for items that are reused in place and for items that serve a new purpose.
- Option 3, Design for Flexibility, is new.

REFERENCED STANDARDS

Canadian Standards Association CSA Z782-06 Guideline for Design for Disassembly and Adaptability in Buildings: shop.csa.ca/en/canada/design-for-the-environment/z782-06/invt/27025282006/

Federal Trade Commission Guide for Use of Environmental Marketing Claims, 260.7(d): ftc.gov/bcp/grnrule/guides980427.htm

EXEMPLARY PERFORMANCE

Option 1. Achieve 95% interior nonstructural element reuse.

Option 2. Achieve 60% furniture and furnishings reuse.

Option 3. Use at least six design-for-flexibility strategies.

DEFINITIONS

differential durability a state in which two materials with different life spans make up one complete component. If one material wears out and cannot be separated and replaced, the entire product must be thrown away.

furniture and furnishings the stand-alone furniture items purchased for the project, including individual and group seating; open-plan and private-office workstations; desks and tables; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted visual-display products (e.g., marker boards and tack boards, excluding electronic displays); and miscellaneous items, such as easels, mobile carts, freestanding screens, installed fabrics, and movable partitions. Hospitality furniture is included as applicable to the project. Office accessories, such as desktop blotters, trays, tape dispensers, waste baskets, and all electrical items, such as lighting and small appliances, are excluded.

integral labeling an information conveyance system that cannot be easily removed. For furniture, such labeling may include radio frequency identification, engraving, embossing, or other permanent marking containing information on material origin, properties, and date of manufacture.

premature obsolescence the wearing out or disuse of components or materials whose service life exceeds their design life. For example, a material with a potential life of 30 years is intentionally designed to last only 15 years, such that its remaining 15 years of service is potentially wasted. In contrast, components whose service life is the same as their expected use are utilized to their maximum potential.

refurbished material an item that has completed its life cycle and is prepared for reuse without substantial alteration of its form. Refurbishing involves renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.

reused area the total area of the building structure, core, and envelope that existed in the prior condition and remains in the completed design

salvaged material a construction component recovered from existing buildings or construction sites and reused. Common salvaged materials include structural beams and posts, flooring, doors, cabinetry, brick, and decorative items.

MATERIALS AND RESOURCES CREDIT

Building Product Disclosure and Optimization—Environmental Product Declarations

This credit applies to:

Commercial Interiors (1-2 points)
Retail (1-2 points)
Hospitality (1-2 points)

INTENT

To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.

REQUIREMENTS

Achieve one or more of the options below, for a maximum of 2 points.

OPTION 1. ENVIRONMENTAL PRODUCT DECLARATION (EPD) (1 POINT)

Use at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the disclosure criteria below.

- Product-specific declaration.
  - Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one quarter (¼) of a product for the purposes of credit achievement calculation.
- Environmental Product Declarations which conform to ISO 14025, 14040, 14044, and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
  - Industry-wide (generic) EPD – Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator are valued as one half (½) of a product for purposes of credit achievement calculation.
  - Product-specific Type III EPD – Products with third-party certification (Type III), including external verification in which the manufacturer is explicitly recognized as the participant by the program operator are valued as one whole product for purposes of credit achievement calculation.
- USGBC approved program – Products that comply with other USGBC approved environmental product declaration frameworks.

OPTION 2. MULTI-ATTRIBUTE OPTIMIZATION (1 POINT)

Use products that comply with one of the criteria below for 50%, by cost, of the total value of permanently installed products in the project. Products will be valued as below.

- Third party certified products that demonstrate impact reduction below industry average in at least three of the following categories are valued at 100% of their cost for credit achievement calculations.
  - global warming potential (greenhouse gases), in CO_2e;
  - depletion of the stratospheric ozone layer, in kg CFC-11;
  - acidification of land and water sources, in moles H+ or kg SO_2;
  - eutrophication, in kg nitrogen or kg phosphate;
  - formation of tropospheric ozone, in kg NO_x or kg ethene; and
  - depletion of nonrenewable energy resources, in MJ.
- USGBC approved program -- Products that comply with other USGBC approved multi-attribute frameworks.

For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost.

Structure and enclosure materials may not constitute more than 30% of the value of compliant building products.

FOR ALL OPTIONS

Meet the requirements of the credit above and include furniture and furnishings within the project's scope of work.

BEHIND THE INTENT

This credit recognizes the selection of products for which the environmental impacts are well known because of industry standard life-cycle information and reporting protocols. Environmental product declarations (EPDs) are a standardized way of communicating the environmental effects associated with a product or system's raw material extraction, energy use, chemical makeup, waste generation, and emissions to air, soil, and water. Although a variety of EPD programs exist, the credit requires that EPDs come from program operators who follow the International Organization for Standardization (ISO) standards, the internationally recognized norm for EPDs. Project teams using EPDs can more accurately compare and evaluate similar products, improving their decisions when selecting materials.

As EPDs become commonplace, this credit will recognize the most advanced disclosures available. Giving preference to products with EPDs supports the transition from a "single-attribute" approach to one that relies on more comprehensive reporting and rewards manufacturers whose products are less harmful to the environment.

The diversity of options and compliance paths in this credit is designed to reward both initial first steps and leadership in life-cycle information disclosure. The credit intends to help transform the market for building products and materials for which life-cycle information is available and encourage manufacturers that have verified their environmental performance.

STEP-BY-STEP GUIDANCE

Select which option(s) to pursue. Products may contribute to both Options 1 and 2. Early product research can help the project team capitalize on opportunities for products contributing to multiple credits and options.

The required scope of this credit is permanently installed building products and furniture within the project scope of work, excluding mechanical, plumbing, electrical (MEP), and specialty equipment and items purchased for temporary use on the project. However, optional MEP products may be included, provided they are also included in the other two cost-based credits, MR Credit Building Disclosure and Optimization—Sourcing of Raw Materials and MR Credit Building Disclosure and Optimization—Materials Ingredients. For more information see *MR Overview, Qualifying Products and Exclusions*.

- Option 1 is for projects with products with product-specific declarations or industry-wide EPDs, or otherwise recognized USGBC-approved program. Products must be sourced from multiple manufacturers, as indicated in the credit requirements. Various thresholds are available to accommodate stages of EPD development in different industries. The weighted value of the product must meet the threshold indicated in the credit requirements.
- Option 2 is for projects with products that come from manufacturers adhering to USGBC-approved programs that will certify verified reductions in the multiple impact categories listed in the credit requirements. USGBC will endorse specific third-party programs if their certifications are based on verified data. This information will be available on the USGBC website. The proportion of qualifying materials must meet the threshold indicated in the credit requirements and includes the weighted value of locally sourced products.

Option 1. Environmental Product Declaration (EPD)

STEP 1. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify at least 20 products from at least five different manufacturers for which the available EPDs meet at least one of the credit criteria.

- Include performance requirements or sole-source compliant products as applicable to the selected option(s) in the project specifications. To ensure compliant purchases, consider creating a Division 1, General Requirements, specification for sustainability criteria that meet MR requirements. Reference that section to distinguish it from other sections that cover products and materials (see *Further Explanation, Environmental Product Declarations* and *Environmental Product Declaration Types*).

- Similar products from the same manufacturer can be counted as separate products if they have distinct formulations, but not if they are aesthetic variations or reconfigurations (see *MR Overview, Defining a Product*).

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction submittals to ensure that selected products meet credit requirements. To track progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Continually track substitutions and change orders during buy-out and installation to ensure that replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance with credit requirements.
- Because these requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. COUNT COMPLIANT PRODUCTS AND MATERIALS AND COMPILE DOCUMENTATION

With the data collected in a tracking tool or the calculator provided by USGBC, use Equation 1 (see *Further Explanation, Calculations*) to calculate the total number of products that comply with Option 1 requirements. This equation calculates compliance based on the number of products, not their cost.

- A product is the unit of purchase. The requirement for EPDs applies to the final unit of purchase—that is, entire assemblies, not individual components.
- Products with EPDs that meet more than one criterion are weighted at the highest valuation factor (not a combined factor).
- Collect all EPDs and life-cycle assessment (LCA) reports for contributing products for credit documentation. Ensure that EPD documentation includes a summary sheet of measured impacts.
- Retain product data for all materials that contribute to credit achievement and be prepared to provide it on request (see *Further Explanation, Documentation of Product-Specific Declarations* and *Example Documentation of an EPD*).

Option 2. Multi-attribute Optimization

STEP 1. RESEARCH PRODUCTS

Identify products that meet one or more of the attributes listed in the credit requirements under Option 2. See *Further Explanation, Impact Categories or Measures.*

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

Collect documentation of environmental claims for each product expected to contribute toward credit achievement. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Request documentation via correspondence with the product's manufacturer or third-party certifying body.
- Continually track substitutions and change orders to ensure that the credit threshold will be met.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE COMPLIANCE

Purchase 50%, by cost, of permanently installed products that meet at least one of the requirements listed in Option 2 of this credit. Calculate compliant materials using Equation 2 and the data collected in the tracking tool (see *Further Explanation, Calculations*).

- Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Once the cap on structural material is met these product can no longer contribute toward the credit, but must be included in the denominator of Equation 2.
- Some products may meet multiple criteria, or are part of assemblies (see *Further Explanation, Documentation of EPD's, Figure 3*).

Compile documentation needed to verify environmental claims for each product. Retain product data for all materials that contribute to credit achievement.

FURTHER EXPLANATION

CALCULATIONS

EQUATION 1. Total number of products with environmental product declarations

$$\text{Total \# of products} = \left\{ \text{\# of products with product specific declarations} \times 0.25 \right\} + \left\{ \text{\# of products with industry specific declarations} \times 0.5 \right\} + \left\{ \text{\# of products with Type III EPDs} \times 1 \right\}$$

EQUATION 2. Percentage of multi-attribute optimization materials cost

$$\text{\% of materials cost} = \frac{\left\{ \text{product}_1 \text{ cost} \left(\text{cost of all permanently installed prodcuts} \right) \left(\text{location valuation factor} \right) \right\} + \left\{ \text{product}_2 \text{ cost} \left(\text{criterion valuation factor} \right) \left(\text{location valuation factor} \right) \right\} + \ldots}{\text{criterion valuation factor}} \times 100$$

where

Product cost = cost of the product contributing toward credit. For assemblies, the cost amount contributing toward credit is based on weight (see *MR Overview, Determining Product Cost*).

Criterion valuation factor = weighting multiplier for the criterion. This factor will be determined for each certification that becomes available.

Location valuation factor = multiplier for the extraction, manufacture, and purchase location (see *MR Overview, Location Valuation Factor*).

ENVIRONMENTAL PRODUCT DECLARATIONS

An EPD is a standardized way of communicating the environmental impacts, such as global warming potential and energy resource depletion, of a product or system. A product category rule (PCR) defines how to standardize this information for a specific product type, such as flooring. The PCR defines scope, system boundary, measurement procedures, impact measures and other technical requirements.

PCR development is the responsibility of the EPD Program Operator and is often organized through standards organizations or industry associations or sponsored by private or government organizations. Many countries maintain lists of PCRs that are publicly available; private Program Operators have PRCs on their websites:

- China EPD program, sepacec.com/cecen
- Japan Ecoleaf program, ecoleaf-jemai.jp/eng
- International EPD system, environdec.com/en/Product-Category-Rules
- Institut Bauen und Umwelt (Institute Construction and Environment), bau-umwelt.de

- Norway EPD system, epd-norge.no
- Taiwan EPD system, pcr-library.edf.org.tw/product_country/taiwan.asp
- Korean EPD system, eng.keiti.re.kr
- UL Environment EPD system, ul.com/global/eng/pages/offerings/businesses/environment/services/certification/epd
- Global Environmental Declaration network, gednet.org

Because an EPD must have a corresponding PCR to contribute to this credit, project teams might find it useful to research EPDs by finding out whether a PCR exists for a product type, and if so, the entity that created it. The entity that created the PCR is likely to have used it to create an EPD.

In Option 1 Environmental Product Declaration, different thresholds are designed to accommodate varying levels of development of EPDs across industries. For example, the flooring industry has an established PCR, and as a result, several carpet and resilient flooring companies now provide EPDs. In industries without established PCRs, some manufacturers provide life-cycle assessments in accordance with ISO. The credit-calculated value for an ISO 14040/44 LCA is lower, to encourage manufacturers to work through their industry associations to develop PCRs, which allow more accurate comparisons between products in similar categories. Generic EPDs are a good starting point for manufacturers; they provide a baseline of information for a specific product category, but are not specific to a company or manufacturing plant.

Product-specific declarations are publicly available and critically reviewed (but not necessarily verified) by a third party to ensure that they conform to ISO 14044, which defines how LCAs are critically reviewed.

Industry-wide (generic) declarations have third-party (Type III) certification, which includes verification. The declaration is generic to a product, such as concrete, not specific to a particular manufacturer or company. For the product to be eligible, the manufacturer must claim representation either directly on the EPD or through the Program Operator for the associated EPD.

Product-specific Type III declarations also use third-party certification that includes verification. Unlike generic EPDs, however, product-specific declarations are specific to a particular manufacturer and do not necessarily reflect the practices of the rest of the industry.

A Type III EPD uses data from a life-cycle assessment (LCA) and is defined by the PCR so that all EPDs for a product are comparable. LCA data can also be aggregated to produce a representative EPD of several products in the same family (type). ISO has developed several standards regarding independent verification of quantitative data (the LCA), PCR development, and EPD review and publication. EPDs can be found on manufacturers' websites or the program operator's website or can be requested from the manufacturer.

For this credit, the scope of any EPD must be at least cradle-to-gate—that is, it must cover the part of a product's life cycle from extraction ("cradle") and material processing to creation of the final product ready for sale by the manufacturer ("gate"); it excludes transportation from the factory to distributors or end customers. EPDs that cover only manufacture ("gate to gate") do not contribute toward the credit.

All EPDs must be consistent with ISO standards 14025, 14040, 14044, and EN 15804 or ISO 21930. These standards address how to set up and perform LCA, how LCA feeds into an EPD, and the appropriate level of detail and content to be included in an EPD (see *Referenced Standards*).

For products not included in EN 15804 or the superseded ISO 21930 (i.e., furniture and other items not considered building products), conformance to ISO 14025 only is acceptable.

EN 15804 is a European standard for PCR development. Products using EN 15804 in North America are expected to adapt regionally specific aspects of the EN standard for North America. Declaration Holders should work with the Program Operator to perform these adaptations.

To contribute to the credit threshold, the EPD must include statements of compliance with a specific PCR and compliance with the ISO standards.

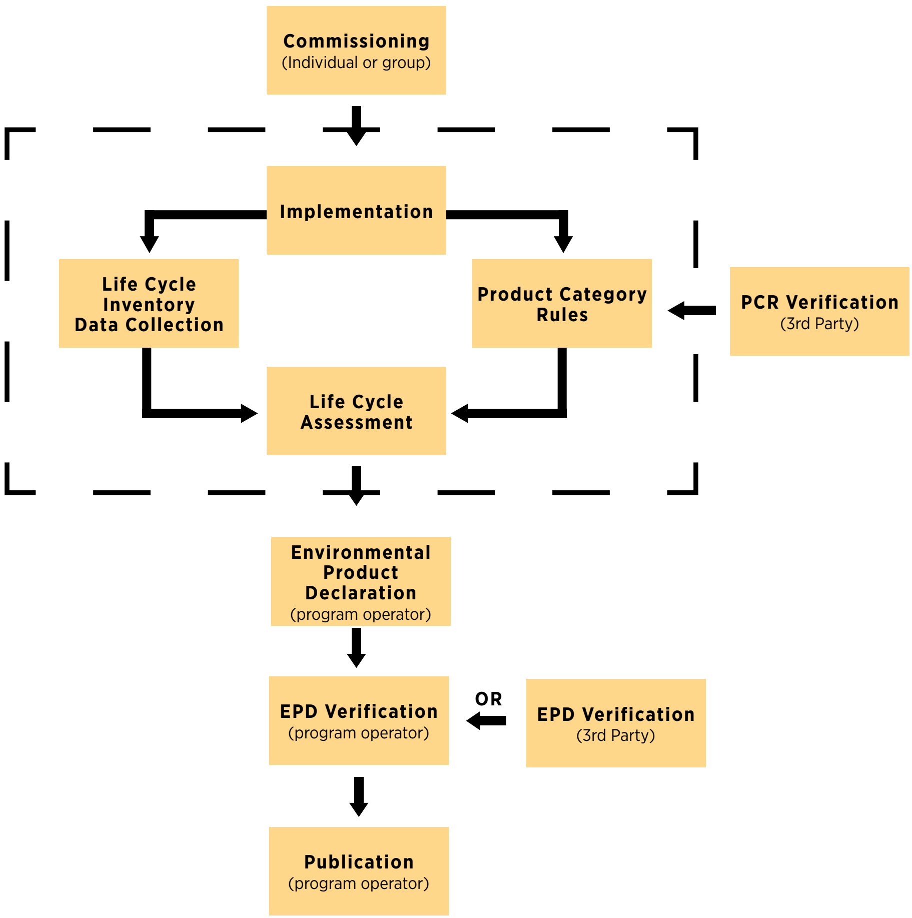


Figure 1. EPD process

TABLE 1. EPD process comparison

	Product specific declaration	Industry wide EPD	Product-specific EPD
Data are critically reviewed	X	X	X
Data are specific to product	X		X
Data are reported according to a PCR		possibly	X

For a manufacturer, the EPD process is as follows:

1. A manufacturer searches for existing product category rules for its product category (aka the product type) see list above for regional entities that maintain PCR libraries.

   If a PCR does not exist, manufacturers work with a program operator to convene a group and develop product category rules for the product type. This process includes a proposal, draft creation, open consultation, panel review, and approval and publication of product category rules.

2. The manufacturer conducts a life-cycle assessment, based on the product's goals and functional unit, global warming potential, primary energy demand, contribution to acidification and eutrophication, and other environmental indicators.
3. The manufacturer creates the EPD using this information and initiates verification by a third party, which determines whether the LCA followed the correct ISO processes and the EPD was created according to the PCR.
4. The manufacturer registers the declaration with a program operator, which verifies the EPD according to ISO standards. Examples of program operators include UL Environmental, ICC-ES, ASTM, NSF, FP Innovations, the Institute for Environmental Research and Education.

DOCUMENTATION OF PRODUCT-SPECIFIC DECLARATIONS

Product-specific declarations are defined for this credit as declarations that are based on a life-cycle assessment of a product but not constituting a full EPD. To document this claim, the project team must provide the following information:

- Name (declaration holder or producer, typically the manufacturer)
- Contact information
- Product type
- Product name
- Product description
- Summary of impact categories measured and overall values
- Functional unit
- Standards met
- Independent review entity's name and statement

DOCUMENTATION OF EPDS

For industry-wide (generic) declarations and product-specific Type III declarations, the project team must provide the following:

- Declaration holder (the company, usually the manufacturer, that the EPD is attributed to)
- EPD program operator (the entity that creates and registers the EPD)
- LCA verifier (the third-party entity that verifies the life-cycle assessment)
- PCR reviewer (the third-party entity that has reviewed the product category rules)

During the selection of products with EPDs, identify two items about the document: the type of EPD it is, and the summary that will be uploaded for credit compliance. Figure 2 illustrates an EPD created by Interface Flor for Type 6 Nylon with GlasBac.

PROGRAM OPERATOR	UL Environment
DECLARATION HOLDER	Interface
DECLARATION NUMBER	110919.11CA29311.101.1
DECLARED PRODUCT	Modular carpet with recycled solution dyed Nylon 6 yarn on GlasBac® backing manufactured by Interface in Lagrange, Georgia USA.
REFERENCE PCR	PCR-Floorcoverings Harmonised Rules for Textile, Laminate and Resilient Floor Coverings
DATE OF ISSUE	September 19, 2011
PERIOD OF VALIDITY	5 years
CONTENTS OF THE DECLARATION	Product definition and information about building physics Information about basic material and the material's origin Description of the product's manufacture Indication of product processing Information about the in-use conditions Life cycle assessment results Testing results and verifications
The PCR review was conducted by:	Insitut Bauen und Umwelt e.V Accepeted by the Advisory board Rheinufer 108 53639 Königswinter Germany info@bau-umwelt.com
This declaration was independently verified in accordance with ISO 14025 by Underwriters Laboratories ☐ INTERNAL ☑ EXTERNAL	[signature] Loretta Tam
This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by:	[signature] Eva Schmincke

This EPD is for a single product

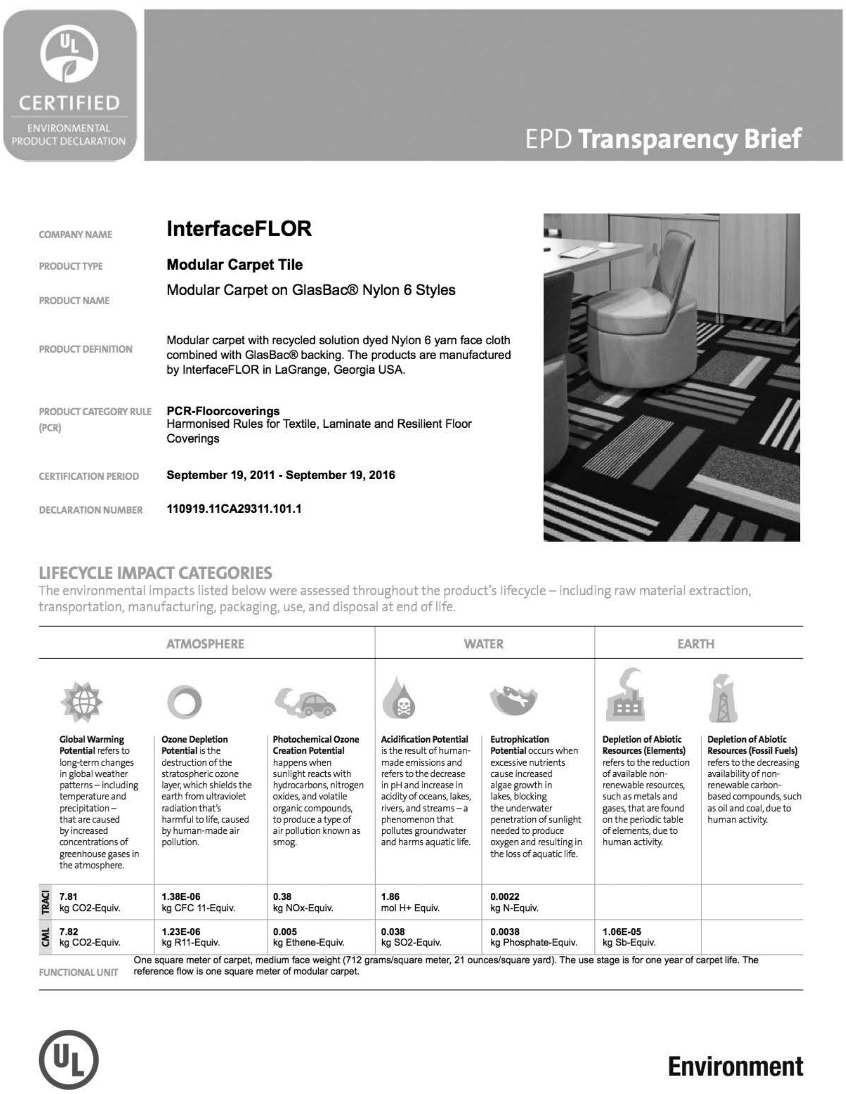
This EPD has a reviewed PCR

This EPD was performed according to ISO 14044

Figure 2. Example of EPD that meets requirements of Type III. Used with permission from Interface.

Such a summary is preferable to the full document, provided it includes the following:

- Name (declaration holder, the producer or group of producers; each producer must be listed to claim the credit)
- Program operator
- Contact information
- Product type
- Product name
- Product description
- Product category rule (title)
- Certification period
- Declaration number
- Summary of impact categories measured and overall values
- Functional unit
- Standards met
- Independent verification body (may be the same as the program operator)



CERTIFIED
ENVIRONMENTAL PRODUCT DECLARATION

EPD **Transparency Brief**

COMPANY NAME	**InterfaceFLOR**
PRODUCT TYPE	**Modular Carpet Tile**
PRODUCT NAME	Modular Carpet on GlasBac® Nylon 6 Styles
PRODUCT DEFINITION	Modular carpet with recycled solution dyed Nylon 6 yarn face cloth combined with GlasBac® backing. The products are manufactured by InterfaceFLOR in LaGrange, Georgia USA.
PRODUCT CATEGORY RULE (PCR)	**PCR-Floorcoverings** Harmonised Rules for Textile, Laminate and Resilient Floor Coverings
CERTIFICATION PERIOD	**September 19, 2011 - September 19, 2016**
DECLARATION NUMBER	**110919.11CA29311.101.1**

LIFECYCLE IMPACT CATEGORIES

The environmental impacts listed below were assessed throughout the product's lifecycle – including raw material extraction, transportation, manufacturing, packaging, use, and disposal at end of life.

	ATMOSPHERE			WATER		EARTH	
	Global Warming Potential refers to long-term changes in global weather patterns – including temperature and precipitation – that are caused by increased concentrations of greenhouse gases in the atmosphere.	**Ozone Depletion Potential** is the destruction of the stratospheric ozone layer, which shields the earth from ultraviolet radiation that's harmful to life, caused by human-made air pollution.	**Photochemical Ozone Creation Potential** happens when sunlight reacts with hydrocarbons, nitrogen oxides, and volatile organic compounds, to produce a type of air pollution known as smog.	**Acidification Potential** is the result of human-made emissions and refers to the decrease in pH and increase in acidity of oceans, lakes, rivers, and streams – a phenomenon that pollutes groundwater and harms aquatic life.	**Eutrophication Potential** occurs when excessive nutrients cause increased algae growth in lakes, blocking the underwater penetration of sunlight needed to produce oxygen and resulting in the loss of aquatic life.	**Depletion of Abiotic Resources (Elements)** refers to the reduction of available non-renewable resources, such as metals and gases, that are found on the periodic table of elements, due to human activity.	**Depletion of Abiotic Resources (Fossil Fuels)** refers to the decreasing availability of non-renewable carbon-based compounds, such as oil and coal, due to human activity.
TRACI	**7.81** kg CO2-Equiv.	**1.38E-06** kg CFC 11-Equiv.	**0.38** kg NOx-Equiv.	**1.86** mol H+ Equiv.	**0.0022** kg N-Equiv.		
CML	**7.82** kg CO2-Equiv.	**1.23E-06** kg R11-Equiv.	**0.005** kg Ethene-Equiv.	**0.038** kg SO2-Equiv.	**0.0038** kg Phosphate-Equiv.	**1.06E-05** kg Sb-Equiv.	

FUNCTIONAL UNIT: One square meter of carpet, medium face weight (712 grams/square meter, 21 ounces/square yard). The use stage is for one year of carpet life. The reference flow is one square meter of modular carpet.

Environment

Figure 3. Sample EPD for carpet tile product. Used with permission from Interface.

IMPACT CATEGORIES OR MEASURES

Option 2 lists a series of environmental indicators targeted for reduction. These impact measures originate from those used in a life cycle assessment (LCA). In the case of option 2, manufacturers or third party programs would be conducting the LCA and releasing results to project teams for documentation of this option.

The impacts measured in LCA are divided into two categories, as described in ISO 21930–2007. Impacts are either expressed in terms of the categories of life-cycle impact assessments (LCIA) or derived from a life-cycle inventory (LCI) and not assigned to impact categories. LCIA is an additional step in analysis that interprets and quantifies the resulting ecological effects of resources used and waste emitted over the life-cycle of the product. In contrast, LCI simply quantifies flows in and out of the process in terms of resources used and depleted and waste created.

The first five measures specified in the credit requirements are impact categories of LCIA; they are the only LCI categories cited in ISO 21930. Other LCIA measures are in use or being developed (e.g., human health and ecotoxicity measures) but are less quantifiable than the measures required for LEED, although they may be reported separately. Other impact assessment methods not listed in Table 4 may be used if the reasons are justified and documented.

The sixth measure in the list, depletion of nonrenewable energy resources, is in the second category because it is derived directly from the LCI (defined in the ISO standard as "phase of life-cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life-cycle").

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
MR building product disclosure and optimization calculator or equivalent tracking tool	X	X
EPD and LCA reports or compliant summary documents for 100% of products contributing toward credit	X	
Documentation of compliance with USGBC-approved program		X

RELATED CREDIT TIPS

MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials. Locally sourced materials contributing to the credit may also contribute to this related credit if compliant harvesting or extraction can be confirmed.

MR Credit Building Product Disclosure and Optimization—Material Ingredients. Manufacturers whose products and materials have EPDs may report ingredients. Ensure that the level of detail reported meets the credit requirements. If the level of detail is sufficient, the product can contribute to both this credit and the related credit.

CHANGES FROM LEED 2009

- This is a new credit.
- Some materials excluded from MR credits in the past may now be included, such as mechanical fixtures, fittings, and rough-in materials that are considered nonmotorized MEP components.

REFERENCED STANDARDS

International Standard ISO 14021-1999, Environmental labels and declarations. Self Declared Claims (Type II Environmental Labeling): iso.org

International Standard ISO 14025–2006, Environmental labels and declarations (Type III Environmental Declarations—Principles and Procedures): iso.org

International Standard ISO 14040–2006, Environmental management. Life cycle assessment principals, and frameworks: iso.org

International Standard ISO 14044–2006, Environmental management. Life cycle assessment requirements, and guidelines: iso.org

CEN Comité Européen de Normalisation (European Committee for Standardization) EN 15804—2012 Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction products: cen.eu

International Standard ISO 21930–2007 Sustainability in building construction -- Environmental declaration of building products: iso.org

Federal Trade Commission, Guides for the Use of Environmental Marketing Claims, 16 CFR 260.7 (e): ftc.gov/bcp/grnrule/guides980427.htm

EXEMPLARY PERFORMANCE

Option 1. Source at least 40 qualifying products from five manufacturers.

Option 2. Purchase 75%, by cost, of permanently installed building products that meet the required attributes.

DEFINITIONS

cradle-to-gate assessment analysis of a product's partial life cycle, from resource extraction (cradle) to the factory gate (before it is transported for distribution and sale). It omits the use and the disposal phases of the product.

enclosure the exterior plus semi-exterior portions of the building. Exterior consists of the elements of a building that separate conditioned spaces from the outside (i.e., the wall assembly). Semiexterior consists of the elements of a building that separate conditioned space from unconditioned space or that encloses semi-heated space through which thermal energy may be transferred to or from the exterior or conditioned or unconditioned spaces (e.g., attic, crawl space, basement).

environmental product declaration a statement that the item meets the environmental requirements of ISO 14021–1999, ISO 14025–2006 and EN 15804, or ISO 21930–2007.

life-cycle assessment an evaluation of the environmental effects of a product from cradle to grave, as defined by ISO 14040–2006 and ISO 14044–2006

product (**permanently installed building product**) an item that arrives on the project site either as a finished element ready for installation or as a component to another item assembled on-site. The product unit is defined by the functional requirement for use in the project; this includes the physical components and services needed to serve the intended function of the permanently installed building product. In addition, similar product within a specification, each contributes as a separate product.

structure elements carrying either vertical or horizontal loads (e.g., walls, roofs, and floors) that are considered structurally sound and nonhazardous

MATERIALS AND RESOURCES CREDIT

Building Product Disclosure and Optimization—Sourcing of Raw Materials

This credit applies to:

Commercial Interiors (1-2 points)
Retail (1-2 points)
Hospitality (1-2 points)

INTENT

To encourage the use of products and materials for which life cycle information is available and that have environmentally, economically, and socially preferable life cycle impacts. To reward project teams for selecting products verified to have been extracted or sourced in a responsible manner.

REQUIREMENTS

OPTION 1. RAW MATERIAL SOURCE AND EXTRACTION REPORTING (1 POINT)

Use at least 20 different permanently installed products from at least five different manufacturers that have publicly released a report from their raw material suppliers which include raw material supplier extraction locations, a commitment to long-term ecologically responsible land use, a commitment to reducing environmental harms from extraction and/or manufacturing processes, and a commitment to meeting applicable standards or programs voluntarily that address responsible sourcing criteria.

- Products sourced from manufacturers with self-declared reports are valued as one half (½) of a product for credit achievement.

- Third-party verified corporate sustainability reports (CSR) which include environmental impacts of extraction operations and activities associated with the manufacturer's product and the product's supply chain, are valued as one whole product for credit achievement calculation. Acceptable CSR frameworks include the following:
    - **Global Reporting Initiative (GRI) Sustainability Report**
    - **Organisation for Economic Co-operation and Develoment (OECD) Guidelines for Multinational Enterprises**
    - **U.N. Global Compact:** Communication of Progress
    - **ISO 26000:** 2010 Guidance on Social Responsibility
    - **USGBC approved program:** Other USGBC approved programs meeting the CSR criteria.

OPTION 2. LEADERSHIP EXTRACTION PRACTICES (1 POINT)

Use products that meet at least one of the responsible extraction criteria below for at least 25%, by cost, of the total value of permanently installed building products in the project.

- **Extended producer responsibility.** Products purchased from a manufacturer (producer) that participates in an extended producer responsibility program or is directly responsible for extended producer responsibility. Products meeting extended producer responsibility criteria are valued at 50% of their cost for the purposes of credit achievement calculation.
- **Bio-based materials.** Bio-based products must meet the Sustainable Agriculture Network's Sustainable Agriculture Standard. Bio-based raw materials must be tested using ASTM Test Method D6866 and be legally harvested, as defined by the exporting and receiving country. Exclude hide products, such as leather and other animal skin material. Products meeting bio-based materials criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
- **Wood products.** Wood products must be certified by the Forest Stewardship Council or USGBC-approved equivalent. Products meeting wood products criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
- **Materials reuse.** Reuse includes salvaged, refurbished, or reused products. Products meeting materials reuse criteria are valued at 100% of their cost for the purposes of credit achievement calculation.
- **Recycled content.** Recycled content is the sum of postconsumer recycled content plus one-half the preconsumer recycled content, based on cost. Products meeting recycled content criteria are valued at 100% of their cost for the purposes of credit achievement calculation
- **USGBC approved program.** Other USGBC approved programs meeting leadership extraction criteria.

For credit achievement calculation, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the base contributing cost of individual products compliant with multiple responsible extraction criteria is not permitted to exceed 100% its total actual cost (before regional multipliers) and double counting of single product components compliant with multiple responsible extraction criteria is not permitted and in no case is a product permitted to contribute more than 200% of its total actual cost.

Structure and enclosure materials may not constitute more than 30% of the value of compliant building products.

FOR ALL OPTIONS

Meet the requirements of the credit above and include furniture and furnishings within the project's scope of work.

BEHIND THE INTENT

Raw material extraction has a direct environmental impact on Earth's ecosystems. For example, conventional logging is the largest source of deforestation in Latin America and subtropical Asia, accounting for more than 70% of resource depletion; mining operations clear another 18% of the world's forests. Unmanaged extraction practices can cause not only deforestation but also degradation of water sources, habitat loss, threats to rare and endangered species, releases of toxic chemicals, and the infringement of indigenous peoples' rights.

This credit encourages the use of responsibly sourced and extracted materials through reporting and demonstration of responsible extraction practices. Corporate sustainability reports (CSRs), based on widely recognized frameworks and standards, can shed light on product supply chains and identify sources of raw material extraction. CSRs have become increasingly popular among all types of businesses, from retail organizations to product manufacturers. As sustainability goals become more prominent, CSRs provide frameworks that allow transparency and environmental impacts to be assessed, improved, and compared with other companies.

In addition to seeking the responsible sourcing of virgin materials, teams are also encouraged to reduce raw material usage by selecting reused and recycled materials. Teams may also follow leadership performance standards and certifications that encourage local sourcing. To recognize the rapidly changing marketplace conditions for product and material reporting, this credit has an additional "USGBC-approved program" criterion designed to recognize any leadership certification programs that may be developed in the future.

By increasing the demand for transparency in mining, quarrying, agriculture, forestry, and other industries, this credit rewards environmental impact reductions that go beyond the individual project and have positive effects on the sources of project materials.

STEP-BY-STEP GUIDANCE

Select which option(s) to pursue. Projects can earn a maximum of 2 points by achieving the requirements for both options, and products may contribute to both options 1 and 2 simultaneously. Early product research can help the project team capitalize on opportunities for products contributing to multiple credits and options.

The required scope of this credit is permanently installed building products and furniture within the project scope of work, excluding mechanical, plumbing, electrical (MEP), and specialty equipment and items purchased for temporary use on the project. However, optional MEP products may be included, provided they are also included in the other two cost-based credits, MR Credit Building Disclosure and Optimization—Environmental Product Declarations and MR Credit Building Disclosure and Optimization—Material Ingredients. For more information see *MR Overview, Qualifying Products and Exclusions*.

- Option 1 Raw Material Source and Extraction Reporting is for projects that have products consisting of materials from manufacturers that have reported sustainable sourcing and extraction methods according to an acceptable framework, as indicated in the credit requirements. Products must be sourced from the minimum number of manufacturers as specified in the credit requirements.
- Option 2 Leadership Extraction Practices is for projects that have products and/or constituent materials that meet at least one of the responsible extraction criteria listed in the credit.

Option 1. Raw Material Source and Extraction Reporting

STEP 1. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify products from manufacturers that can provide reports of raw materials from their suppliers.

- To meet the credit requirements, reports must include information on the following:
  - Raw material supplier extraction locations
  - Commitment to long-term ecologically responsible land use

  - Commitment to reducing environmental harms from extraction and manufacturing processes
  - Commitment to meeting voluntary standards or programs that address responsible sourcing
- The reports may be available in the form of a corporate sustainability report (CSR) (see *Further Explanation, Raw Material Reporting* and *Corporate Sustainability Reports*).
- Include performance requirements or sole-source compliant products as applicable to the selected option(s) in the project specifications. To ensure compliant purchases, consider creating a Division 1, General Requirements, specification for sustainability criteria that meet MR requirements. Reference that section to distinguish it from other sections that cover products and materials.
- Similar products from the same manufacturer can be counted as separate products if they have distinct formulations but not if they are aesthetic variations or reconfigurations (see *MR Overview, Defining a Product)*.
- Research sourcing disclosure reports for contributing products. Third-party verified reports—also called externally assured reports—are counted at full value for credit compliance; self-declared reports are counted at half value. Retain all reports for credit documentation.
- For a material procured directly from a raw material supplier, such as timber from a forest products company or stone from a quarry, verify that any reporting meets the requirements.
- For a product made by a manufacturer that uses raw materials extracted by others, ask the manufacturer or supplier to provide documentation of compliant reporting.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

Track purchasing of products throughout the construction of the project. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- The best source of documentation is the manufacturer or the organization that manages the reporting program. Reports are typically available online, but in some cases it might be necessary to contact a company representative. Documentation may also be available from third-party websites that compile the information of many companies in one place. Use formal correspondence to request CSRs or other documentation indicating that the required information has been disclosed if it is not readily available.
- Continually track substitutions and change orders to ensure that replacement products meet the credit requirements.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE COMPLIANT PRODUCTS AND MATERIALS AND COMPILE DOCUMENTATION

Using the data collected in the tracking tool, calculate the number of compliant products, using Equation 1 (see *Further Explanation, Calculations)*.

- In this option, compliance is based on the number of products, not their cost.
- Collect all sourcing disclosure reports. Retain the reports for all materials that contribute to credit achievement.

Option 2. Leadership Extraction Practices

STEP 1. RESEARCH PRODUCTS

Specify products that meet one or more of the criteria listed in the credit requirements.

- Different components or ingredients in a product may contribute to different credit criteria.
- Each product, component, or ingredient that meets several criteria receives credit for each criterion met. For exceptions see *Further Explanation, Calculating FSC Credit Contributions*.

Review preliminary design concepts and identify opportunities to use and procure biobased, qualified wood as well as salvaged and recycled-content materials and products covered by extended producer responsibility, especially for applications that use either significant quantities of materials or small amounts of high-cost materials.

- The amount of biobased content in a product is determined by the manufacturer according to ASTM Standard D6866. Testing per ASTM Standard D6866 may be necessary to determine the fraction of biobased content if it cannot be determined by other means (see *Further Explanation, Documentation for Wood and Biobased Products*).

- Wood must be certified by the Forest Stewardship Council (FSC) unless it is considered reused, salvaged, or recycled. Look for vendors that hold an FSC chain-of-custody certificate. Material covered by both FSC and the Sustainable Agriculture Standard, such as non-wood forest products and bamboo, may be certified under either FSC or Sustainable Agriculture Network standards (see *Further Explanation, Materials Reuse Considerations*).
- Extended producer responsibility (also known as a closed-loop recycling program and as product take-back) puts a used product back into the production stream (see *Further Explanation, Extended Producer Responsibility*). The program can be sponsored by the product's manufacturer or other service.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction product submittals to ensure that the selected products meet credit requirements. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Continually track substitutions and change orders to ensure that replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance.
- Because these requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE PRODUCT AND MATERIAL COSTS AND COMPILE DOCUMENTATION

Use Equation 2 to determine the total value of compliant products (see *Further Explanation, Calculations*). Compliance is based on products' cost.

- Structure and enclosure materials may not constitute more than 30% of the value of compliant building products. Once the cap on structural material is met, these products can no longer contribute toward the credit but must be included in the denominator of Equation 2.
- Some products may meet multiple criteria or are part of assemblies (see *MR Overview, Determining Material Contributions*).
- Collect documentation. For certification programs, provide documentation for all products.

FURTHER EXPLANATION

CALCULATIONS

EQUATION 1. Number of products with raw material extraction reporting

$$\text{Total \# of products} = \left\{ \text{\# of products with manufacturer declared reports} \times 0.5 \right\} + \left\{ \text{\# of products with 3}^{\text{rd}}\text{ party verified reports} \times 1 \right\}$$

EQUATION 2. Percentage of responsibly sourced products

$$\%\ \text{of materials cost} = \frac{\left\{ \text{applicable product cost}_1 \left(\text{criterion}_1\ \text{valuation factor}\right)\left(\text{location valuation factor}\right) \right\} + \left\{ \text{applicable product cost}_2 \left(\text{criterion}_2\ \text{valuation factor}\right)\left(\text{location valuation factor}\right) \right\} + \dots}{\text{Cost of all permanently installed prodcuts}} \times 100$$

where

Product cost = the cost of the product contributing toward credit (see *MR Overview, Determining Product Cost*).

Criterion valuation factor = multiplier assigned to each sourcing criterion. Criteria are:

- Bio-based nonwood products meeting Sustainable Agriculture Standard, value 1.0, by cost
- Wood products certified to FSC standards, 1.0 value (see *Further Explanation, Calculating FSC Credit Contributions*).
- Reused materials, value 1.0, by cost
- Postconsumer recycled materials, value 1.0, by cost
- Preconsumer recycled materials, value 0.5, by cost
- Location valuation factor = multiplier for the extraction, manufacture, and purchase location (see *MR Overview, Location Valuation Factor*)
- Extended producer responsibility is valued at 50%; that is, the valuation factor is 0.5. Products that are part of an extended producer responsibility program may be counted in their entirety even if only part of the product is recycled.

RAW MATERIAL REPORTING AND CORPORATE SUSTAINABILITY REPORTS

For a product to count toward credit achievement, its report must be current for the product at its time of installation. Reports published within one year of the project's LEED registration date, or reports that cover a period that ends within that year are acceptable.

A compliant report must be issued by either the manufacturer or the raw material supplier and cover at least the criteria listed in the rating system requirements. At least 90% of the contents of each product must be from raw materials covered by a compliant report; no partial credit is allowed for products that do not meet this threshold. Reports obtained directly from raw material suppliers must verify the use of the raw material in products purchased for the project building. A manufacturer's report must trace activities to the source of extraction of the product's raw materials. In either case, acceptable frameworks for raw material reporting include the following:

Global Reporting Initiative (GRI) Sustainability Report

The GRI reporting framework is widely recognized as the most comprehensive. Its corporate sustainability reporting program offers reporting services, a publicly available database of reports, and tracking of required progress. Reports are assigned a score of A, B, or C, reflecting how closely the framework was followed in the report; this letter grade is not an indicator of quality but pertains only to the application.

The reporting framework also supports third-party verification ("external assurance") through a network of approved assurance providers. A plus sign (+) after the score indicates that the report has been externally assured. For a product to count toward credit achievement, the "assurance scope" must cover either the entire report or all sections of the report that directly address raw materials extraction practices. The "level of assurance" for the relevant sections must be "reasonable/high" for the report to be considered third-party verified. If the level is "limited/moderate," the report is not considered third-party verified for the purposes of this credit. The report can still count as a manufacturer-declared report, however, provided it includes all the information specified in the credit requirements.

A report status of "GRI-checked" or "third-party checked" applies only to the application level. These checks are not the same as external assurance and do not qualify the report as third-party verified for the purposes of this credit.

For more details on these report qualifiers, refer to globalreporting.org/resourcelibrary/GRI-Data-Legend-Sustianability-Disclosure-Database-Profiling.pdf. The framework can also be used as a stand-alone guidance document. The current version of the framework is G3.1. The next version, G4, is intended to align better with other reporting programs worldwide.

Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises

These guidelines are a comprehensive corporate social responsibility instrument developed by governments. The recommendations, addressed to multinational enterprises operating in or from adhering countries, set forth voluntary principles and standards for responsible business conduct in such areas as employment and industrial relations, human rights, environment, information disclosure, antibribery practices, consumer interests, science and technology, competition, and taxation. The guidelines are general and not intended to define specific reporting requirements, so it is up to the product's manufacturer to ensure that its report covers the required measures and, if it is third-party verified, that the verification process is truly independent. Project teams should seek a signed letter from the manufacturer on company letterhead attesting to that conformance with the credit requirements.

UN Global Compact: Communication of Progress

The UNGC is a policy framework for the development, implementation, and disclosure of 10 sustainability principles in four core areas: human rights, labor, environment, and anticorruption. The GRI Sustainability Reporting Guidelines can be used to produce the Global Compact's annual Communication on Progress, the mechanism that UNGC uses to demonstrate progress toward its principles. The GRI guidelines provide a structure for reporting and independent verification. See the GRI Sustainability Reports section, above, for details on how to use that format to meet the credit requirements. Project teams should seek a signed letter from the manufacturer on company letterhead attesting to conformance with the credit requirements.

ISO 26000: 2010 Guidance on Social Responsibility

ISO 26000 provides guidance on how businesses and organizations can operate in an ethical and transparent way that contributes to the health and welfare of society. Not a standard to which a company's report can be certified, it helps clarify what social responsibility is, helps businesses and organizations translate principles into effective actions, and shares best practices relating to social responsibility.

To document product compliance with Option 1, provide a publicly available document confirming the manufacturer's third-party-verified corporate sustainability report. Reports are often available on websites, but because web pages can change without notice, project teams are advised to print and retain paper copies.

EXTENDED PRODUCER RESPONSIBILITY

Extended producer responsibility (EPR) is a waste management strategy that promotes integrating the life-cycle environmental costs associated with goods into the market price of the products. EPR is based on the idea that because producers have the greatest control over product design, they also have the ability and responsibility to reduce their products' toxicity and waste.

The Organisation for Economic Co-Operation and Development (OECD) defines extended producer responsibility as an environmental policy approach in which a producer's responsibility for a product is extended to the postconsumer stage of the product's life cycle. An EPR policy (1) shifts responsibility (physically and/or economically, fully or partially) upstream toward the producer and away from municipalities; and (2) creates incentives for producers to take into account environmental considerations when designing their products. There are two basic types of EPR programs:

- **Manufacturer-based programs.** The manufacturer of the product has a take-back or recycling program for the product purchased (Figure 1). Documentation for Option 2 can be a brochure describing the EPR program and including contact information, plus proof that the product purchased for the project is included in the program. Documentation may also be a letter from the manufacturer verifying that an EPR program is in place and that the product purchased for the project is eligible, with contact information.
- **Third-party program.** In some cases a separate business collects material and sells or transports it back to manufacturers. Verifying that the material is in fact recycled is of the utmost importance. Acceptable documentation is a brochure that describes the recycling process and states the average rate of return for the material.

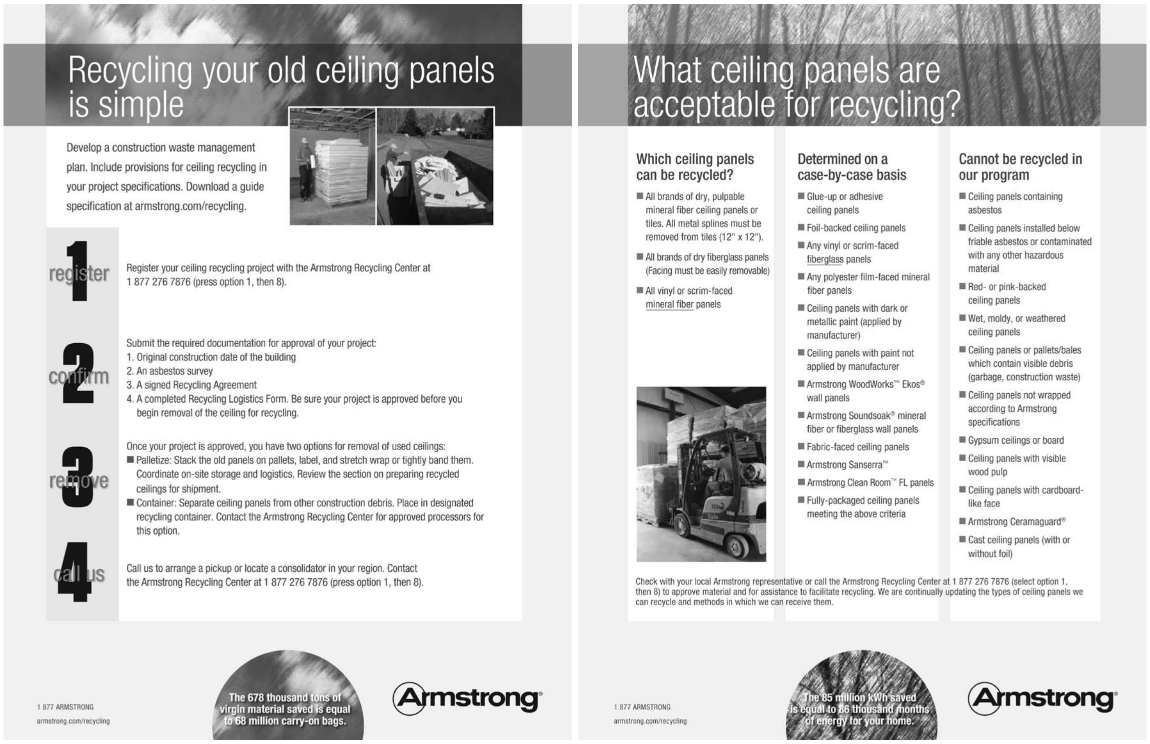


Figure 1. Education pamphlet about extended producer responsibilty from Armstrong for commercial ceiling tiles.

DOCUMENTATION FOR WOOD AND BIO-BASED PRODUCTS

Documentation for Wood

To contribute toward credit achievement, wood products that are not reused, salvaged, or recycled must be certified to the standards of the Forest Stewardship Council. Bamboo, nonwood forest products, and other materials that are not actually wood but are certified by FSC can count toward this credit. Collect vendor invoices for wood products purchased for the project (see *Further Explanation, FSC Chain of Custody*).

Documentation for Biobased materials

Biobased products are defined by ASTM D6866, but testing (by the manufacturer or a contracted party) is not required in all cases. Manufacturers use this test to determine the amount of biobased material in a product. If the percentage of biobased materials, by weight, in the product are known, testing to this standard may not be necessary.

Nonwood products must be grown on farms that meet the Sustainable Agriculture Standard of the Sustainable Agricultural Network (SAN). Products originating on farms that meet the Sustainable Agriculture Standard must adhere to the guidelines and policies of the Rainforest Alliance—including traceability, chain of custody and use of seal—and receive pre-approval from the Rainforest Alliance in order to bear the Rainforest Alliance Certified™ seal. The Rainforest Alliance is a member of SAN and hosts its international secretariat, providing traceability, market linkages, and technical assistance. Several certification bodies in different countries are accredited to conduct Rainforest Alliance certification. A full listing of certified farms and operations can be found on the SAN website, sanstandards.org. A list of Rainforest Certified products can be found at rainforest-alliance.org. To date, nearly all Rainforest Alliance Certified agricultural products are foods, coffee, tea, and cut flowers.

Because the number of Rainforest Alliance–certified crops in building materials is limited, project teams may include products with manufacturer-declared conformance to the Sustainable Agriculture Standard (except bamboo and nonwood forest products that could be FSC certified) under the following three conditions:

- The product's manufacturer provides a signed letter on company letterhead from the raw material supplier attesting that its practices meet the standard.

- The letter includes a link to a publicly available document that specifies how the raw material supplier's practices conform to each paragraph in all 10 sections of the standard and attesting that each "critical criterion" is met.
- Both the letter and the detailed documentation are dated within one year before the date of project registration.

FSC CHAIN OF CUSTODY

Chain-of-Custody (CoC) certification requirements are established by Forest Stewardship Council Chain of Custody Standard 40-004 v2-1. To view this and all FSC standards, see the FSC website, ic.fsc.org, for listings.

Every entity that processes or trades FSC-certified material before it is shipped to the project site must have FSC CoC certification. On-site installers of FSC-certified products must have CoC certification only if they modify the products off the project site.

CALCULATING FSC CREDIT CONTRIBUTIONS

FSC-certified products must be itemized on the vendor's invoice. Their value toward credit contribution is calculated as one of the following, as determined by the FSC claim on the invoice provided by the supplier(terminology in parenthesis is being phased out but may still be in use):

- Products identified as FSC 100% (FSC Pure) contribute 100% FSC content.
- Products identified as FSC Mix Credit (FSC Mixed Credit) contribute 100% FSC content.
- Products identified as FSC Mix [NN]% (FSC Mixed [NN]%) contribute the FSC content percentage indicated. For example, a product identified as "FSC Mix 75%" is valued at 75% of the product's cost (Equation 3).

EQUATION 3. Credit contribution of FSC Mix

$$\text{FSC product value (\$)} = \text{Total product cost (\$)} \times \text{FSC Mix [NN] \%}$$

- Products identified as FSC Recycled Credit contribute 100% postconsumer recycled content.
- Products identified as FSC Recycled [NN] % contribute the percentage postconsumer recycled content percentage indicated [NN].

Multiple Sustainable Claims and FSC

FSC and recycled content. Some products identified as FSC Mix Credit or FSC Mix [NN] % also have pre- or postconsumer recycled content, the latter of which is commonly reported separately by the product manufacturer. In these instances the project team must choose whether to classify the product (or some fraction of the assembly) as FSC certified or as recycled content; the material cannot contribute to both claims simultaneously.

FSC and SAN certified products. Products certified by both FSC and to the Sustainable Agriculture Standard they may receive credit for each criteria.

Documenting FSC Claims

Project teams must document FSC certification for all wood products that contribute to credit achievement. FSC-certified products qualify for credit only when purchased from a vendor with an FSC chain-of-custody certificate that is current at the time of sale. The status of a CoC certification can be verified at info.fsc.org.

Each product shipped to the project site and contributing toward credit must be documented by an invoice from the CoC certificate holder as follows:

- The invoice must have the vendor's CoC certificate code (e.g., RA-COC-001025, SCS-COC-000345, or SGS-COC-002563). The invoice must itemize FSC-certified products and specific FSC claims.
- The invoice may aggregate the value of products, provided the cost of FSC products is isolated from other wood products and the vendor's CoC certificate code is on the invoice.
- The invoice must show the entity being invoiced and indicate the delivery is intended for the LEED project.

An alternative documentation process is available for architectural woodworkers (manufacturers of millwork, casework, and furniture) who supply custom wood products to the project. The purpose of this alternative process is to allow FSC-certified materials used in a custom millwork, casework, or furniture package to contribute toward the credit even if the entire package is not eligible to be invoiced with a FSC claim. Documentation for this alternative process must meet all of the following requirements:

- The woodworker (whether an individual or a company) must be FSC CoC certified, and the CoC certificate number must appear on the project invoice.
- The woodworker must install the custom millwork, casework, or furniture.
- The woodworker's invoice must isolate product costs from installation costs.
- The woodworker must provide a document, separate from the project invoice, detailing FSC-certified wood materials used and total cost of wood materials used. (The woodworker does not need to provide itemized material cost calculations but must maintain calculation records for auditing purposes by the FSC certifying body.)
- The contract cost may include assembly labor but must exclude on-site labor (see *MR Overview, Determining Product Cost*).

The project team should complete a spreadsheet itemizing wood components by cost and identifying FSC-certified and noncertified components to determine overall contributions to the credit, to be entered into the MR calculator. Calculate the FSC-certified contribution value toward the credit by multiplying the percentage of FSC-certified wood by the overall value of the contract. Calculate the percentage of FSC-certified wood by dividing the cost of FSC-certified wood by the total cost of the wood.

Submit the FSC-certified contribution value as well as the total contract amount. Include the woodworker's CoC certificate number, invoice, and itemized costs.

MATERIAL REUSE CONSIDERATIONS

Determine the cost of each material. The cost of reused or reclaimed materials is either the actual cost paid or, the replacement value, whichever is higher.

The replacement value can be determined by pricing a comparable material in the local market; exclude labor and shipping. If a project team receives a discount from a vendor, the replacement value should be the discounted price, not the list value.

If the actual cost of the reused or salvaged material is below the cost of an equivalent new item, use the higher value (actual cost) of the new item. If the cost to reclaim an item found on site is less than the cost of an equivalent new item, use the cost of the new item (or replacement cost).

Generally, opportunities to reuse building materials may be limited. Core materials that may be eligible include salvaged brick, structural timber, railroad ties, stone, and pavers. When considering the reuse of salvaged materials, confirm that they do not contain toxic substances, such as lead or asbestos.

Reused Materials Found On-Site

Components that are retained either in their original function or in a new role are eligible for this credit. For reused materials found on site, the source location distance is zero.

Reused Materials Found Off-Site

Materials obtained off-site qualify as reused if they were previously used in a building or other application. These materials may be purchased as salvaged, like any other project material, or moved from another facility, including facilities used or owned by the LEED project owner.

For salvaged furniture taken from the owner's previous facility or location, demonstrate that these materials were purchased at least two years before the date of project registration. For example, if the owner is moving to a new building, furniture and furnishings relocated to the new site can contribute to this credit because their reuse will eliminate the need for purchasing new furniture and furnishings. Alternatively, furniture that is leased must have been in service for at least two years before being installed in the current project. Document this claim.

Location Valuation Factor for Salvaged or Reused Materials

For reused materials, the source location of extraction or harvest is the location of the materials before their removal to the project site.

For material taken directly from another building, the source location is the building. For items purchased from a building materials salvage store or recycling facility, the source location is the store or facility. In this case, it is not necessary to track material to the original building.

RECYCLED CONTENT

Recycled content claims for products must conform to the definition in ISO 14021–1999, Environmental Labels and Declarations, Self-Declared Environmental Claims (Type II Environmental Labeling).

Many common materials have recycled content because of how they are manufactured; examples are steel, gypsum board, and acoustical ceiling tile. Design and construction teams may need to research which materials contain high levels of recycled content or verify which factories and which models of a product line feature the desired recycled content. Average recycled content claims given in a range are not acceptable for the purposes of this criterion.

Although it is a good practice, reusing materials reclaimed from the same process in which they were generated does not contribute toward the recycled content of the material. Putting waste back into the same manufacturing process from which it came is not considered recycling because it was not diverted from the waste stream.

Reuse of materials includes rework, regrind, or scrap product (ISO 14021); these count as preconsumer recycled only if they are used in a different product than the one whose production generated the waste. For example, glass culls that are reused to make new glass products do not count, but planer shavings, plytrim, sawdust, chips, bagasse, and sunflower seed hulls are considered preconsumer recycled content when used to make new products. .

Distinguish between postconsumer and preconsumer recycled content when tracking materials for the purpose of credit calculations. To calculate the percentage of recycled-content materials used in a project, list all recycled-content materials and products and their costs. For each product, identify the percentage of postconsumer and/or preconsumer recycled content by weight, and list the recycled content information source. The information must come from a reliable, verifiable source, such as the product's manufacturer.

Postconsumer Recycled Content

Postconsumer recycled content is consumer waste, much of which comes from residential curbside recycling programs for aluminum, glass, plastic, and paper. Other postconsumer feedstock is generated when construction and demolition debris is recycled. To be a feedstock, the raw materials must have served a useful purpose in the consumer market before being used again.

Preconsumer Recycled Content

Preconsumer recycled content comes from process waste that is used to make a different product. For instance, a composite board manufacturer may use sawdust from a lumber mill or waste straw from a wheat farm. This definition does not include in-house industrial scrap or trimmings, which are normally fed back into the same manufacturing process.

The end product must be considered when determining whether a waste product is preconsumer or postconsumer. For example, a power plant's end product is electricity, so waste products from the combustion of coal may be considered preconsumer waste but not postconsumer; the power plant is not an end-use consumer of the coal.

Default Recycled Content

For steel products where no recycled content information is available, assume the recycled content to be 25% postconsumer. No other material is known to have a similarly consistent minimum recycled content.

Many steel products contain 90% or higher recycled content if manufactured by the electric arc furnace process, so it may be beneficial to obtain actual information from the manufacturer rather than relying on the default value.

Average Recycled Content

Recycled content claims must be specific to the installed product. Installed product refers to a item distinguished by color, type, and/or location of manufacture, as identified to the consumer by SKU or other means.

Project teams may use the average recycled content value provided by a single manufacturer for a single product. Recycled content claims for custom products must be product specific; industry-wide or national averages are not acceptable. In all cases, if recycled content is given as a range, use the lowest recycled-content percentage.

EXAMPLES

Option 2 Example Calculation: MDF Panel with FSC-Certified Veneer

A project is installing $10,000 worth of veneer paneling. The MDF core is 90% of the product by weight, of which 80% is preconsumer waste wood that meets the ISO 14021 requirement. The veneer is 10% of the product by weight and FSC certified. The MDF is extracted, manufactured, and purchased within 100 miles (160 km); the veneer is imported.

TABLE 1. Sample calculation for product assembly meeting sustainable criteria

Component	Percentage of product by weight	Value of component	Sustainable criteria		Location valuation factor?	Sustainable criteria value
			Percentage of component	Requirement		
MDF core	90%	$9,000	80%	Preconsumer recycled content	Yes	$14,400
Veneer	10%	$1,000	100%	FSC certified	No	$1,000
Total sustainable criteria value						**$15,400**

Option 2 Example Calculation: Salvaged Doors

A project team purchases 50 doors salvaged from a local deconstruction site and sold through a local Habitat for Humanity ReStore for $500. The value of equivalent new doors is documented at $400 each, or $20,000. Their contribution to the credit is as follows:

$20,00 × 1.0 criterion valuation × 2.0 location valuation = $40,000

($40,000 / $800,000) × 100 = 5%

CAMPUS

Group Approach

All project spaces in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
MR building product disclosure and optimization calculator or equivalent tracking tool	X	X
Corporate sustainability reports for 100% of products contributing toward credit	X	
Documentation of product claims for credit requirements or other USGBC approved program		X

RELATED CREDIT TIPS

MR Credit Interiors Life-Cycle Impact Reduction, Option 1. Reused, salvaged, and refurbished floors, walls, and ceilings may contribute to either this credit (on the basis of cost) or the related credit (on the basis of surface area) but may not be double-counted.

MR Credit Interiors Life-Cycle Impact Reduction, Option 2. Reused, salvaged, and refurbished furniture that contributes to the related option may be double-counted under this credit but must be included consistently across all Building Product Disclosure and Optimization credits.

MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations. Products may be double-counted if they meet the requirements of both credits.

MR Credit Building Product Disclosure and Optimization—Material Ingredients. Products may be double-counted if they meet the requirements of both credits.

CHANGES FROM LEED 2009

Multiple criteria from the following LEED 2009 credits have been combined into this credit. Except as noted, the criteria are unchanged from LEED 2009. Other criteria are now incorporated into other MR credits, such as Interiors Life-Cycle Impact Reduction and Building Product Disclosure and Optimization—Environmental Product Declarations (see *Related Credit Tips*).

- **MR Credit Resource Reuse.** Materials that are reused on-site are no longer required to be repurposed.
- **MR Credit Recycled Content.** The requirements for recycled content have not changed; however, this criterion is now combined with other criteria in a single option.
- **MR Credit Regional Materials.** The 500-mile (805-km) radius requirement was decreased to 100 miles (160 km). The definition of *regional* has been expanded to include the distribution and purchase location and now includes all points of manufacture.
- **MR Credit Rapidly Renewable Materials.** Biobased materials are no longer defined by the harvest cycle of the raw materials; instead, products must meet the Sustainable Agriculture Standard to count toward this credit.

REFERENCED STANDARDS

Global Reporting Initiative (GRI) Sustainability Report: globalreporting.org/Pages/default.aspx

Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises: oecd.org/daf/internationalinvestment/guidelinesformultinationalenterprises/

U.N. Global Compact, Communication of Progress: unglobalcompact.org/cop/index.html

ISO 26000—2010 Guidance on Social Responsibility: iso.org/iso/home/standards/iso26000.htm

Forest Stewardship Council: ic.fsc.org

Sustainable Agriculture Network: www.sanstandards.org

The Rainforest Alliance: rainforest-alliance.org/

ASTM Test Method D6866: astm.org/Standards/D6866.htm

International Standards ISO 14021–1999, Environmental Labels and Declarations—Self Declared Environmental Claims (Type II Environmental Labeling): iso.org/iso/catalogue_detail.htm?csnumber=23146

EXEMPLARY PERFORMANCE

Option 1. Source at least 40 products from five manufacturers.

Option 2. Purchase 50%, by cost, of the total value of permanently installed building products that meet the responsible extraction criteria.

DEFINITIONS

bio-based material commercial or industrial products (other than food or feed) that are composed in whole, or in significant part, of biological products, renewable agricultural materials (including plant, animal, and marine materials), or forestry materials. For the purposes of LEED, this excludes leather and other animal hides.

chain of custody (**CoC**) a procedure that tracks a product from the point of harvest or extraction to its end use, including all successive stages of processing, transformation, manufacturing, and distribution

enclosure the exterior plus semi-exterior portions of the building. Exterior consists of the elements of a building that separate conditioned spaces from the outside (i.e., the wall assembly). Semiexterior consists of the elements of a building that separate conditioned space from unconditioned space or that encloses semi-heated space through which thermal energy may be transferred to or from the exterior or conditioned or unconditioned spaces (e.g., attic, crawl space, basement).

extended producer responsibility measures undertaken by the maker of a product to accept its own and sometimes other manufacturers' products as postconsumer waste at the end of the products' useful life. Producers recover and recycle the materials for use in new products of the same type. To count toward credit compliance, a program must be widely available. For carpet, extended producer responsibility must be consistent with NSF/ANSI 140–2007. Also known as closed-loop program or product take-back.

furniture and furnishings the stand-alone furniture items purchased for the project, including individual and group seating; open-plan and private-office workstations; desks and tables; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted visual-display products (e.g., marker boards and tack boards, excluding electronic displays); and miscellaneous items, such as easels, mobile carts, freestanding screens, installed fabrics, and movable partitions. Hospitality furniture is included as applicable to the project. Office accessories, such as desktop blotters, trays, tape dispensers, waste baskets, and all electrical items, such as lighting and small appliances, are excluded.

postconsumer recycled content waste generated by households or commercial, industrial and institutional facilities in their role as end users of a product that can no longer be used for its intended purpose

preconsumer recycled content matter diverted from the waste stream during the manufacturing process, determined as the percentage of material, by weight. Examples include planer shavings, sawdust, bagasse, walnut shells, culls, trimmed materials, overissue publications, and obsolete inventories. The designation excludes rework, regrind, or scrap materials capable of being reclaimed within the same process that generated them (ISO 14021). Formerly known as postindustrial content.

raw material the basic substance from which products are made, such as concrete, glass, gypsum, masonry, metals, recycled materials (e.g., plastics and metals), oil (petroleum polylactic acid), stone, agrifiber, bamboo, and wood

recycled content defined in accordance with the International Organization of Standards document ISO 14021, Environmental labels and declarations, Self-declared environmental claims (Type II environmental labeling)

reuse the reemployment of materials in the same or a related capacity as their original application, thus extending the lifetime of materials that would otherwise be discarded. Reuse includes the recovery and reemployment of materials recovered from existing building or construction sites. Also known as salvage.

structure elements carrying either vertical or horizontal loads (e.g., walls, roofs, and floors) that are considered structurally sound and nonhazardous

wood plant-based materials that are eligible for certification under the Forest Stewardship Council. Examples include bamboo and palm (monocots) as well as hardwoods (angiosperms) and softwoods (gymnosperms)

MATERIALS AND RESOURCES CREDIT

Building Product Disclosure and Optimization—Material Ingredients

This credit applies to:

Commercial Interiors (1-2 points)
Retail (1-2 points)
Hospitality (1-2 points)

INTENT

To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts. To reward project teams for selecting products for which the chemical ingredients in the product are inventoried using an accepted methodology and for selecting products verified to minimize the use and generation of harmful substances. To reward raw material manufacturers who produce products verified to have improved life-cycle impacts.

REQUIREMENTS

OPTION 1. MATERIAL INGREDIENT REPORTING (1 POINT)

Use at least 20 different permanently installed products from at least five different manufacturers that use any of the following programs to demonstrate the chemical inventory of the product to at least 0.1% (1000 ppm).

- **Manufacturer Inventory.** The manufacturer has published complete content inventory for the product following these guidelines:
  - A publicly available inventory of all ingredients identified by name and Chemical Abstract Service Registration Number (CASRN)

   - Materials defined as trade secret or intellectual property may withhold the name and/or CASRN but must disclose role, amount and GreenScreen benchmark, as defined in GreenScreen v1.2.
- **Health Product Declaration.** The end use product has a published, complete Health Product Declaration with full disclosure of known hazards in compliance with the Health Product Declaration open Standard.
- **Cradle to Cradle.** The end use product has been certified at the Cradle to Cradle v2 Basic level or Cradle to Cradle v3 Bronze level.
- **USGBC approved program.** Other USGBC approved programs meeting the material ingredient reporting criteria.

AND/OR

OPTION 2. MATERIAL INGREDIENT OPTIMIZATION (1 POINT)

Use products that document their material ingredient optimization using the paths below for at least 25%, by cost, of the total value of permanently installed products in the project.

- **GreenScreen v1.2 Benchmark.** Products that have fully inventoried chemical ingredients to 100 ppm that have no Benchmark 1 hazards:
   - If any ingredients are assessed with the GreenScreen List Translator, value these products at 100% of cost.
   - If all ingredients are have undergone a full GreenScreen Assessment, value these products at 150% of cost.
- **Cradle to Cradle Certified.** End use products are certified Cradle to Cradle. Products will be valued as follows:
   - Cradle to Cradle v2 Gold: 100% of cost
   - Cradle to Cradle v2 Platinum: 150% of cost
   - Cradle to Cradle v3 Silver: 100% of cost
   - Cradle to Cradle v3 Gold or Platinum: 150% of cost
- **International Alternative Compliance Path – REACH Optimization.** End use products and materials that do not contain substances that meet REACH criteria for substances of very high concern. If the product contains no ingredients listed on the REACH Authorization or Candidate list, value at 100% of cost.
- **USGBC approved program.** Products that comply with USGGBC approved building product optimization criteria.

AND/OR

OPTION 3. PRODUCT MANUFACTURER SUPPLY CHAIN OPTIMIZATION (1 POINT)

Use building products for at least 25%, by cost, of the total value of permanently installed products in the project that:

- Are sourced from product manufacturers who engage in validated and robust safety, health, hazard, and risk programs which at a minimum document at least 99% (by weight) of the ingredients used to make the building product or building material, and
- Are sourced from product manufacturers with independent third party verification of their supply chain that at a minimum verifies:
   - Processes are in place to communicate and transparently prioritize chemical ingredients along the supply chain according to available hazard, exposure and use information to identify those that require more detailed evaluation
   - Processes are in place to identify, document, and communicate information on health, safety and environmental characteristics of chemical ingredients
   - Processes are in place to implement measures to manage the health, safety and environmental hazard and risk of chemical ingredients
   - Processes are in place to optimize health, safety and environmental impacts when designing and improving chemical ingredients
   - Processes are in place to communicate, receive and evaluate chemical ingredient safety and stewardship information along the supply chain

- Safety and stewardship information about the chemical ingredients is publicly available from all points along the supply chain

Products meeting Option 3 criteria are valued at 100% of their cost for the purposes of credit achievement calculation.

For credit achievement calculation of options 2 and 3, products sourced (extracted, manufactured, purchased) within 100 miles (160 km) of the project site are valued at 200% of their base contributing cost. For credit achievement calculation, the value of individual products compliant with either option 2 or 3 can be combined to reach the 25% threshold but products compliant with both option 2 and 3 may only be counted once.

Structure and enclosure materials may not constitute more than 30% of the value of compliant building products.

FOR ALL OPTIONS

Meet the requirements of the credit above and include furniture and furnishings within the project's scope of work.

BEHIND THE INTENT

The occupants of an average office building, school, or retail store have little knowledge of the building products that surround them every day. Often, not even those who specify the materials have enough information on which to base their own selection criteria, given that disclosure data are hard to acquire. Despite the regulatory safeguards for some toxic chemicals, 96% of the roughly 85,000 chemicals on the U.S. market have never been screened for possible health effects.[1]

Persistent bioaccumulative and toxic chemicals (PBTs) and persistent organic pollutants (POPs) are often found in building products and materials. PBTs linger in the environment, accumulate in organisms high on the food chain (including humans), and can cause harm even in very small doses. PBTs released during the manufacture, use, or disposal of a product can threaten the health of plants and animals many miles away. Even less is known about which chemicals are potential carcinogens, mutagens, neurotoxicants, or developmental toxicants.

By adhering to the precautionary principle and supporting green chemistry, this credit encourages project teams to avoid products containing potentially harmful chemicals, which will ultimately spur innovation in materials from manufacturers. The precautionary principle states, "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[2] Green Chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.[3] Companies practicing green chemistry research are developing safer alternatives to priority chemicals so that one day there will be "green lists" instead of "red lists." Such companies are also developing corporate policies that include the precautionary principle, establish credible monitoring and assurance programs, and strengthen relationships with suppliers.[4]

This credit aims to support manufacturers that disclose information about the ingredients in their products, allowing project teams to make better-informed decisions. The programs described below use hazard assessment approaches that evaluate multiple human and environmental health endpoints at a level of detail that goes beyond the scope of most life-cycle assessments. Project teams may demonstrate responsible product selection by providing manufacturers' reports or by ensuring the absence of materials of concern, using specified programs.

STEP-BY-STEP GUIDANCE

Select which option(s) to pursue. Projects can earn a maximum of 2 points by achieving the requirements for two options, and products may contribute to Options 1 and 2. A project that cannot achieve Option 1 is not precluded from achieving Option 2 and vice versa. For Option 3 Product Manufacturer Supply Chain Optimization, check USGBC's website for updates on how to achieve compliance (see *MR Overview, Qualifying Products and Exclusions*).

- Option 1 Material Ingredient Reporting is for projects that have at least 20 permanently installed products consisting of materials from manufacturers that have disclosed their ingredient inventory in one of the listed formats, as indicated in the credit requirements. Products must be sourced from at least five manufacturers.
- Option 2. Material Ingredient Optimization is for projects with 25% permanently installed products, by cost, that meet at least one of the material ingredient optimization paths listed in the credit requirements.

1. *epa.gov/osw/nonhaz/municipal/pubs/msw2009rpt.pdf* (accessed July 3, 2013).
2. *Report of the United Nations Conference on Environment and Development; http:/www.un.org/documents/ga/conf151/aconf15126-1annex1.htm* (accessed May 29, 2013)
3. *Anastas and Warner, Green Chemistry: Theory and Practice* (New York: Oxford University Press, 2000).
4. *Healthy Business Strategies for Transforming the Toxic Chemical Economy, Clean Production Action* (June 2006), *cleanproduction.org/library/CPA-HealthyBusiness-1.pdf* (accessed May 29, 2013).

Option 1. Material Ingredient Reporting

STEP 1. ASSESS OPTION FEASIBILITY

Research at an early phase can help the project team identify products that contribute to multiple credits and options. Review the approved programs and assess the feasibility of finding enough products that meet project requirements (see *Further Explanation, Material Ingredient Reporting*).

- Some of these programs are new and have documented or certified only a few products in a way that complies with the requirements.
- The Cradle to Cradle Products Innovation Institute publishes a searchable registry of certified products.
- Products can comply under different programs; it is not necessary to find 20 products that all comply using the same path.

STEP 2. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify at least 20 products, from at least five different manufacturers (see *MR Overview, Qualifying Products and Exclusions*).

- All ingredients in the end product must be characterized through a USGBC-approved program.
- Similar products from the same manufacturer can be counted as separate products if they have distinct formulations, but not if they are just aesthetic variations or reconfigurations.

STEP 3. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction submittals to ensure that the selected products meet credit requirements. To review progress toward credit achievement, regularly enter the information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Continually track substitutions and change orders to ensure replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance.
- Because these requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 4. COUNT COMPLIANT PRODUCTS AND COMPILE DOCUMENTATION

Using the data collected in the tracking tool, tally the number of products that comply with Option 1 requirements. Collect all ingredient disclosure reports for contributing products for credit documentation.

- Documentation availability varies by reporting program.
- Retain product data for all materials that contribute to credit achievement and be prepared to provide the information on request.
- The best source of documentation is the manufacturer or the organization that manages the reporting program. Reports are typically available online, but in some cases it might be necessary to contact a company representative.
- Documentation may also be available from third-party websites that collect the information of many companies.

Option 2. Material Ingredient Optimization

STEP 1. SPECIFY AND SELECT COMPLIANT PRODUCTS

Specify products meeting one or more of the criteria listed in the credit requirements. Note that this option evaluates complete products; therefore, the criteria for assemblies found in other MR credits do not apply to this option.

STEP 2. TRACK PURCHASES THROUGHOUT CONSTRUCTION

During construction, coordinate a review of the construction submittals to ensure selected products meet credit requirements. To review progress toward credit achievement, regularly enter information into the MR building product disclosure and optimization calculator provided by USGBC or an equivalent custom tool.

- Continually track substitutions and change orders to ensure that replacement products meet the credit requirements. Any product substitutions should be carefully reviewed by the design team and contractor for compliance.
- Because these credit requirements are not typical for all construction teams and suppliers, conduct a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance.
- Check in periodically with team members (particularly owners, architects, interior designers, contractors, subcontractors, and suppliers) to verify progress toward credit achievement and address any gaps in credit compliance.

STEP 3. CALCULATE PRODUCT AND MATERIAL COSTS AND COMPILE DOCUMENTATION

Using Equation 1, determine the total value of compliant products (see *Further Explanation, Calculations*). This option calculates compliance based on product cost.

Collect relevant documentation:

- For regional and local claims, provide a representative sample of documentation.
- For certification programs, provide documentation for all products.

FURTHER EXPLANATION

CALCULATIONS

Use the following equation for Option 2 Material Ingredient Optimization (see *Further Explanation, Material Ingredient Optimization*).

EQUATION 1. Percentage of compliant materials' cost

$$\%\ \text{of materials cost} = \frac{\left\{ \text{product}_1\ \text{cost} \left(\text{program valuation factor}\right)\left(\text{location valuation factor}\right)\right\} + \left\{ \text{product}_2\ \text{cost} \left(\text{program valuation factor}\right)\left(\text{location valuation factor}\right)\right\} + \ldots}{\text{Cost of all permanently installed prodcuts}} \times 100$$

where

Product cost = price charged to the project owner for the product. Each product can be counted only once, even if it meets the requirements of multiple programs.

Program valuation factor = multiplier assigned to each compliance program:

- GreenScreen version 1.2 benchmark. Products that have fully inventoried chemical ingredients to 100 ppm:
  - Any ingredients assessed Benchmark U ("unspecified") and/or no ingredients with Benchmark 1 hazards, as defined by the GreenScreen List Translator, 100% value (by cost)
  - All ingredients fully assessed by GreenScreen and no ingredients with Benchmark 1 hazards, 150% value (by cost)
- Cradle to Cradle Certified version 2.1.1:
  - Gold, 100% value (by cost)
  - Platinum, 150% value (by cost)

- Cradle to Cradle Certified version 3.0:
  - Silver, 100% value (by cost)
  - Gold or Platinum, 150% value (by cost)
- REACH Optimization. This is an alternative compliance path for projects outside the U.S. If the product contains no ingredients listed on the REACH authorization or candidate list, value it at 100% of cost.

Location valuation factor = multiplier for the extraction, manufacture, and purchase location (see *MR Overview, Location Valuation Factor*).

MATERIAL INGREDIENT REPORTING

Under Option 1, products can be documented as compliant and thus contribute to credit achievement in any of three ways (Table 1).

TABLE 1. Manufacturers' documentation for compliant products

Program	What has to be reported?	To whom?	Based on what framework?
Manufacturer's inventory	All ingredients down to 0.1%; any not named must have risks listed	Public	Health risks based on GreenScreen Benchmark 1
Health Product Declaration	All ingredients down to 0.1% and full disclosure of health hazards from ingredients; some ingredients can remain unnamed but health hazards must still be reported	Public	Health risks based on HPD authoritative lists (closely match GreenScreen List Translator)
Cradle to Cradle	All ingredients down to 0.01%, with some banned substances	Independent, accredited assessors (some data protected under nondisclosure agreement between the assessor and suppliers); data not disclosed under NDA may be made public at manufacturer's discretion	Version 2.1.1: proprietary screening Version 3.0: Material Health Assessment Methodology (includes hazard screening and risk assessment)

Manufacturer's Inventory

Manufacturers may publicly disclose all ingredients by name and Chemical Abstract Service (CAS) registry number. No third-party verification is required for this option, but the information must be publicly available; direct disclosure to the designer or contractor is not acceptable.

If a specific ingredient cannot be disclosed for proprietary reasons, the manufacturer may withhold the name and CAS registry number but still provide the following information:

- Role or function in the product
- Amount, as a percentage of total product content or ppm
- Any potential health hazards associated with the ingredient as defined in authoritative hazard lists from GreenScreen

All ingredients that constitute 0.1% (1,000 ppm) or more of the product must be accounted for. This threshold is 10 times lower than the typical 1% minimum threshold for reporting on a material safety data sheet (MSDS).

Health Product Declaration version 1.0

Disclosure is done through Health Product Declaration (HPD), which is an open standard for reporting product ingredients and their associated health hazards. Manufacturers that use HPDs must provide the nonproprietary information listed above (role or function, amount, and health hazards) for every ingredient, not just those whose names have been withheld. The manufacturer affirms "Full disclosure of known hazards" on the front summary page and further affirms the level of disclosure with the check box under "Residuals disclosure." For the material to comply with the credit requirements, the HPD standards for the 1,000-ppm level must be attained and the appropriate box on the summary page checked.

An HPD is several pages long, with a one-page summary listing company information, metadata about the report, and ingredients, and continuing on subsequent pages with more detail about individual ingredients and their associated health hazards, plus details on any certifications and associated materials. GreenScreen Benchmarks, if any, are listed for each ingredient in HPDs, in the contents section. A report from a certified GreenScreen profiler may also be used to document the GreenScreen benchmarks for a product's ingredients.

Manufacturers that use the standard HPD format reduce uncertainty about whether the information that they have provided meets the credit requirements, and they create a report that should be useful in other settings as well.

Cradle to Cradle Certified, version 2.1.1 and version 3.0
Project teams may also select Cradle to Cradle Certified (C2C) products. C2C requires that ingredients be disclosed to an independent, accredited C2C assessor. The percent of the product defined and assessed impacts the level of certification. Products certified under v2.1.1, have had at least 95% by weight of their materials assessed at any level and 100% of their materials assessed at the Gold and Platinum levels. Products certified under v3.0, have had at least 75% or 95% by weight of their materials assessed at the Bronze and Silver levels respectively, and 100% of their materials at the Gold and Platinum levels. Eligible products will have their scorecard available in the C2C product registry. The product scorecard shows the level of achievement for all five standard attributes, the overall certification level for the product (Basic, Bronze, Silver, Gold, or Platinum), the certificate expiration date, and the version of the standard that the product is certified against. For each certified product the registry includes an image of the product, the product description and certification level, and the expiration date of the current certification. Product certification claims from manufacturers' websites should always be verified against this registry because they may be out-of-date (see *Further Explanation, Example, Cradle to Cradle (C2C) certification*). During the material health assessment, assessors review the scientific literature available for all chemical ingredients contained in a material above 100 ppm, use structure activity relationship models and chemical analog data to fill data gaps, and compare the collected information against the C2C hazard criteria. Through this process, the environmental and human health hazards of the chemical ingredients are classified using a green–yellow–red rating system. In a second step, assessors evaluate whether exposure to any of the identified or suspected hazardous chemicals are plausible in the context of the materials containing these chemicals and the product use and end of life scenarios. If avenues for exposure to these chemicals in a material exist, the material will receive an overall risk assessment rating of 'x'. Gold and Platinum certified products do not contain any x-assessed materials. Products certified at the Silver level under v3.0 do not contain materials that have been x-assessed due to the presence of a carcinogen, mutagen, or reproductive toxicant (CMR). Products certified at any level under v3.0 do not contain banned list chemicals. Chemicals on the v3.0 banned lists include PVC and related compounds, certain flame retardants, PFOS and PFOA, certain phthalates, halogenated hydrocarbons and toxic heavy metals. C2C certification addresses a total of five product attributes and ingredient screening is just one part of the program.

Other USGBC-approved programs
As the industry evolves, additional programs and protocols for reporting on material ingredients are likely to emerge. USGBC will determine whether any new programs are acceptable and issue rating system addenda to include them as additional approaches to earning the credit.

MATERIAL INGREDIENT OPTIMIZATION

Under Option 2, GreenScreen (a program of Clean Production Action), Cradle to Cradle Certified, and the European Union's REACH program (for projects outside the U.S.) can be used as frameworks for documenting the substitution of potentially problematic substances.

Option 2 goes beyond Option 1's reporting requirement and encourages the use of products that are made without problematic ingredients. It offers these four approaches:

- No GreenScreen Benchmark 1 materials (see the following section)
- Cradle to Cradle certified gold or platinum certification (see above, under *Material Ingredient Reporting*)
- REACH (see *Further Explanation, International Tips*)
- Other programs that may be approved by USGBC in the future

GreenScreen Benchmark 1
The GreenScreen hazard assessment method evaluates individual chemicals. GreenScreen version 1.2 is based on a toxicological assessment that starts with a collection of authoritative lists of "chemicals of concern" published by governmental and nongovernmental organizations (GreenScreen List Translator). These substances are known to be associated with certain health problems. The assessment then proceeds to reviews of the scientific literature, use of structure activity relationship models and chemical analog data to fill data gaps (Full GreenScreen). Chemicals are assigned to one of four main categories: those of highest concern, as indicated in the authoritative lists, are assigned

Benchmark 1. Chemicals that are not on the major authoritative lists and pass a toxicological review based on Clean Production Action's protocols can be assigned benchmarks that indicate lower levels of concern; Benchmark 4 is the lowest level of concern. A full GreenScreen assessment overrides the results of a screening using the GreenScreen List Translator only.

The GreenScreen List Translator has been automated by two software providers. It can be accessed through the Chemical and Material Library found in Healthy Building Network's Pharos Tool and in the GS List Translator module in the GreenWERCS software tool by The Wercs. The Interstate Chemicals Clearinghouse has created a website where GreenScreen assessments can be posted by various participating State governments and shared with no costs or restrictions.

Option 1 of this credit requires only the GreenScreen List Translator review of ingredients to ensure that none of the ingredients are on the authoritative lists and thus flagged as Benchmark 1 substances. Project teams should look for documentation from manufacturers that either identifies all ingredients in the product or identifies and characterizes any benchmark hazards.

Option 2 requires the Full GreenScreen toxicological assessment to ensure that none of the ingredients are Benchmark 1. Project teams should look for documentation from manufacturers that shows each ingredient in the product has been subject to a full GreenScreen assessment by a licensed GreenScreen Profiler and that the product contains only Benchmark 2 and higher ingredients.

For Manufacturers and Suppliers

GreenScreen's List Translator assigns hazard classifications based on the various governmental and authoritative hazard lists including lists of chemicals classified using the Globally Harmonized System of Classification and Labeling. The GreenScreen List Translator can be used to identify chemicals that achieve or may achieve the Benchmark 1 level of concern. Under Option 1, manufacturers that keep certain ingredients proprietary must characterize any health hazards from those ingredients, as indicated by the List Translator or a full GreenScreen assessment.

Under Option 2, the manufacturer must warrant that no ingredients in the product at levels of 0.01% or more (100 ppm) are designated as Benchmark 1 chemicals based on the referenced lists defined by the List Translator. These products achieve compliance at the first level of the option.

The second level of compliance requires that all ingredients be Benchmark 2 or higher. There is no definitive List Translator for Benchmark 2, so manufacturers must engage an independent third party to screen all their ingredients, using the screening protocol defined by GreenScreen, and certify that none of them are Benchmark 1.

EXAMPLES

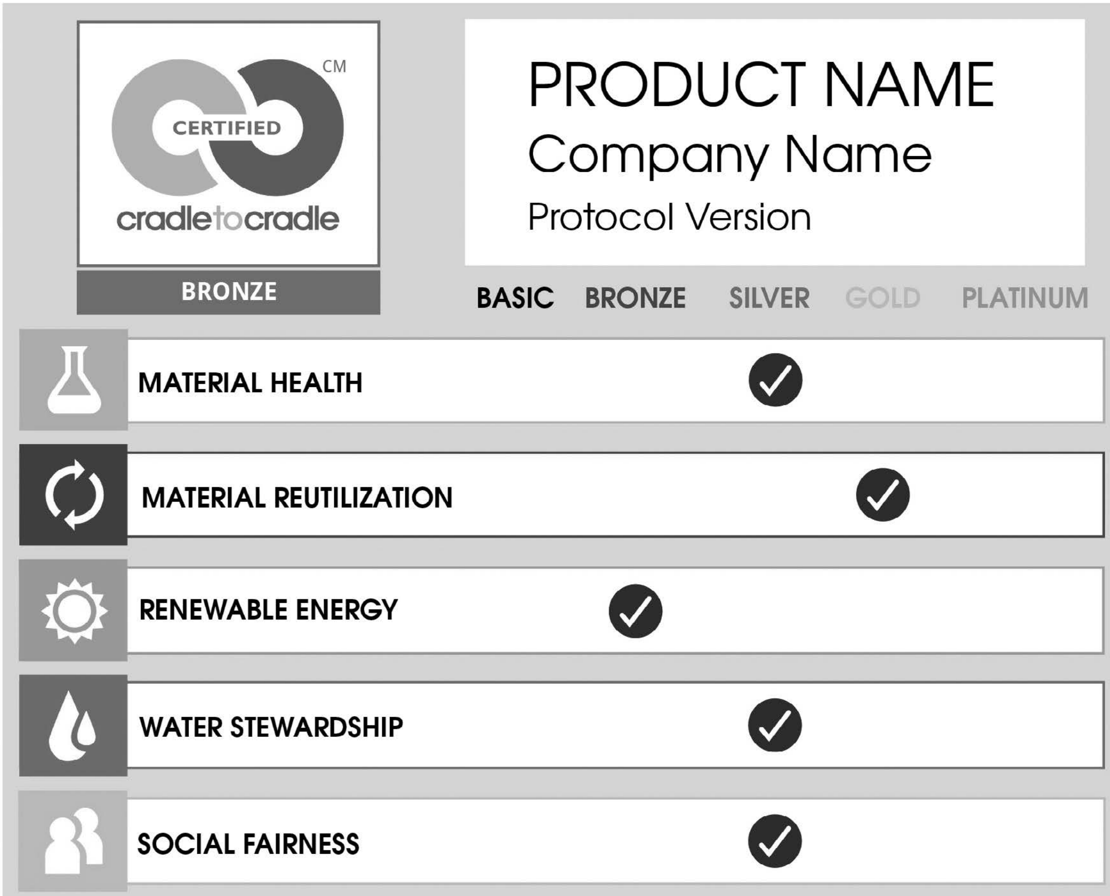


Figure 1. Cradle to Cradle (C2C) certification

Example GreenScreen List Translator Result

The GreenScreen List Translator, version 1.2, identifies each list that GreenScreen references, including its source, which hazards in the GreenScreen it covers, whether it is "authoritative" or "screening," and which GreenScreen hazard level and subsequent Benchmark score applies, along with other data.

TABLE 2. GreenScreen List Translator Result. Used with permission from Clean Production Action.

ID	List	List category	Green screen hazard	List type	A or B	Hazard range	Display iii hazard box (see notes)	Benchmark score
154	IARC	Group 2A: Agent is probably carcinogenic to humans	Carcinogenicity	Authoritative	A	H	H	1
158	MAK	Carcinogenic Group 1	Carcinogenicity	Authoritative	A	H	H	1
159	MAK	Carcinogenic Group 2	Carcinogenicity	Authoritative	A	H	H	1
174	NIOSH-C	Occupational Cancer	Carcinogenicity	Authoritative	A	H	H	1
175	NTP-OHAaT	Clear Evidence of Adverse Effects - Developmental Toxicity	Developmental Toxicity	Authoritative	A	H	H	1

INTERNATIONAL TIPS

Alternative Compliance Path for International Projects: Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

The European Union's REACH legislation requires all chemicals sold in quantity in the EU to be registered in a central database and prioritized for evaluation and possible avoidance based on their hazard profile. The program maintains several lists of "Substances of Very High Concern."

Products can contribute to Option 2 under this credit if they come with clear documentation from the supplier that they do not contain any substances on the "Authorization List" (chemicals that can only be used with special authorization) nor on the "Candidate List" (chemicals being considered for the Authorization List). Because these lists can change over time, the supplier documentation must be dated; if a substance in the product was added to one of these lists after that documentation was produced and after the project's registration date, the product is still considered compliant. Projects in the U.S. may also use this alternative compliance path.

- Authorization List: echa.europa.eu/web/guest/addressing-chemicals-of-concern/authorisation/recommendation-for-inclusion-in-the-authorisation-list/authorisation-list
- Candidate List: echa.europa.eu/web/guest/candidate-list-table

REACH also provides for a "Restriction List" of chemicals that are to be banned from production and use, but as of August 2013 no substances had made it onto that list. Any substances that are moved from the Authorization List and Candidate List to the Restriction List continue to be treated as substances to be avoided in Option 2-compliant products.

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2	Option 3
MR building product disclosure and optimization calculator or equivalent tracking tool	X	X	
Documentation of chemical inventory through Health Product Declaration, Cradle to Cradle certification labels, manufacturers' lists of ingredients, with GreenScreen assessment reports for confidential ingredients, or USGBC-approved programs (if applicable)	X		
Verification of ingredient optimization through Cradle to Cradle certification labels, manufacturers' lists of ingredients with GreenScreen benchmarks listed for all ingredients, or manufacturers' declaration (for REACH), or USGBC-approved programs (if applicable)		X	
Documentation of supply chain optimization			X

RELATED CREDIT TIPS

MR Credit Interiors Life-Cycle Impact Reduction. This credit requires more detailed ingredient information than is typically used in a building life-cycle assessment study.

MR Credit Building Product Disclosure and Optimization—Environmental Product Declarations. This credit is structured similarly to the related credit, but because it requires more detailed ingredient information than typically used for an environmental product declaration, it reveals different information about the products.

MR Credit Building Product Disclosure and Optimization—Sourcing of Raw Materials. This credit is structured similarly to the related credit and uses the same calculation methodology.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

Chemical Abstracts Service: cas.org/about-cas

Health Product Declaration: hpdcollaborative.org

Cradle-to-Cradle Certified℠ Product Standard: c2ccertified.org/product_certification

Registration, Evaluation, Authorisation and Restriction of Chemicals (**REACH**): echa.europa.eu/support/guidance-on-reach-and-clp-implementation

GreenScreen: cleanproduction.org/Greenscreen.v1-2.php

EXEMPLARY PERFORMANCE

Option 1. Purchase at least 40 permanently installed building products that meet the credit criteria.

Option 2. Purchase at least 50%, by cost, of permanently installed building products that meet the credit criteria.

DEFINITIONS

product (**permanently installed building product**) an item that arrives on the project site either as a finished element ready for installation or as a component to another item assembled on-site. The product unit is defined by the functional requirement for use in the project; this includes the physical components and services needed to serve the intended function of the permanently installed building product. In addition, similar product within a specification, each contributes as a separate product.

MATERIALS AND RESOURCES CREDIT

Construction and Demolition Waste Management

This credit applies to:

Commercial Interiors (1-2 points)
Retail (1-2 points)
Hospitality (1-2 points)

INTENT

To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.

REQUIREMENTS

Recycle and/or salvage nonhazardous construction and demolition materials. Calculations can be by weight or volume but must be consistent throughout.

Exclude excavated soil, land-clearing debris, and alternative daily cover (ADC). Include wood waste converted to fuel (biofuel) in the calculations; other types of waste-to-energy are not considered diversion for this credit.

However, for projects that cannot meet credit requirements using reuse and recycling methods, waste-to-energy systems may be considered waste diversion if the European Commission Waste Framework Directive 2008/98/EC and Waste Incineration Directive 2000/76/EC are followed and Waste to Energy facilities meet applicable European Committee for Standardization (CEN) EN 303 standards.

OPTION 1. DIVERSION (1–2 POINTS)

Path 1. Divert 50% and Three Material Streams (**1 point**)
Divert at least 50% of the total construction and demolition material; diverted materials must include at least three material streams.

OR

Path 2. Divert 75% and Four Material Streams (**2 points**)
Divert at least 75% of the total construction and demolition material; diverted materials must include at least four material streams.

OR

OPTION 2. REDUCTION OF TOTAL WASTE MATERIAL (2 POINTS)

Do not generate more than 2.5 pounds of construction waste per square foot (12.2 kilograms of waste per square meter) of the building's floor area.

BEHIND THE INTENT

Diversion of construction waste has increased greatly in recent years because of new market incentives, better recycling and reuse infrastructure, and more sophisticated sorting technology. However, the majority of diverted materials are those that occur in high volume, such as structural waste, or are easily resold, valuable materials such as metals.

Both planning and implementation are critical to reducing construction waste. This credit rewards projects that implement the plan created in MR Prerequisite Construction and Demolition Waste Management Planning. It encourages the diversion of a greater quantity and diversity of materials across multiple material steams by setting thresholds for both an overall diversion percentage and a minimum number of material streams. With an option that rewards waste reduction, the credit also offers an alternative to diversion.

For more on the benefits of diverting construction and demolition waste, please refer to the prerequisite.

STEP-BY-STEP GUIDANCE

The process for waste management should be developed as part of the construction waste management (CWM) plan in the corresponding prerequisite. Review the steps in MR Prerequisite Construction and Demolition Waste Planning and select an option.

- Option 1 focuses on diverting construction and demolition waste from landfills by implementing the CWM plan created in the prerequisite and meeting minimum thresholds.
- Option 2 is appropriate for projects implementing source reduction strategies in both the design and construction phases. Before selecting this option, estimate the amount of waste produced by the project to see whether the performance threshold is realistic.

Option 1. Diversion

STEP 1. IMPLEMENT CWM PLAN

Implement the procedures outlined in the CWM plan developed for the corresponding prerequisite to achieve diversion goals and meet minimum thresholds.

- Establish on-site infrastructure, practices, and policies for off-site sorting, and develop a tracking system, as applicable. Identify at least three material streams that will be diverted (see *Further Explanation, Identifying Material Streams*).
- Track all the construction and demolition waste leaving the site. Retain waste hauler reports for documentation. Record estimated weight or volume of materials that are reused on site or salvaged for reuse on other projects by subcontractors or vendors.
- Retain receipts and estimate weight or volume for materials donated to charities, reuse retailers, or other recipients that can verify and track incoming and outgoing materials.

To contribute to this credit, commingled waste diversion must comply with one of the following requirements:

- The waste-sorting facility provides a waste diversion percentage specific to the project's waste based on measurement of each component waste material. Visual inspection is not an acceptable method of evaluation for documenting this percentage.
- The project team uses the facility's average diversion rate, which must be regulated by the local or state authority and must exclude alternative daily cover (ADC). This system must be a closed system; shipping waste to another municipality to manage, thus burdening another system, does not count as diverting the waste.

STEP 2. CALCULATE DIVERSION RATE

Applying Equation 1 to the total waste generated and diverted, determine the construction and demolition waste diversion rate. To ensure that the credit requirements will be met, project teams should calculate the diversion rate periodically (e.g., monthly or bimonthly) so that adjustments can be made to meet diversion goals.

EQUATION 1. Diversion rate

$$\text{Diversion rate} = \frac{\text{Total waste diverted from landfill}}{\text{Total waste produced by project}} \times 100$$

- The performance threshold requires both a minimum diversion percentage and diversion of at least three (Path 1) or four (Path 2) material streams.
- Ensure that units are consistent for all materials, in either weight or volume.
- Diverted waste includes all recycled, salvaged, reused, and donated materials.
- ADC does not count as diversion but must be included in total construction and demolition waste.
- Exclude hazardous waste, land-clearing debris, soil, and landscaping materials.
- Projects that cannot meet the credit threshold via reuse or recycling are eligible to claim diversion through waste-to-energy systems, provided they meet applicable standards and requirements (see *Further Explanation, Waste-to-Energy*). Wood-derived fuel may contribute toward diversion.

STEP 3. PRODUCE CWM REPORT

Create a final waste report for the project that includes the following information (see *Further Explanation, Example*):

- Total construction and demolition waste produced by the project
- Types of waste material and quantity of each material
- Total waste diverted and diversion rate (percentage)

The report must address ADC and other materials that are included in the calculation even if they do not count toward diversion. If a single hauler is used for all waste, this company may be able to provide this report. If multiple haulers or diversion strategies are used, the project team must compile waste management information from all sources into a single report.

Option 2. Reduction of Total Waste

STEP 1. DESIGN FOR REDUCED WASTE

Project teams should consider design strategies that will greatly reduce the amount of waste generated on site. Strategies such as prefabrication, modular construction, and designs that use industry standard sizes greatly reduce the amount of waste that needs to be managed and diverted from landfill and incineration (see *Further Explanation, Source Reduction*).

STEP 2. CALCULATE TOTAL WASTE REDUCTION

Calculate threshold achievement using Equation 2.

EQUATION 2. Waste per area calculation

$$\text{Waste per area} = \frac{\text{Total construction and demolition waste generated}}{\text{Project gross floor area}} \times 100$$

- Under Option 2, materials reused on site do not count as waste.
- Include all waste materials donated, sent to reuse facilities, or reused on other projects.
- Include all waste materials sent to recycling facilities, landfills, and incinerators.

FURTHER EXPLANATION

CALCULATIONS

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

WASTE TRACKING (OPTION 1)

One best practice is tracking waste throughout the entire project. The project team may determine the best strategy for ongoing tracking, which will then feed into the MR construction and demolition waste management calculator provided by USGBC or an equivalent tracking tool.

Web-based tools can provide contractors with an easy, step-by-step process for electronically tracking and submitting waste management and recycling plans. Electronic tracking can save them time and money by identifying materials that can be recycled, locating the nearest recycling facilities, following recycling progress in real time, gathering comprehensive statistics, and creating reports regarding waste generation and recycling for project, clients, company, government, as well as for green rating systems.

Some tools provide LEED credit templates so that data can be transferred directly to LEED report formats.

TABLE 1. Sample waste-tracking tool

Material stream		Diverted waste per report date				Total	Units
		Sept	Oct	Nov	Dec		
Material streams contributing toward credit	Plastic	1.25	2.5	10	5	18.75	yards
	Carpet	2.5	2.5	2.5	0	7.5	yards
	Paper/Cardboard	5	2.5	2.5	5	15	yards
	Clean Wood	0	25	0	1.25	26.25	yards
	Metal	1.25	2.5	5.5	7	16.25	yards
	Sheetrock	2.5	2.5	4	5	14	yards
	Brick/Concrete Masonry	10.5	2.5	5.5	8.75	27.25	yards
	Asphalt Shingles	10	0	0	0	10	yards
					Total diverted waste	135	yards
Material streams not contributing toward credit	Landfill	10.75	7.5	15	10	43.25	yards
	Screen Fines (ADC)	5	1.25	0	2.5	8.75	yards
	6″ Minus (ADC)	1.25	1.25	5	5.5	13	yards
					Total landfill/ADC waste	65	yards
					Total waste	200	yards
					Percent (%) diverted	67.5	%

Figure 1. Sample waste-tracking tool

IDENTIFYING MATERIAL STREAMS

Under Option 1 of this credit, project teams must divert at least three material streams from landfill. A material stream is defined as a flow of materials coming from a job site into markets for building materials. A stream can be either of the following:

- a specific material category that is diverted in a specific way; or
- a mixture of several material categories that are diverted in a specific way.

Examples of material streams include deconstructed materials sent to reuse markets, commingled waste sent to mixed-waste recycling facility, source separation where each material is sent to a specific facility, manufacturers' or suppliers' take-back of materials, and reuse of deconstructed materials on-site.

As a best practice, a material stream should constitute at least 5% (by weight or volume) of total diverted materials. The option requires that multiple material streams be diverted for several reasons: to stimulate markets for recovered materials by keeping materials separated at the job site, thus increasing recycling rate of materials; to encourage better project planning, job site diversion best practices, and new sorting and diversion techniques; and to encourage manufacturers to use closed-loop product systems.

WASTE-TO-ENERGY

Waste-to-energy may be considered a viable diversion strategy if the project team follows the European Commission Waste Framework Directive 2008/98/EC and the European Commission Waste Incineration Directive 2000/76/EC. These standards consist of performance metrics of both efficiency and emissions for different types of energy recovery systems. In addition, the facility must meet the applicable European standards based on the fuel type. See Referenced Standards for more information on these directives:

- EN 303-1—1999/A1—2003, Heating boilers with forced draught burners
- EN 303-2—1998/A1—2003, Heating boilers with forced draught burners
- EN 303-3—1998/AC—2006, Gas-fired central heating boilers
- EN 303-4—1999, Heating boilers with forced draught burners
- EN 303-5—2012, Heating boilers for solid fuels
- EN 303-6—2000, Heating boilers with forced draught burners
- EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner

Project teams pursuing this compliance option must demonstrate that reuse and recycling strategies were exhausted before sending material to waste-to-energy facilities.

The combustion of wood or "wood-derived fuel" is not considered waste-to-energy and is exempt from the criteria above.

SOURCE REDUCTION

Source reduction eliminates waste produced by a project in the following three ways:

- Prefabrication is a viable alternative for many wall assemblies. Because prefabrication occurs off site in a dedicated facility, the manufacturer can achieve high efficiencies in its use of equipment and materials, thereby reducing waste.
- Modular designs are likely to have a longer lifespan if they use of durable materials and permanent fastening. They are also safer to build because large assemblies are constructed in controlled environments, reducing workers' exposure to elevated work tasks.
- Designing for standard material lengths eliminates large amounts of off-cuts and scrap. If incorporated early in the design process, this strategy does not add additional cost to a project.

Under Option 2, exclude on-site reused materials. Materials reused on site are not considered waste for the purposes of calculating this option only.

CAMPUS

Group Approach

All projects in the group may be documented as one. Multiple project spaces may share waste hauling contracts and on-site collection equipment. Data aggregation is allowed, provided that each project included is pursuing the same option.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
MR construction and demolition waste management calculator or equivalent tool, tracking total and diverted waste amounts and material streams	X	
Documentation of recycling rates for commingled facilities	X	
Justification for use of waste-to-energy as diversion strategy (if applicable)	X	
Documentation of waste-to-energy facilities adhering to relevant EN standards (if applicable)	X	
Total waste per area		X

RELATED CREDIT TIPS

MR Prerequisite Construction and Demolition Waste Management Planning. The diversion accomplished in this credit should be done according to the plan developed in the related prerequisite.

CHANGES FROM LEED 2009

- A compliance option has been added for total project waste reduction per gross floor area of the project.
- Multiple material streams must be diverted to earn the credit for waste diversion (Option 1).
- ADC has been specifically excluded from diversion calculations. In LEED 2009 it could count as diverted waste.
- Waste-to-energy may count as a diversion method if the facility meets European Union requirements for waste management and emissions into air, soil, surface water, and groundwater.

REFERENCED STANDARDS

Certification of Sustainable Recyclers: recyclingcertification.org

European Commission Waste Framework Directive 2008/98/EC:

- ec.europa.eu/environment/waste/framework/index.htm
- eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:312:0003:0030:en:PDF

European Commission Waste Incineration Directive 200/76/EC:

- europa.eu/legislation_summaries/environment/waste_management/l28072_en.htm
- central2013.eu/fileadmin/user_upload/Downloads/Document_Centre/OP_Resources/Incineration_Directive_2000_76.pdf

EN 303-1—1999/A1—2003, Heating boilers with forced draught burners, Terminology, general requirements, testing and marking: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-2—1998/A1—2003, Heating boilers with forced draught burners, Special requirements for boilers with atomizing oil burners: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-3—1998/AC—2006, Gas-fired central heating boilers, Assembly comprising a boiler body and a forced draught burner: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-4—1999, Heating boilers with forced draught burners, Special requirements for boilers with forced draught oil burners with outputs up to 70 kW and a maximum operating pressure of 3 bar, Terminology, special requirements, testing and marking: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-5—2012, Heating boilers for solid fuels, manually and automatically stoked, nominal heat output of up to 500 kW: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-6—2000, Heating boilers with forced draught burners, Specific requirements for the domestic hot water operation of combination boilers with atomizing oil burners of nominal heat input not exceeding 70 kW: cen.eu/cen/Products/Search/Pages/default.aspx

EN 303-7—2006, Gas-fired central heating boilers equipped with a forced draught burner of nominal heat output not exceeding 1000 kW: cen.eu/cen/Products/Search/Pages/default.aspx

EXEMPLARY PERFORMANCE

Achieve both Options 1 (either Path 1 or 2) and Option 2.

DEFINITIONS

alternative daily cover (**ADC**) material other than earthen material placed on the surface of the active face of a municipal solid waste landfill at the end of each operating day to control vectors, fires, odors, blowing litter, and scavenging. Generally these materials must be processed so they do not allow gaps in the exposed landfill face. (CalRecycle)

clean waste nonhazardous materials left over from construction and demolition. Clean waste excludes lead and asbestos.

commingled waste building waste streams that are combined on the project site and hauled away for sorting into recyclable streams. Also known as single-stream recycling.

land-clearing debris and soil materials that are natural (e.g., rock, soil, stone, vegetation). Materials that are man-made (e.g., concrete, brick, cement) are considered construction waste even if they were on site.

source reduction a decrease in the amount of unnecessary material brought into a building in order to produce less waste. For example, purchasing products with less packaging is a source reduction strategy.

waste-to-energy the conversion of nonrecyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery

Indoor Environmental Quality (EQ)

OVERVIEW

The Indoor Environmental Quality (EQ) category rewards decisions made by project teams about indoor air quality and thermal, visual, and acoustic comfort. Green buildings with good indoor environmental quality protect the health and comfort of building occupants. High-quality indoor environments also enhance productivity, decrease absenteeism, improve the building's value, and reduce liability for building designers and owners.[1] This category addresses the myriad design strategies and environmental factors—air quality, lighting quality, acoustic design, control over one's surroundings—that influence the way people learn, work, and live.

The relationship between the indoor environment and the health and comfort of building occupants is complex and still not fully understood. Local customs and expectations, occupants' activities, and the building's site, design, and construction are just a few of the variables that make it difficult to quantify and measure the direct effect of a building on its occupants.[2] Therefore, the EQ section balances the need for prescriptive measures with more performance-oriented credit requirements. For example, source control is addressed first, in a prerequisite, and a later credit then specifies an indoor air quality assessment to measure the actual outcome of those strategies.

The EQ category combines traditional approaches, such as ventilation and thermal control, with emerging design strategies, including a holistic, emissions-based approach (Low-Emitting Materials credit), source control and monitoring for user-determined contaminants (Enhanced Indoor Air Quality Strategies credit), requirements for lighting quality (Interior Lighting credit), and advanced lighting metrics (Daylight credit). A new credit covering acoustics is now available.

1. *U.S. Environmental Protection Agency, Health Buildings Healthy People: A Vision for the 21st Century, epa.gov/iaq/pubs/hbhp.html* (*October 2001*) (*accessed July 25, 2013*).
2. *Mitchell, Clifford S., Junfeng Zhang, Torben Sigsgaard, Matti Jantunen, Palu J. Lioy, Robert Samson, and Meryl H. Karol, Current State of the Science: Health Effects and Indoor Environmental Quality, Environmental Health Perspectives 115*(*6*) (*June 2007*).

CROSS-CUTTING ISSUES

FLOOR AREA CALCULATIONS AND FLOOR PLANS

For many of the credits in the EQ category, compliance is based on the percentage of floor area that meets the credit requirements. In general, floor areas and space categorization should be consistent across EQ credits. Any excluded spaces or discrepancies in floor area values should be explained and highlighted in the documentation. See *Space Categorization*, below, for additional information on which floor area should be included in which credits.

SPACE CATEGORIZATION

The EQ category focuses on the interaction between the occupants of the building and the indoor spaces in which they spend their time. For this reason, it is important to identify which spaces are used by the occupants, including any visitors (transients), and what activities they perform in each space. Depending on the space categorization, the credit requirements may or may not apply (Table 1).

Occupied versus unoccupied space

All spaces in a building must be categorized as either occupied or unoccupied. Occupied spaces are enclosed areas intended for human activities. Unoccupied spaces are places intended primarily for other purposes; they are occupied only occasionally and for short periods of time—in other words, they are inactive areas.

Examples of spaces that are typically unoccupied include the following:

- Mechanical and electrical rooms
- Egress stairway or dedicated emergency exit corridor
- Closets in a residence (but a walk-in closet is occupied)
- Data center floor area, including a raised floor area
- Inactive storage area in a warehouse or distribution center

For areas with equipment retrieval, the space is unoccupied only if the retrieval is occasional.

Regularly versus nonregularly occupied spaces

Occupied spaces are further classified as regularly occupied or nonregularly occupied, based on the duration of the occupancy. Regularly occupied spaces are enclosed areas where people normally spend time, defined as more than one hour of continuous occupancy per person per day, on average; the occupants may be seated or standing as they work, study, or perform other activities. For spaces that are not used daily, the classification should be based on the time a typical occupant spends in the space when it is in use. For example, a computer workstation may be largely vacant throughout the month, but when it is occupied, a worker spends one to five hours there. It would then be considered regularly occupied because that length of time is sufficient to affect the person's well-being, and he or she would have an expectation of thermal comfort and control over the environment.

Occupied spaces that do not meet the definition of regularly occupied are nonregularly occupied; these are areas that people pass through or areas used an average of less than one hour per person per day.

Examples of regularly occupied spaces include the following:

- Airplane hangar
- Auditorium
- Auto service bay
- Bank teller station
- Conference room
- Correctional facility cell or day room
- Data center network operations center
- Data center security operations center
- Dorm room
- Exhibition hall
- Facilities staff office
- Facilities staff workstation
- Food service facility dining area
- Food service facility kitchen area
- Gymnasium
- Hospital autopsy and morgue
- Hospital critical-care area
- Hospital dialysis and infusion area
- Hospital exam room
- Hospital operating room
- Hospital patient room
- Hospital recovery area
- Hospital staff room
- Hospital surgical suite
- Hospital waiting room
- Hospital diagnostic and treatment area
- Hospital laboratory
- Hospital nursing station
- Hospital solarium
- Hospital waiting room
- Hotel front desk
- Hotel guest room
- Hotel housekeeping area
- Hotel lobby
- Information desk
- Meeting room
- Natatorium
- Open-office workstation
- Private office
- Reception desk
- Residential bedroom
- Residential dining room
- Residential kitchen
- Residential living room
- Residential office, den, workroom
- Retail merchandise area and associated circulation
- Retail sales transaction area
- School classroom
- School media center
- School student activity room
- School study hall
- Shipping and receiving office
- Study carrel
- Warehouse materials-handling area

Examples of nonregularly occupied spaces include the following:

- Break room
- Circulation space
- Copy room
- Corridor
- Fire station apparatus bay
- Hospital linen area
- Hospital medical record area
- Hospital patient room bathroom
- Hospital short-term charting space
- Hospital prep and cleanup area in surgical suite
- Interrogation room
- Lobby (except hotel lobby)*
- Locker room
- Residential bathroom
- Residential laundry area
- Residential walk-in closet
- Restroom
- Retail fitting area
- Retail stock room
- Shooting range
- Stairway

**Hotel lobbies are considered regularly occupied because people often congregate, work on laptops, and spend more time there than they do in an office building lobby.*

Occupied space subcategories

Occupied spaces, or portions of an occupied space, are further categorized as individual or shared multioccupant, based on the number of occupants and their activities. An individual occupant space is an area where someone performs distinct tasks. A shared multioccupant space is a place of congregation or a place where people pursue overlapping or collaborative tasks. Occupied spaces that are not regularly occupied or not used for distinct or collaborative tasks are neither individual occupant nor shared multioccupant spaces.

Examples of individual occupant spaces include the following:

- Bank teller station
- Correctional facility cell or day room
- Data center staff workstation
- Hospital nursing station
- Hospital patient room
- Hotel guest room
- Medical office
- Military barracks with personal workspaces
- Open-office workstation
- Private office
- Reception desk
- Residential bedroom
- Study carrel

Examples of shared multioccupant spaces include the following:

- Active warehouse and storage
- Airplane hangar
- Auditorium
- Auto service bay
- Conference room
- Correctional facility cell or day room
- Data center network operations center
- Data center security operations center
- Exhibition hall
- Facilities staff office
- Food service facility dining area
- Food service facility kitchen area
- Gymnasium
- Hospital autopsy and morgue
- Hospital critical-care area
- Hospital dialysis and infusion area
- Hospital exam room
- Hospital operating room
- Hospital surgical suite
- Hospital waiting room
- Hospital diagnostic and treatment area
- Hospital laboratory
- Hospital solarium
- Hotel front desk
- Hotel housekeeping area
- Hotel lobby
- Meeting room
- Natatorium
- Retail merchandise area and associated circulation
- Retail sales transaction area
- School classroom
- School media center
- School student activity room
- School study hall
- Shipping and receiving office
- Warehouse materials-handling area

Occupied spaces can also be classified as densely or nondensely occupied, based on the concentration of occupants in the space. A densely occupied space has a design occupant density of 25 people or more per 1,000 square feet (93 square meters), or 40 square feet (3.7 square meters) or less per person. Occupied spaces with a lower density are nondensely occupied.

Table 1 outlines the relationship between the EQ credits and the space categorization terms. If the credit is listed, the space must meet the requirements of the credit.

TABLE 1. Space types in EQ credits

Space Category	Prerequisite or Credit
Occupied space	• Minimum Indoor Air Quality Performance, ventilation rate procedure and natural ventilation procedure • Minimum Indoor Air Quality Performance, monitoring requirements • Enhanced Indoor Air Quality Strategies, Option 1 C • Enhanced Indoor Air Quality Strategies, Option 1 D • Enhanced Indoor Air Quality Strategies, Option 1 E • Enhanced Indoor Air Quality Strategies, Option 2 B • Enhanced Indoor Air Quality Strategies, Option 2 E • Indoor Air Quality Assessment, Option 2, Air Testing (sampling must be representative of all occupied spaces) • Thermal Comfort, design requirements • Acoustic Performance (CI, Hospitality)
Regularly occupied space	• Interior Lighting, Option 2, strategy A • Interior Lighting, Option 2, strategy D • Interior Lighting, Option 2, strategy E • Interior Lighting, Option 2, strategy G • Interior Lighting, Option 2, strategy H • Daylight • Quality Views
Individual occupant space	• Thermal Comfort, control requirements • Interior Lighting, Option 1
Shared multioccupant space	• Thermal Comfort, control requirements • Interior Lighting, Option 1
Densely occupied space	• Enhanced Indoor Air Quality Strategies, Option 2 C

Table 2 outlines the relationship between the EQ credits and the space categorization terms specific to each rating system (see Definitions). Unless otherwise stated, if the credit is listed, the space must meet the requirements of the credit.

TABLE 2. Rating system–specific space classifications

Rating system	Space type	Prerequisite or Credit
Hospitality	Guest rooms	• Interior Lighting* • Thermal Comfort, control requirements*
Retail	Office and administrative areas	• Thermal Comfort, control requirements • Interior Lighting, Option 2

*Hotel guest rooms are excluded from the credit requirements.

The following credits are not affected by space classifications:

- Environmental Tobacco Smoke Control
- Enhanced Indoor Air Quality Strategies, Option 1 A
- Enhanced Indoor Air Quality Strategies, Option 1 B
- Enhanced Indoor Air Quality Strategies, Option 2 A
- Enhanced Indoor Air Quality Strategies, Option 2 D (no specific spaces; applicable spaces are determined by the project team)
- Low-Emitting Materials
- Construction Indoor Air Quality Management Plan
- Indoor Air Quality Assessment, Option 1, Flush-Out (the floor area from all spaces must be included in calculation for total air volume; the flush-out must be demonstrated at the system level)
- Interior Lighting, Option 2, strategy B
- Interior Lighting, Option 2, strategy C
- Interior Lighting, Option 2, strategy F

TRICKY SPACES

Pay extra attention to how the following types of spaces are classified in specific credits.

Residential

- See the *Project Type Variations* sections in Thermal Comfort and Interior Lighting for guidance on providing appropriate controllability in residential buildings.

Auditoriums

- Exceptions to Daylight and Quality Views are permitted. See the *Project Type Variations* sections in Daylight and Quality Views.

Gymnasiums

- See the *Project Type Variations* section in Thermal Comfort for guidance on dealing with high levels of physical activity.
- Exceptions to Quality Views are permitted. See the *Project Type Variations* section in Quality Views.

Transportation Terminals

- For Thermal Comfort and Interior Lighting, Option 1, Lighting Control, most of the areas in a transportation terminal can be considered shared multioccupant. Most areas in transportation terminals are also regularly occupied.

Dormitories and Military Barracks

- These spaces fall in-between a work space and residence.
- Dorm rooms or military barracks with personal workspaces are considered individual occupant spaces. Military barracks without personal workspaces are considered shared multioccupant.

Industrial Facilities

- For Thermal Comfort and Interior Lighting, Option 1, Lighting Control, most of the active warehouse and storage areas are considered multioccupant.
- Most areas in industrial facilities are also regularly occupied.

INDOOR ENVIRONMENTAL QUALITY PREREQUISITE

Minimum Indoor Air Quality Performance

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).

REQUIREMENTS

Meet the requirements for both ventilation and monitoring.

Ventilation

Mechanically Ventilated Spaces

For mechanically ventilated spaces (and for mixed-mode systems when the mechanical ventilation is activated), chose one of the following cases.

CASE 1. SYSTEMS ABLE TO MEET REQUIRED OUTDOOR AIRFLOW RATES

OPTION 1. ASHRAE STANDARD 62.1–2010

Determine the minimum outdoor air intake flow for mechanical ventilation systems using the ventilation rate procedure from ASHRAE 62.1–2010 or a local equivalent, whichever is more stringent and meet the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quality (with errata), or a local equivalent, whichever is more stringent.

OPTION 2. CEN STANDARDS EN 15251–2007 AND EN 13779–2007

Projects outside the U.S. may instead meet the minimum outdoor air requirements of Annex B of Comité Européen de Normalisation (CEN) Standard EN 15251–2007, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics; and meet the requirements of CEN Standard EN 13779–2007, Ventilation for nonresidential buildings, Performance requirements for ventilation and room conditioning systems, excluding Section 7.3, Thermal environment; 7.6, Acoustic environment; A.16; and A.17.

Case 2. Systems Unable to Meet Required Outdoor Airflow Rates

If meeting the outdoor airflow rates in Case 1 is not feasible because of the physical constraints of the existing ventilation system, complete an engineering assessment of the system's maximum outdoor air delivery rate. Supply the maximum possible to reach the minimum setpoint in Case 1 and not less than 10 cubic feet per minute (5 liters per second) of outdoor air per person.

Naturally Ventilated Spaces

For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), determine the minimum outdoor air opening and space configuration requirements using the natural ventilation procedure from ASHRAE Standard 62.1–2010 or a local equivalent, whichever is more stringent. Confirm that natural ventilation is an effective strategy for the project by following the flow diagram in the Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Nondomestic Buildings, Figure 2.8 and meet the requirements of ASHRAE Standard 62.1–2010, Section 4, or a local equivalent, whichever is more stringent.

All Spaces

The indoor air quality procedure defined in ASHRAE Standard 62.1–2010 may not be used to comply with this prerequisite.

Monitoring

Mechanically Ventilated Spaces

For mechanically ventilated spaces (and for mixed-mode systems when the mechanical ventilation is activated), monitor outdoor air intake flow as follows:

- For variable air volume systems with an outdoor air intake in the project scope of work, provide a direct outdoor airflow measurement device capable of measuring the minimum outdoor air intake flow with an accuracy of +/–10% of the design minimum outdoor airflow rate, as defined by the ventilation requirements above. An alarm must indicate when the outdoor airflow value varies by 15% or more from the outdoor airflow setpoint.
- For constant-volume systems included in the project scope of work, balance outdoor airflow to the design minimum outdoor airflow rate defined by ASHRAE Standard 62.1–2010 (with errata), or higher. Install a current transducer on the supply fan, an airflow switch, or similar monitoring device.

Naturally Ventilated Spaces

For naturally ventilated spaces (and for mixed-mode systems when the mechanical ventilation is inactivated), comply with at least one of the following.

- Provide a direct exhaust airflow measurement device capable of measuring the exhaust airflow with an accuracy of +/–10% of the design minimum exhaust airflow rate. An alarm must indicate when airflow values vary by 15% or more from the exhaust airflow setpoint.
- Provide automatic indication devices on all natural ventilation openings intended to meet the minimum opening requirements. An alarm must indicate when any one of the openings is closed during occupied hours.
- Monitor carbon dioxide (CO_2) concentrations within each thermal zone. CO_2 monitors must be between 3 and 6 feet (900 and 1 800 millimeters) above the floor and within the thermal zone. CO_2 monitors must have an audible or visual indicator or alert the building automation system if the sensed CO_2 concentration exceeds the setpoint by more than 10%. Calculate appropriate CO_2 setpoints by using the methods in ASHRAE 62.1–2010, Appendix C.

BEHIND THE INTENT

By diluting pollutants created by a building's occupants and other contaminant sources, ventilation with outdoor air contributes to the occupants' comfort and well-being. The exact connections between ventilation rates and occupants' health are still being researched, but a multidisciplinary scientific review of the current state of knowledge shows some strong associations.[1] Maintaining good indoor air quality (IAQ) depends on controlling pollutant sources, removing contaminants from outdoor air, and supplying at least some outdoor air, among other factors. The standards referenced in this prerequisite outline well-tested methods for determining the amount of outdoor air each type of space requires. These standards were chosen because they strike a balance between providing fresh air and maintaining energy efficiency.

Different kinds of occupants, activities, and equipment in a building will make for different IAQ parameters, so requirements vary both by space type in a building and by project type. For example, residential projects must meet additional prescriptive requirements that protect occupants from indoor contaminants, such as combustion byproducts and radon, and health care facilities have more stringent ventilation and space pressurization requirements to prevent cross-contamination.

Intelligent ventilation design is only the first step. Monitoring, as required by this prerequisite, helps maintain IAQ during all stages of a building's operation. Even though occupants may not notice reductions in outdoor airflow or exhaust airflow, indoor air pollutants begin to build up the moment proper ventilation ceases. The combination of intelligent ventilation design with monitoring provides confidence that occupants enjoy comfort and well-being.

Indoor air quality is directly affected by the ventilation system serving the space. For this reason, the credit requirements must be met whether the HVAC system is a part of the project scope of work or controlled by the tenant.

STEP-BY-STEP GUIDANCE

STEP 1. EVALUATE OUTDOOR AIR QUALITY

Investigate local outdoor air quality at the project location. If pursuing Option 1 for mechanically ventilated spaces, or using naturally ventilated spaces, follow ASHRAE 62.1–2010, Section 4, or a local equivalent, whichever is more stringent. If pursuing Option 2 for mechanically ventilated spaces, see *Comité Européen de Normalisation (CEN) Standard EN 13779–2007, Section 6.2.3, Outdoor Air*.

STEP 2. IDENTIFY PROJECT'S VENTILATION STRATEGY

Determine how ventilation air is or will be provided to the building and to the project spaces.

Determine which elements and systems are considered part of the base building, and which are part of the LEED project. The ventilation system serving the project space may be independent of the system serving the rest of the building, or it may be shared with other areas in the building. Determine whether any requirements for this prerequisite fall outside the project space and/or tenant's control. The ventilation requirements must be met regardless of whether the ventilation systems are in the project's scope of work, but the monitoring requirements apply only to the systems in the project scope of work.

If a new ventilation system is being installed for the project, determine whether mechanical ventilation, natural ventilation, or a mixed-mode approach is appropriate for the project (see *Further Explanation, Ventilation Strategies*).

If the project is being served by a central HVAC system, confirm as early as possible that the system will function adequately in the project space and meet the ASHRAE standard's provisions. Perform an engineering assessment of an existing ventilation system (see *Further Explanation, Existing Ventilation System*).

1. *Sundell, Jan, Hal Levin, and Davor Novosel, Ventilation Rates and Health: Report of an Interdisciplinary Review of the Scientific Literature (National Center for Energy Management and Building Technologies Task 06-01, September 2006), ncembt.org/downloads/Sundell%20J_VentilationRatesAndHealthReportOfAnInterdisciplinaryReviewOfTheScientificLiterature_NCEMBT-070914.pdf (accessed June 10, 2013).*

STEP 3. CATEGORIZE SPACES

Create a table of all rooms and spaces in the project and identify the following for each space.

- Ventilation strategy
- Net occupiable space, as defined in ASHRAE Standard 62.1–2010, page 4, or room floor area if using CEN Standard 15251
- Occupancy category, as listed in ASHRAE Standard 62.1–2010, Table 6-1, or CEN Standard 15251, Table B.2
- If applicable, identify whether the building is very low polluting, low polluting, or not low polluting (see CEN Standard 15251, Annex C).
- Design occupancy (see *Getting Started, Occupancy*)

It may be appropriate to group rooms or spaces into ventilation zones (see *Further Explanation, Types of Mechanical Ventilation Systems*). If the project shares a ventilation system that is also serving other areas in the building, collect occupancy and net occupiable space information for those areas as well.

STEP 4. IDENTIFY APPROPRIATE PREREQUISITE REQUIREMENTS

Follow the steps below for mechanical ventilation or natural ventilation, depending on the ventilation strategy used in each space.

For mixed-mode systems, projects must comply with mechanical ventilation requirements when the mechanical system is active, and natural ventilation requirements when the mechanical ventilation system is inactive.

Mechanically Ventilated Spaces (and Mixed-Mode Spaces When Mechanical Ventilation Is Active)

STEP 1. DETERMINE PRELIMINARY HVAC SYSTEM CONFIGURATION

Identify the following basic mechanical system features, which will affect the calculation of outdoor air required:

- Single-zone, 100% outdoor air, or multiple-zone systems
- Underfloor, overhead or side air distribution and location of return grilles
- Supply air temperature: cooling only or heating and cooling
- Variable air volume (VAV) or constant volume (CV) supply

STEP 2. CALCULATE REQUIRED OUTDOOR AIRFLOW UNDER OPTION 1

Complete the ventilation rate procedure in ASHRAE Standard 62.1–2010, Section 6.2, to determine the minimum amount of outdoor air that must be supplied to the project spaces or building.

- Complete a separate ventilation rate procedure calculation for each ventilation system that serves the project spaces.
- Account for all occupied spaces in the calculation. Any spaces not within the LEED project boundary must be properly accounted for in the calculation (see *Further Explanation, Shared Ventilation System*).
- Perform ventilation rate procedure calculations for worst-case conditions, which typically occur in the heating mode when supply airflows are lowest or supply air temperature is highest. From Table 6-2 of the standard, select the zone air distribution effectiveness (E_z) value that corresponds to the air distribution configuration of the worst-case conditions. E_z is typically less than 1.0 when the system is in heating mode. If E_z is greater than 1.0, see EA Prerequisite Minimum Energy Performance, *Further Explanation, Common Issues with Energy Modeling, Ventilation (zone air distribution effectiveness)*.
- As applicable, evaluate and document assumptions for all variables required for the ventilation rate procedure calculation. These variables include the percentage of total design airflow rate at condition analyzed (D_s), the primary air fraction of supply air at condition analyzed (E_p), the system ventilation efficiency (E_v), and the fraction of local recirculated air that is representative of system return air (E_r).
- For special conditions that apply to systems designed to respond to varying operating conditions, such as with demand-controlled ventilation, see *Further Explanation, Considerations for Variable Operating Conditions.*

Ensure that the appropriate method is selected for each system in the project. The ventilation rate procedure calculation differs for single-zone, 100% outdoor air, and multiple-zone systems. Suggested methods are as follows:

- For single-zone systems or 100% outdoor air systems, use the calculator provided by USGBC or a user-generated spreadsheet. The 62MZCalc spreadsheet is not applicable to these systems and should not be used to perform the ventilation calculations.
- For multiple-zone systems, use the 62MZCalc spreadsheet. This includes VAV and CV systems in which one or more air handlers supply a mixture of outdoor air and recirculated air to more than one ventilation zone (see *Further Explanation, Calculations for Multiple-Zone Systems*).

Energy modeling software may also be used to perform ventilation rate procedure calculations for all three system types. Direct outputs from the programs are acceptable, provided they include sufficient information about the values used for all variables in the calculation.

If the local code is more stringent than ASHRAE 62.1–2010, *see Further Explanation, Local Equivalent to ASHRAE 62.1–2010.*

ALTERNATIVE STEP 2. CALCULATE REQUIRED OUTDOOR AIRFLOW UNDER OPTION 2

Follow the calculations outlined in Comité Européen de Normalisation (CEN) Standard 15251–2007, Annex B, to determine the minimum amount of outdoor air that must be supplied by each ventilation system that serves the project spaces.

STEP 3. REVISE DESIGN TO MEET OUTDOOR AIR REQUIREMENTS, IF NECESSARY

If the ventilation calculations in Step 2 indicate that the preliminary design does not provide enough outdoor air to meet the selected reference standard, revise the design and recalculate the minimum amount of outdoor air to confirm compliance.

For single-zone and 100% outdoor air systems, increase the amount of outdoor air supplied by the system. For multiple-zone systems, increase supply airflow to the critical zone or increase the amount of outdoor air supplied by the system. If an existing system is physically incapable of meeting the minimum outdoor airflow requirement even after adjustments have been made, Case 2 of the rating system applies (see *Further Explanation, Existing Ventilation System*).

In the final calculations, ensure that the net occupiable space, design occupancy, number of air handlers, and outdoor air volume are consistent with the project's mechanical schedules and documentation provided for other LEED credits. Create a summary table that lists the required outdoor air intake flow and design outdoor air intake flow for each ventilation system.

STEP 4. MEET MINIMUM REQUIREMENTS

Ensure that the design meets the minimum requirements of the selected referenced standard. Many of the minimum requirements, such as the location of air intakes, apply to functional aspects of the HVAC system that are most commonly located in parts of the building outside the project space.

Option 1. ASHRAE Standard 62.1–2010

- Confirm compliance with Sections 4 through 7.
- Indicate whether the project is in a nonattainment area for fine particulate matter (PM2.5), and if so, confirm that filters with minimum efficiency reporting values (MERV) of 11 or higher have been or will be installed.
- Indicate whether the project is in an area where ozone exceeds the most recent three-year average, annual fourth-highest daily maximum eight-hour average ozone concentration of 0.107 ppm, and if so, confirm that the project has or will have air-cleaning devices for ozone.
- If using a local code instead of ASHRAE 62.1–2010, see *Further Explanation, Local Equivalent to ASHRAE 62.1–2010.*

Option 2. CEN Standards EN 15251–2007 and EN 13779–2007

- Confirm compliance with the requirements in CEN Standard 13770–2007, excluding Section 7.3 Thermal environment, 7.6 Acoustic environment, A.16, and A.17.

STEP 5. IMPLEMENT AIRFLOW MONITORING

Incorporate airflow monitoring equipment if the ventilation systems are included in the LEED project's scope of work. The monitoring equipment does not have to be dedicated to the project spaces, but each ventilation system serving the project spaces must have a measurement device. The technique for monitoring outdoor air depends on the HVAC system.

For VAV systems—for example, a 100% outdoor air energy recovery unit with demand-controlled ventilation, or any system that provides a variable amount of supply or outdoor air—a direct outdoor airflow measurement device must measure the intake flow rate (Figure 1).

- Indirect measurements, such temperature or current transducers, cannot directly measure the airflow rate and thus are not allowed for VAV systems.
- If a 100% outdoor air system provides ventilation air to the return of downstream terminal devices (e.g., fan coil units, heat pumps), the measurement device needs to measure the outdoor airflow rate at the 100% outdoor air unit only, not at each terminal device. The ventilation rate procedure must still be calculated for each terminal device.
- For device requirements, see the specific language in the prerequisite requirements.

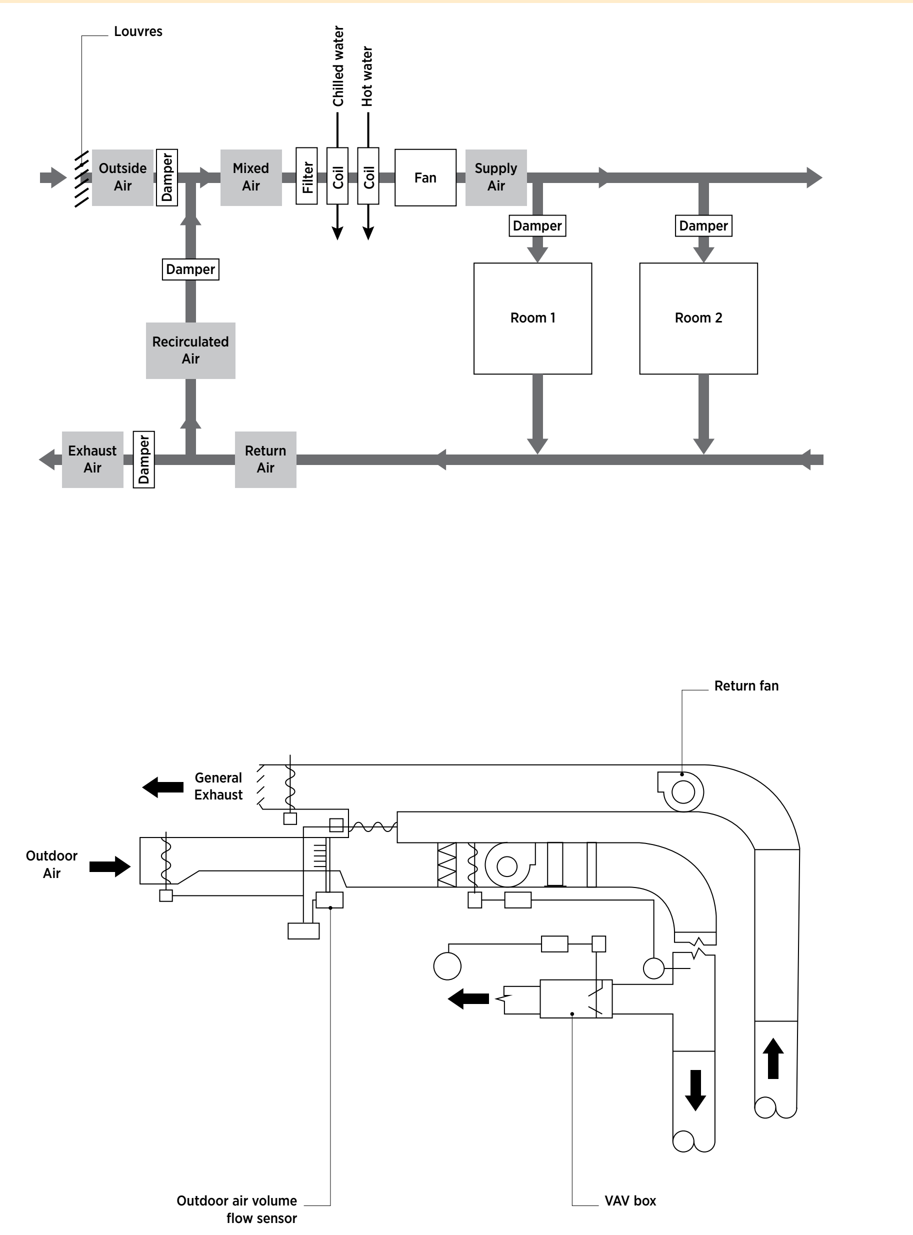


Figure 1. Example schematic for outdoor air sensor location

For constant volume systems, balancing ensures that the correct amount of outdoor air is being supplied to the building.

- Once the system has been balanced, a current transducer on the supply fan, airflow switch, pressure transducer, or similar monitoring device must be installed.

- If a 100% outdoor air system provides ventilation air to the return of downstream terminal devices (e.g., fan coil units, heat pumps), the measurement device needs to be installed at the 100% outdoor air system only, not at each terminal device. The ventilation rate procedure must still be calculated to each terminal device.

For all systems, retain equipment cutsheets showing the accuracy of the monitoring device(s), copies of control sequences and diagrams, and test and balance reports that show airflow setpoints for each ventilation system.

Naturally Ventilated Spaces (and Mixed-Mode Systems When Mechanical Ventilation Is Inactivated)

STEP 1. CONFIRM NATURAL VENTILATION EFFECTIVENESS

Use Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, Natural Ventilation in Non-Domestic Buildings, Figure 2.8 (flow chart), to confirm that natural ventilation is appropriate. Retain a copy of the flow chart path for the project.

STEP 2. IDENTIFY CEILING HEIGHTS AND NATURAL VENTILATION OPENINGS

Collect the following information for each naturally ventilated space and add to the table of rooms and spaces:

- Minimum ceiling height in the space
- Location of natural ventilation openings (on one side, two opposite sides, or two adjacent sides)
- Size of the natural ventilation openings (openable area)

STEP 3. PERFORM NATURAL VENTILATION PROCEDURE

Use the natural ventilation procedure in ASHRAE 62.1–2010, Section 6.4, to determine the size of openings required in each space and the maximum distance from the openings that can be considered naturally ventilated.

- Compare the calculation results with the design and revise, if necessary, to ensure that all spaces meet the requirements of the standard.
- If the project includes an engineered natural ventilation system approved by the authority having jurisdiction, the requirements of Section 6.4 do not apply (see *Further Explanation, Authority Having Jurisdiction Exception*).
- Confirm compliance with the exhaust ventilation requirements of ASHRAE Standard 62.1–2010, Section 6.5.

STEP 4. CONFIRM MECHANICAL SYSTEM EXCEPTION OR COMPLIANCE

If the project qualifies for an exception to the mechanical ventilation requirement in ASHRAE 62.1–2010, Section 6.4, prepare an explanatory narrative.

If the project does not qualify for exception, follow the step-by-step instructions for mechanical ventilation systems to demonstrate compliance with ASHRAE 62.1–2010 when mechanical ventilation is active (see *Further Explanation, Natural Ventilation Exceptions*).

STEP 5. IMPLEMENT MONITORING SYSTEM

Incorporate airflow monitoring equipment into the natural ventilation system design through one of the following three monitoring strategies.

Direct exhaust airflow measurement device

- Incorporate exhaust airflow monitoring equipment that has an accuracy of +/–10% of the design minimum exhaust airflow rate.
- Naturally ventilated systems induce passive air movement from openings to the point of exhaust, requiring that airflow measurement devices be placed at the exhaust location.
- Configure the exhaust airflow monitoring equipment to generate an alarm when airflow values vary by 15% or more from the exhaust airflow setpoint.
- Retain equipment cutsheets for the monitorings, plans indicating sensor locations, and copies of control sequences and diagrams.

Alarmed openings for naturally ventilated spaces

- Identify all windows, louvers, and trickle vents used for natural ventilation.
- Each opening counted as a natural ventilation intake for this prerequisite must have an alarm under this strategy. For example, an office with two windows intended to provide natural ventilation must have alarms installed on both windows. However, if only one window is counted as a natural ventilation intake, only one window is required to have an alarm.

Carbon dioxide (CO_2) monitors

- Install a CO_2 sensor in each thermal zone.
- CO_2 sensors must be located in the breathing zone, as defined in the prerequisite requirements (Figure 2). CO_2 sensors installed in return air ducts cannot be used to meet the requirements.
- Determine CO_2 concentration setpoint(s) using the methods in ASHRAE 62.1–2010, Appendix C. See ASHRAE 62.1–2010 User's Manual, Appendix A, for calculations and examples.
- Configure the CO_2 monitoring system to generate an audible or visual alarm to the system operator if the differential CO_2 concentration exceeds the setpoint by more than 10%.

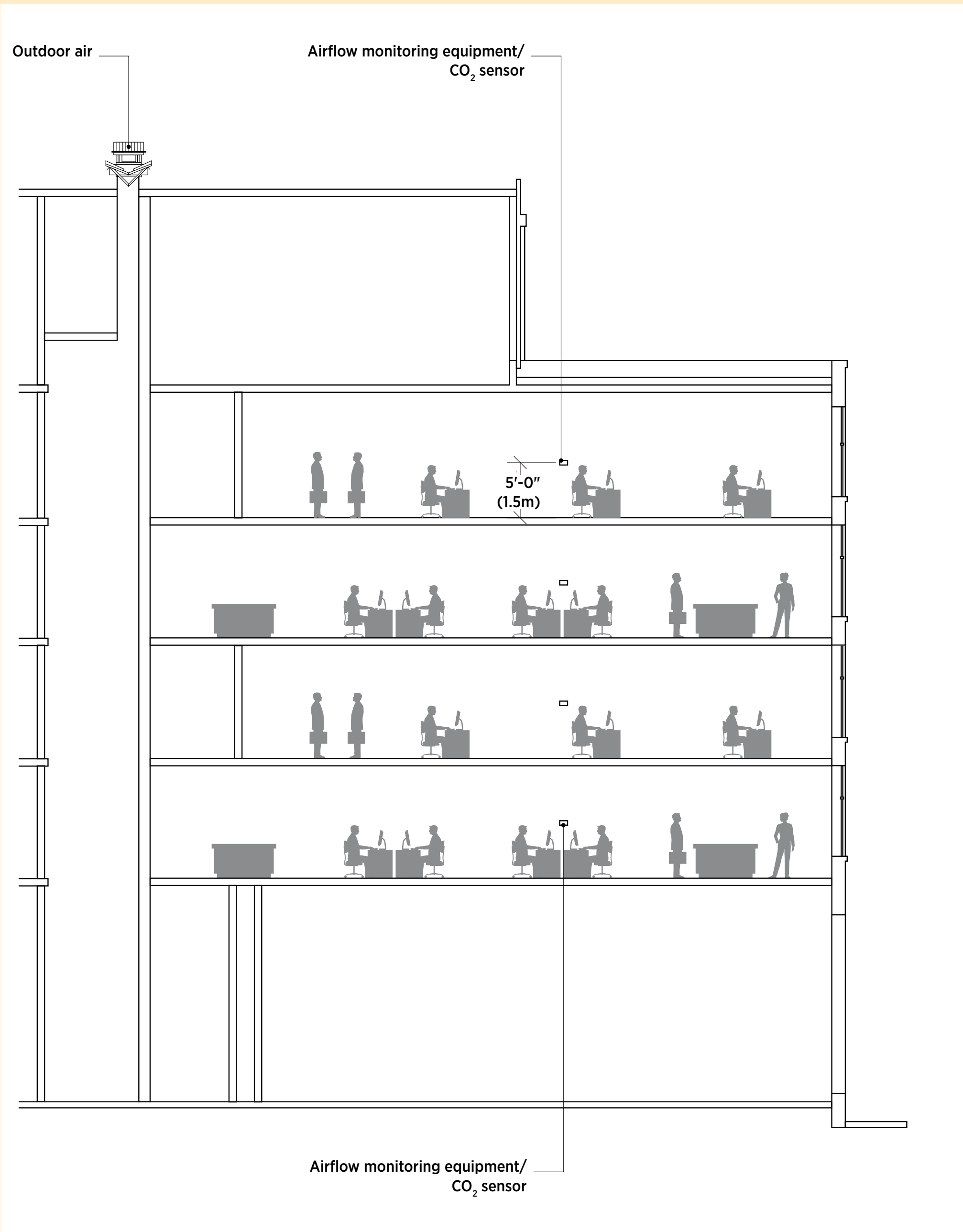


Figure 2. Example CO_2 sensor locations

FURTHER EXPLANATION

CALCULATIONS

For mechanical ventilation, Option 1, see ASHRAE 62.1–2010, Section 6.2, and ASHRAE 62.1–2010 User's Manual, Chapter 6.2. Refer to *ASHRAE Journal* articles[2] for additional information on the calculations.

For mechanical ventilation, Option 2, see CEN Standards EN 15251–2007 and EN 13779–2007.

For natural ventilation, see ASHRAE 62.1–2010, Section 6.4, and ASHRAE 62.1–2010 User's Manual, Chapter 6.4.

VENTILATION STRATEGIES

Investigate local outdoor air quality at the project location. If pursuing Option 1 for mechanically ventilated spaces, follow ASHRAE 62.1–2010, Section 4, or a local equivalent, whichever is more stringent. If pursuing Option 2 for mechanically ventilated spaces, see CEN Standard EN 13779–2007, Section 6.2.3.

Use the results of this analysis to inform ventilation strategy selection and system design. For example, natural ventilation may not be appropriate in high-pollution areas, where outdoor air requires significant filtration. Outdoor air quality may also affect mechanical equipment filtration specifications.

Consider how the building's form, location, orientation, programming, and depth of the floor plate can create opportunities for low-energy, high-quality natural ventilation or mixed-mode systems. For help in determining whether natural ventilation is feasible for a building or space, see Chartered Institute of Building Services Engineer (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Nondomestic Buildings, Figure 2.8 (flow chart).

ASHRAE Standard 62.1–2010 requires mechanical ventilation systems in addition to natural ventilation, unless specific exceptions are met. See ASHRAE Standard 62.1–2010, Section 6.4.

If mechanical ventilation is preferred, consider separating ventilation from thermal conditioning with a dedicated outdoor air system. These systems ensure that the correct amount of ventilation air is provided while minimizing overventilation and reducing energy consumption.

SHARED VENTILATION SYSTEM

If the project space is being served by a ventilation system that is also serving other areas in the building, the ventilation rate procedure (or CEN calculations) must account for the other areas in one of the following ways:

- Account for the total system population, area, supply air, and outdoor air volume. If applicable, the critical zone may be determined based on the spaces listed for the project. Perform floor area–weighted calculations to determine the required outdoor air ventilation rates.
- If a specific percentage of outdoor air, by volume, is being provided to the project space, this percentage may be used to determine the design outdoor airflow volume. The ventilation rate procedure is required only for the project spaces. This method is acceptable only if the majority of space use and occupancy in the building is consistent with the LEED project (e.g., the project is one or more floors in a downtown high-rise).
- To document compliance with this method, describe how the percentage of outdoor air by volume was determined and how the spaces outside the LEED project are used.

EXISTING VENTILATION SYSTEM

If the project space is ventilated by an existing mechanical system that cannot meet the minimum outdoor air requirements, as determined by ventilation rate procedure calculations, and physical or legal constraints prohibit its modification, Case 2 of the rating system applies.

For this option, an engineering assessment of the system must be performed. The assessment must identify the maximum outdoor air volume from the system and the constraints that prevent the required outdoor air rates, as determined by ventilation rate procedure calculations, from being delivered to the project space. Ensure that the

2. *Stanke, Dennis, "Single-Zone & Dedicated-OA Systems," ASHRAE Journal (October 2004); "Single-Path Multiple-Zone System Design," ASHRAE Journal (January 2005); "Designing Dual-Path Multiple-Zone Systems," ASHRAE Journal (May 2005).*

ventilation system provides the maximum amount of outdoor air possible at the worst-case operating conditions at existing setpoints. This prerequisite requires a minimum of 10 cubic feet per minute per person of outdoor air.

NATURAL VENTILATION EXCEPTIONS

ASHRAE Standard 62.1–2010, Section 6.4, requires naturally ventilated spaces to include a mechanical ventilation system unless one of the following exceptions applies:

- Ventilation openings comply with Section 6.4 and are permanently open.
- Ventilation openings comply with Section 6.4 and have controls that prevent them from being closed during times of expected occupancy.
- The naturally ventilated zone is not served by heating or cooling equipment.
- The system is an engineered natural ventilation system approved by the authority having jurisdiction (see *Further Explanation, Authority Having Jurisdiction Exception*).

TYPES OF MECHANICAL VENTILATION SYSTEMS

ASHRAE 62.1–2010 defines a ventilation zone as any area with similar occupancy categories, occupant density, zone air distribution effectiveness, and zone primary airflow per unit area. This differs from the definition of a thermal zone.

There are three main types of mechanical ventilation systems.

Single-zone system
This system delivers a mixture of outdoor air and recirculated air to only one ventilation zone. For example, a single rooftop unit that provides ventilation and conditioned air to three separate offices is likely to be considered a single-zone system, provided the offices are similar, as defined above.

Alternatively, a single rooftop unit that provides ventilation and conditioned air to an office and a conference room would not be considered a single-zone system, since these two spaces differ in occupancy category and occupant density, even though the unit itself is often considered "single-zone" because it only has one thermal zone. In this case, the unit must be analyzed using the method for multiple-zone recirculating systems.

A separate ventilation rate procedure calculation must be made for each single-zone system serving the building.

100% outdoor air system
This type of system delivers only outdoor air directly to one or more ventilation zones. The ventilation air cannot contain any recirculated air. For example, an energy recovery unit that provides 100% outdoor ventilation air to each space via a separate distribution system and mixes this air with air from only the same zone would be considered a 100% outdoor air system.

Alternatively, an energy recovery unit that provides 100% outdoor ventilation air to zone-level fan coil units that mix outdoor air with return air from other ventilation zones before delivering it to the space would not be considered a 100% outdoor air system. In this case, each fan coil unit must be analyzed as either a single-zone or a multiple-zone recirculating system.

A separate ventilation rate procedure calculation must be made for each 100% outdoor air system serving the building.

Multiple-zone recirculating system
This type of system delivers a mixture of outdoor air and recirculated air to more than one ventilation zone. Typical examples include a constant volume rooftop unit that serves more than one ventilation zone or a VAV system that serves an entire building.

A separate ventilation rate procedure calculation must be made for each multiple-zone recirculating system serving the building (see *Further Explanation, Calculations for Multiple-Zone Recirculating Systems*).

CALCULATIONS FOR MULTIPLE-ZONE RECIRCULATING SYSTEMS

Because of the complexity of the calculations for multiple-zone recirculating systems, project teams must use the 62MZCalc spreadsheet, or energy modeling software to perform the ventilation rate procedure calculations and determine the amount of outdoor air required at the system level.

System ventilation efficiency

Multiple-zone system calculations need to account for the inefficiency that occurs when the zones have different ratios of outdoor ventilation air to supply the air required for thermal conditioning. The calculations account for this through system ventilation efficiency (Ev) and by determining the critical zone.

The critical zone is the zone with the highest proportion of required outdoor air to provided supply air. Critical zones are often densely occupied spaces, such as conference rooms. When all zones are entered into the 62MZCalc spreadsheet, the critical zone for the system is determined automatically.

For large projects, it may not be feasible to enter each individual zone into the 62MZCalc spreadsheet. In these cases, the mechanical engineer can determine the outdoor air required for the system simply by identifying the potentially critical zone(s). For a detailed discussion of identifying critical zones, see ASHRAE Standard 62.1–2010, Appendix A–A3.1, Selecting Zones for Calculation, and ASHRAE 62.1–2010 User's Manual, Example 6-L.

Diversity factor

Alternatively, the multiple-zone system calculations may include a diversity factor to account for the movement of occupants between spaces, per ASHRAE Standard 62.1–2010, Section 6.2.5.3.1. For example, in a school, it is reasonable to assume that not all rooms are occupied simultaneously, because students and staff would not be in a classroom if they are eating lunch in the cafeteria. In this case, diversity can be applied, provided the classroom and cafeteria are served by the same ventilation system.

Diversity may not be applied to either single-zone or 100% outdoor air systems. If applying diversity, all calculations and assumptions must be included with the documentation.

If preliminary calculations indicate that a multiple-zone system does not comply with ASHRAE 62.1–2010 outdoor air requirements, consider the following before increasing outdoor air at the air-handling unit(s):

- Increase the amount of supply air (e.g., zone primary airflow, Vpz) to the critical zone. This has the effect of decreasing the primary outdoor air fraction, Zpz, which will increase system efficiency and reduce the total amount of outdoor air required.
- For systems with VAV terminal units, increase the minimum terminal unit flow rate setting for the critical zone. This has the same effect described above.

CONSIDERATIONS FOR VARIABLE OPERATING CONDITIONS

ASHRAE 62.1–2010 permits ventilation systems to reflect or respond to changes in zone occupancy in two ways, time-average population and dynamic reset. These two strategies cannot be applied simultaneously, however.

Time-average population. In spaces where peak occupancy occurs over only a short period, a time-average design population may be used, per ASHRAE 62.1–2010, Section 6.2.6.2 (see ASHRAE 62.1–2010 User's Manual, Examples 6-W, 6-X, 6-Y, 6-Z, and 6-AA). Project teams must include all calculations and assumptions used when submitting the ventilation rate procedure calculations for time-average population.

Dynamic reset. The system varies the flow of outdoor air as operating conditions change, thereby reducing the amount of energy needed to condition outdoor air. Demand-controlled ventilation is one of the most common reset strategies. Refer to ASHRAE 62.1–2010, Section 6.2.7, for dynamic reset requirements, some of which include the following:

- A minimum level of outdoor, based on the area outdoor air rate, must be provided to each ventilation zone at all times when dynamic reset is implemented. Refer to the ASHRAE standard's Section 6.2.7.1.2.
- The ventilation system must be controlled to provide the required amount of outdoor air in each zone, based on current occupancy. For a multiple-zone recirculating system, a single CO_2 sensor mounted in the return duct does not meet the requirements of ASHRAE 62.1–2010, since it does not guarantee that the appropriate amount of outdoor air will be provided to the critical zones. Refer to ASHRAE 62.1–2010 User's Manual, Appendix A, and the ASHRAE Journal[3] for demand-controlled ventilation approaches for multiple-zone systems and for CO_2 setpoint calculations.

3. *Stanke, Dennis, "Dynamic Reset for Multiple-Zone Systems," ASHRAE Journal (March 2010).*

LOCAL EQUIVALENT TO ASHRAE STANDARD 62.1–2010

If local code is more stringent than ASHRAE 62.1–2010 for the system design, use the local code.

For mechanically ventilated spaces, prepare the following documentation:

- A detailed summary comparing the two standards' requirements
- A comparison demonstrating that outdoor air requirements established by the local code for occupants and for floor area are at least as stringent as the ASHRAE standard
- Evidence that the local code incorporates the zone- and system-level efficiency of the ventilation systems in an equivalent or more stringent way than the ASHRAE ventilation rate procedure

For naturally ventilated spaces, prepare the following documentation:

- A detailed summary comparing the two standards' requirements for fenestration opening area, distance from window, and ceiling height
- A description of the engineered ventilation modeling approach, and documentation of approval by the local code authority

AUTHORITY HAVING JURISDICTION EXCEPTION

In some situations, compliance with this prerequisite is acceptable through an authority having jurisdiction exception. With this exception, the local code authority (the authority having jurisdiction) approves the plans and specifications used for the project's engineered natural ventilation approach. There are three possible situations for this exception: (1) the local code is ASHRAE Standard 62.1–2010, (2) the ventilation code governing the project is any code other than ASHRAE Standard 62.1–2010, and (3) USGBC is serving as the authority having jurisdiction for the purposes of LEED certification.

If USGBC is the authority having jurisdiction, a ventilation strategy that meets the intent of ASHRAE 62.1–2010 but does not meet the requirements of the ventilation rate procedure may be approved. It is highly recommended that project teams contact USGBC for approval of the engineered natural ventilation approach as early as possible, rather than waiting until the system has been fully designed.

If the local code is ASHRAE Standard 62.1–2010, provide the following documentation:

- Evidence that ASHRAE Standard 62.1–2010 (or a later version) is required for local building code compliance
- A description of the engineered ventilation modeling approach
- Documentation of plan approval by the local code authority

If the ventilation code governing the project is other than ASHRAE Standard 62.1–2010, provide the following:

- Evidence that the alternate code is at least as stringent as ASHRAE 62.1–2010 in its entirety (see *Further Explanation, Local Equivalent to ASHRAE Standard 62.1–2010*).
- A description of the engineered ventilation modeling approach
- Documentation of plan approval by the local code authority

If USGBC is serving as the authority having jurisdiction for the purposes of LEED certification, provide the following:

- A description of the engineered ventilation modeling approach
- Drawings and calculations or airflow analyses
- Evidence that the project's engineered natural ventilation system meets the intent of ASHRAE 62.1–2010. This documentation must clearly identify how the project does not meet the standard's natural ventilation requirements, and how the ventilation design has been engineered to meet the intent of the standard.

OCCUPIED VERSUS OCCUPIABLE

ASHRAE Standard 62.1–2010 requires occupiable spaces to be ventilated. For consistency with other LEED credits, this prerequisite uses the term *occupied*. Spaces classified as occupiable per Standard 62 are considered occupied for the purposes of LEED certification (see *Definitions*).

EXAMPLES

For mechanical ventilation, see ASHRAE 62.1–2010 User's Manual, Examples 6-F through 6-V.

For natural ventilation, see ASHRAE 62.1–2010 User's Manual, Examples 6-AC through 6-AF.

PROJECT TYPE VARIATIONS

Apparatus Bays in Fire Stations
Typically, these spaces are not designed for human occupancy and would not be required to meet the prerequisite requirements. However, if these spaces will be occupied, then the space must be ventilated according to the prerequisite requirements.

Vehicle Repair Facilities and Maintenance Bays
These space types include military buildings where trucks, tanks, aircraft, and other vehicles are being serviced. Because these are occupied spaces, they must meet the prerequisite requirements.

CAMPUS

Group Approach
Submit separate documentation for each project space.

Campus Approach
Ineligible. Each LEED project must pursue the prerequisite individually.

REQUIRED DOCUMENTATION

Documentation	Case 1 Options 1 and 2	Case 2	Naturally ventilated	Mixed mode
Description of ventilation systems within project scope of work; description of any shared ventilation systems and their effect on minimum ventilation rate calculations	X	X		X
Confirmation that project meets minimum requirements of ASHRAE 62.1–2010, Sections 4–7, or CEN Standard 13779–2007	X	X		X
Confirmation that project has MERV 11 or higher filters (if project is in nonattainment area for PM2.5)	X	X		
Confirmation that the project is in a non-attainment area for ozone (if applicable)	X	X	X	
Ventilation rate procedure or CEN calculations and documentation of assumptions for calculation variables	X	X		X
Engineering assessment of system's maximum outdoor air delivery rate, as applicable		X		X (if using Case 2)
Confirmation that project meets minimum requirements of ASHRAE Standard 62.1–2010, Section 7, and exhaust ventilation requirements of Section 6.5			X	X
Documentation of CIBSE flow diagram process for project			X	X
Natural ventilation procedure calculations and ventilation opening information			X	X
Any natural ventilation exception from mechanical ventilation system (ASHRAE 62.1–2010, Section 6.4)			X	X
Any exception from authority having jurisdiction			X	X
Controls drawing showing monitoring devices (outdoor airflow measuring device, current transducer, airflow switch, or similar monitor, automatic indication device, CO_2 sensor)	X	X	X	X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. Outdoor air can increase the amount of energy needed to heat and cool the building. Dynamic reset, such as demand-controlled ventilation, can reduce energy use.

EQ Credit Enhanced Indoor Air Quality Strategies. Airflow monitoring and increased ventilation addressed by this prerequisite will assist in earning the related credit.

EQ Credit Indoor Air Quality Assessment. The building's minimum outdoor air ventilation rate may affect the duration of the flush-out required for Option 2, Occupied Flush-Out, of the related credit.

CHANGES FROM LEED 2009

- ASHRAE Standard 62.1 has been updated to version 2010 from version 2007.
- ASHRAE 62.1–2010 natural ventilation calculations now consider window configuration and ceiling height.
- ASHRAE 62.1–2010 now requires supplementary mechanical ventilation systems for naturally ventilated spaces in some cases.
- Project teams are required to confirm the appropriate application of natural ventilation through CIBSE AM10, Figure 2.8 (flow chart).
- Projects outside the U.S. are now allowed to demonstrate achievement via CEN requirements (rather than ASHRAE 62.1–2010).
- This prerequisite now includes the monitoring requirements previously included in Indoor Environmental Quality Credit 1, Outdoor Air Delivery Monitoring. Additionally, the monitoring requirements now distinguish between variable air volume and constant volume systems.

REFERENCED STANDARDS

ASHRAE 62.1–2010: ashrae.org

ASHRAE Standard 170–2008: ashrae.org

2010 FGI Guidelines for Design and Construction of Health Care Facilities: fgiguidelines.org

CEN Standard EN 15251–2007: cen.eu

CEN Standard EN 13779–2007: cen.eu

CIBSE Applications Manual AM10, March 2005: cibse.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

occupiable space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are occupied only occasionally and for short periods of time (ASHRAE 62.1–2010)

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

unoccupied space an area designed for equipment, machinery, or storage rather than for human activities. An equipment area is considered unoccupied only if retrieval of equipment is occasional.

INDOOR ENVIRONMENTAL QUALITY PREREQUISITE

Environmental Tobacco Smoke Control

This prerequisite applies to:

Commercial Interiors
Retail
Hospitality

INTENT

To prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke.

REQUIREMENTS

Locate the project in a building that prohibits smoking by all occupants and users both inside the building and outside the building except in designated smoking areas located at least 25 feet (7.5 meters) from all entries, outdoor air intakes, and operable windows. Also prohibit smoking outside the property line in spaces used for business purposes.

If the requirement to prohibit smoking within 25 feet (7.5 meters) cannot be implemented because of code, provide documentation of these regulations.

Signage must be posted within 10 feet (3 meters) of all building entrances indicating the no-smoking policy.

BEHIND THE INTENT

Tobacco use kills more than five million people worldwide every year.[1] Smoking also puts nonsmokers at risk by exposing them to environmental tobacco smoke (ETS), often called secondhand smoke. In 2006, nearly half of all nonsmoking Americans were regularly exposed to secondhand smoke.[2] ETS exposure at home or in the workplace increases nonsmokers' risk of developing lung cancer, heart disease, and other serious health problems.[3]

Prohibiting indoor smoking is the only way to fully eliminate the health risks associated with ETS.[4] For this reason, designated indoor smoking rooms are not allowed in LEED-certified buildings. The prerequisite also prohibits smoking in outdoor areas used for business purposes. A business that uses a public sidewalk or courtyard for seating or kiosks still maintains control over those areas, even though they are typically outside the property boundary line. They are included under this prerequisite because the business owner still has control over the smoking policy in these areas.

Restricting the introduction of ETS into the building interior not only benefits human health, it also improves the longevity of building surfaces, air distribution systems, furniture, and furnishings when compared with those in buildings that allow smoking.[5]

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE SMOKE-FREE LOCATIONS

The smoking requirements apply to the LEED project space as well as areas occupied or managed by the base building and/or all other tenants.

- Identify the location of building openings, including entries, outdoor air intakes, and operable windows. Identify the property line and the location of outdoor areas used for business purposes, both inside and outside the property line. Indicate these elements on a site plan, map, or sketch.
- Emergency exits do not qualify as building openings if the doors are alarmed, because alarmed doors will not be opened. Emergency exits without alarms qualify as building openings.

The requirements may be challenging if the building does not already have a no-smoking policy. Commercial interiors projects should discuss smoking requirements with the owner and other tenants early in the project timeline to ensure compliance in areas not under the project team's control.

STEP 2. DESIGNATE LOCATIONS OF EXTERIOR SMOKING AREAS

Determine whether the project has or will have designated outdoor smoking areas. Locate any area designated for smoking at least 25 feet (7.5 meters) from smoke-free areas, based on the information gathered in Step 1. The 25-foot (7.5-meter) distance is a straight-line calculation.

- Consider design strategies that may encourage people to use the designated smoking area, such as covered seating.
- Educate occupants on the smoking policy and encourage them to self-police. This is particularly important in retail situations.
- Ash trays signal that smoking is allowed in a particular area. Be sure these are placed outside the 25-foot (7.5-meter) perimeter.

1. *World Health Organization, WHO Report on the Global Tobacco Smoke Epidemic (Geneva, 2009). who.int/tobacco/mpower/2009/gtcr_download/en/index.html (accessed June 10, 2013).*
2. *U.S. Department of Health and Human Services, The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General (Atlanta, Georgia, 2006), surgeongeneral.gov/library/reports/secondhandsmoke/report-index.html (accessed June 10, 2013).*
3. *Ibid.*
4. *Ibid.*
5. *Mudarri, D.H., The Costs and Benefits of Smoking Restrictions: An Assessment of the Smoke-Free Environment Act of 1993 (H.R.3434) (Washington, DC: Environmental Protection Agency, Office of Radiation and Indoor Air, Indoor Air Division, 1994), tobaccodocuments.org/landman/89268337-8360.html (accessed June 10, 2013).*

STEP 3. CONFIRM THAT SMOKING IS PROHIBITED IN NONDESIGNATED AREAS

Provide confirmation from the owner that smoking outside of designated areas is prohibited in any space used by the building for business purposes, even if the space falls outside the property line. Examples of spaces used for business purposes include sidewalk seating, kiosks, and courtyards.

- Smoking must be prohibited in areas within 25 feet (7.5 meters) from building openings.
- If smoking cannot be prohibited for the full 25-foot (7.5-meter) distance because of code restrictions, provide documentation of the regulation (see *Further Explanation, Code Limitations and Restrictions*).
- Smoking in the prohibited area is not allowed, even when the 25-foot (7.5-meter) distance extends beyond the property line. The boundary of the space for business purposes, other than a building opening, indicates the end of a nonsmoking area (see *Further Explanation, Property Line Less Than 25 Feet from the Building*).

The exterior smoking requirement must be complied with at the building level, regardless of where the project is located in the building.

- Exterior spaces used for business purposes by any tenants in the building or the owner of the building must be no-smoking, even if the spaces fall outside the property line.
- For example, if the LEED project occupies second-floor space in a building with multiple tenants, smoking is not allowed within 25 feet (7.5 meters) of any opening for the entire building.

STEP 4. DETERMINE LOCATIONS OF NO-SMOKING SIGNAGE

Post signage within 10 feet (3 meters) of all building entrances indicating that smoking is not allowed.

- Language on the signage is up to the project team. Two examples of successful language include "No smoking allowed within 25 feet" and "Smoking is allowed in designated smoking areas only."
- It may be helpful to stripe sidewalks to show the no-smoking boundary.

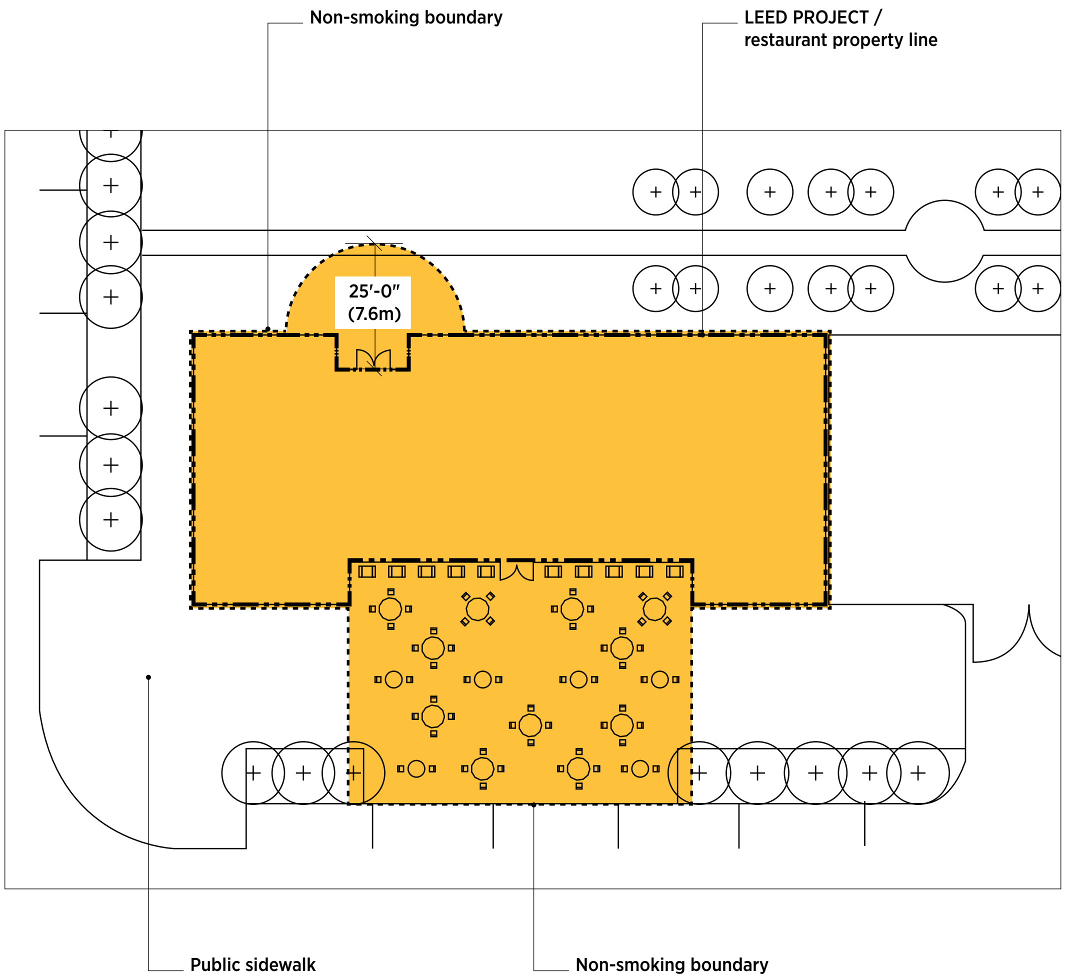
FURTHER EXPLANATION

PROPERTY LINE LESS THAN 25 FEET (7.5 METERS) FROM THE BUILDING

Projects with a property line less than 25 feet (7.5 meters) from the building must consider space usage when determining the outdoor smoking policy. The no-smoking requirement still applies to spaces outside the property line used for business purposes. Public sidewalks are not considered used for business purposes, but smoking must still be prohibited on sidewalks within 25 feet (7.5 meters) of openings. Building staff should be educated about this policy so that they can direct smokers to designated smoking areas and away from entrances or windows.

Examples of common business activities that would require the smoking prohibition include outdoor seating, outdoor stadium areas, courtyards, and banking kiosks.

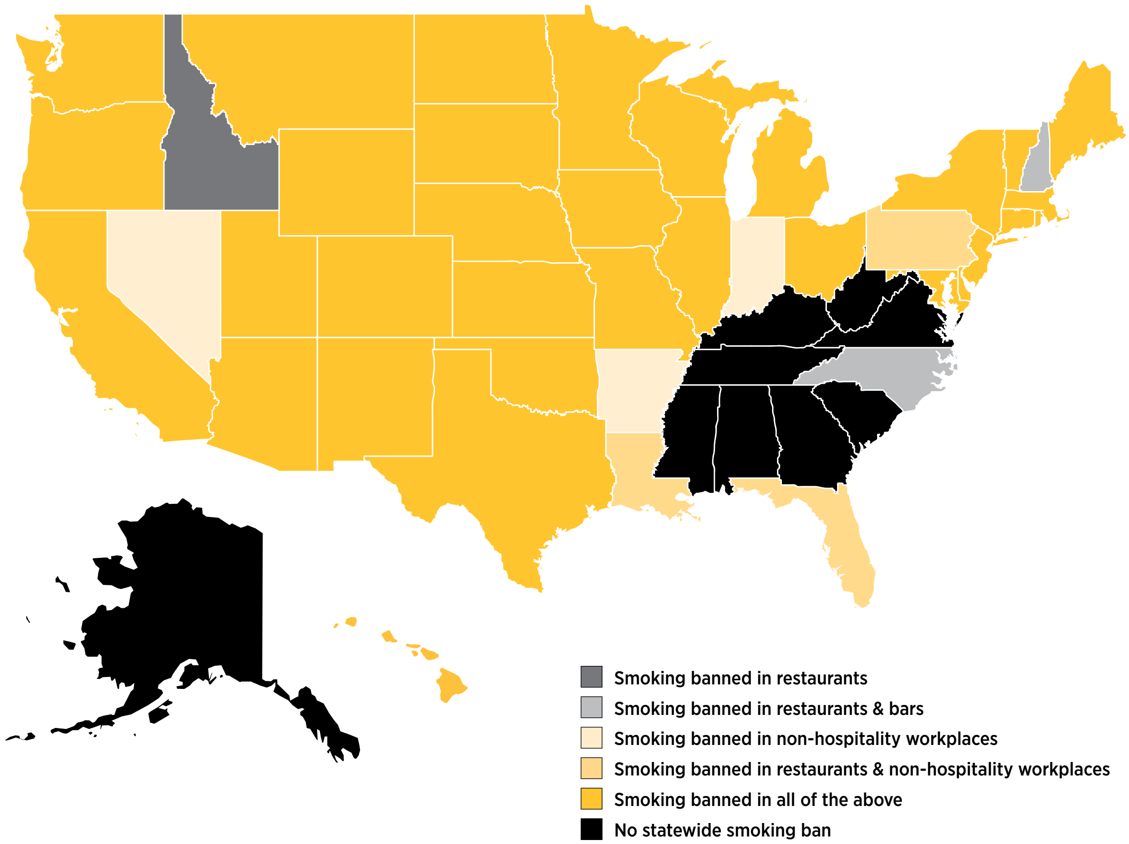
Figure 1. Example site plan with no smoking areas



CODE LIMITATIONS AND RESTRICTIONS

Many local governments ban smoking in the workplace and in public spaces. These regulations do not always meet the 25-foot (7.5-meter) distance for exterior smoking required by this prerequisite. In most cases, LEED projects can extend the smoking ban to the required 25 feet (7.5 meters), regardless of existing code. However, if existing code explicitly prohibits this, building owners may still achieve the prerequisite by providing documentation of the code.

Figure 2. Smoking bans by state



PROJECT TYPE VARIATIONS

Multitenant

Owners and property management teams for multitenant buildings may find it useful to communicate the interior and exterior smoking policy in tenant guidelines, handbooks, or similar documents.

CAMPUS

Group Approach

All project spaces in the group may be documented as one.

Campus Approach

Eligible.

REQUIRED DOCUMENTATION

Documentation	All projects where smoking is prohibited
Description of project's no-smoking policy, including information on how policy is communicated to building occupants and enforced	X
Scaled site plan or map showing location of designated outdoor smoking and no-smoking areas, location of property line, and site boundary and indicating 25-foot (7.5-meter) distance from building openings	X
Drawings, photos, or other evidence of signage communicating no-smoking policy	X
Any code or landlord restrictions that prevent establishment of no-smoking requirements	X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

- Designated interior smoking rooms are no longer permitted, with the exception of residential projects. This change recognizes the overwhelming evidence and broad consensus that exposure to ETS harms human health, and it supports increased levels of indoor air quality performance in LEED projects.
- The no-smoking policy has been expanded to apply to spaces outside the property line if the space is used for business purposes and is within 25 feet (7.5 meters) of building openings or outdoor air intakes.
- Projects must prohibit smoking by all occupants and users throughout the entire building. This expands on the previous requirement to prohibit smoking in the tenant space and common areas only.
- A specific requirement for the location of exterior posted signs has been added.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Enhanced Indoor Air Quality Strategies

This credit applies to:

Commercial Interiors (1-2 points)
Retail (1-3 points)
Hospitality (1-2 points)

INTENT

To promote occupants' comfort, well-being, and productivity by improving indoor air quality.

REQUIREMENTS

OPTION 1. ENHANCED IAQ STRATEGIES (1 POINT)

Comply with the following requirements, as applicable.

Mechanically ventilated spaces:

A. entryway systems;
B. interior cross-contamination prevention; and
C. filtration.

Naturally ventilated spaces:

A. entryway systems; and
B. natural ventilation design calculations.

Mixed-mode systems:

A. entryway systems;
B. interior cross-contamination prevention;
C. filtration;
D. natural ventilation design calculations; and
E. mixed-mode design calculations.

A. Entryway Systems
Install permanent entryway systems at least 10 feet (3 meters) long in the primary direction of travel to capture dirt and particulates entering the building at regularly used exterior entrances. Acceptable entryway systems include permanently installed grates, grilles, slotted systems that allow for cleaning underneath, rollout mats, and any other materials manufactured as entryway systems with equivalent or better performance. Maintain all on a weekly basis.

B. Interior Cross-Contamination Prevention
Sufficiently exhaust each space where hazardous gases or chemicals may be present or used (e.g., garages, housekeeping and laundry areas, copying and printing rooms), using the exhaust rates determined in EQ Prerequisite Minimum Indoor Air Quality Performance or a minimum of 0.50 cfm per square foot (2.54 l/s per square meter), to create negative pressure with respect to adjacent spaces when the doors to the room are closed. For each of these spaces, provide self-closing doors and deck-to-deck partitions or a hard-lid ceiling.

C. Filtration
Each ventilation system that supplies outdoor air to occupied spaces must have particle filters or air-cleaning devices that meet one of the following filtration media requirements:

- minimum efficiency reporting value (MERV) of 13 or higher, in accordance with ASHRAE Standard 52.2–2007; or
- Class F7 or higher as defined by CEN Standard EN 779–2002, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance.

Replace all air filtration media after completion of construction and before occupancy.

D. Natural Ventilation Design Calculations
Demonstrate that the system design for occupied spaces employs the appropriate strategies in Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005, Natural Ventilation in Non-Domestic Buildings, Section 2.4.

E. Mixed-Mode Design Calculations
Demonstrate that the system design for occupied spaces complies with CIBSE Applications Manual 13–2000, Mixed Mode Ventilation.

OPTION 2. ADDITIONAL ENHANCED IAQ STRATEGIES (1 POINT COMMERCIAL INTERIORS AND HOSPITALITY, 2 POINTS RETAIL)

Comply with the following requirements, as applicable.

Mechanically ventilated spaces (select one):

A. exterior contamination prevention;
B. increased ventilation;
C. carbon dioxide monitoring; or
D. additional source control and monitoring.

Naturally ventilated spaces (select one):

A. exterior contamination prevention;
B. additional source control and monitoring; or
C. natural ventilation room by room calculations.

Mixed-mode systems (select one):

A. exterior contamination prevention;
B. increased ventilation;
C. additional source control and monitoring; or
D. natural ventilation room-by-room calculations.

A. Exterior Contamination Prevention

Design the project to minimize and control the entry of pollutants into the building. Ensure through the results of computational fluid dynamics modeling, Gaussian dispersion analyses, wind tunnel modeling, or tracer gas modeling that outdoor air contaminant concentrations at outdoor air intakes are below the thresholds listed in Table 1 (or local equivalent for projects outside the U.S., whichever is more stringent).

TABLE 1. Maximum concentrations of pollutants at outdoor air intakes

Pollutants	Maximum concentration	Standard
Those regulated by National Ambient Air Quality Standards (NAAQS)	Allowable annual average **OR** 8-hour or 24-hour average where an annual standard does not exist **OR** Rolling 3-month average	National Ambient Air Quality Standards (NAAQS)

B. Increased Ventilation

Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates as determined in EQ Prerequisite Minimum Indoor Air Quality Performance.

C. Carbon Dioxide Monitoring

Monitor CO_2 concentrations within all densely occupied spaces. CO_2 monitors must be between 3 and 6 feet (900 and 1 800 millimeters) above the floor. CO_2 monitors must have an audible or visual indicator or alert the building automation system if the sensed CO_2 concentration exceeds the setpoint by more than 10%. Calculate appropriate CO_2 setpoints using methods in ASHRAE 62.1–2010, Appendix C.

D. Additional Source Control and Monitoring

For spaces where air contaminants are likely, evaluate potential sources of additional air contaminants besides CO_2. Develop and implement a materials-handling plan to reduce the likelihood of contaminant release. Install monitoring systems with sensors designed to detect the specific contaminants. An alarm must indicate any unusual or unsafe conditions.

E. Natural Ventilation Room-by-Room Calculations

Follow CIBSE AM10, Section 4, Design Calculations, to predict that room-by-room airflows will provide effective natural ventilation.

BEHIND THE INTENT

Indoor pollutants and particulates are brought indoors by occupants, through ventilation system intakes or building openings, and from activities conducted within the building. Designing for effective indoor air quality (IAQ) can help produce a comfortable indoor environment for building occupants and prevent the human health problems associated with poor indoor air quality.

This credit identifies IAQ strategies that extend beyond the outdoor air requirements of EQ Prerequisite Minimum Indoor Air Quality Performance. Design strategies include the installation of entryway systems to prevent contaminants from being brought inside by occupants, use of enhanced filtration media, increased ventilation, and monitoring strategies for ventilation systems. Each strategy alone is beneficial, but a combination of multiple strategies is encouraged.

STEP-BY-STEP GUIDANCE

STEP 1. DETERMINE HOW PROJECT IS VENTILATED

Determine whether the project will use mechanical ventilation, natural ventilation, or a mixed-mode approach (see EQ Prerequisite Minimum Indoor Air Quality Performance).

STEP 2. SELECT ONE OR BOTH OPTIONS

Determine which option(s) and strategies the project will pursue, based on the information in Table 1 and the credit requirements.

- Option 1 requires implementing all strategies applicable to the project's ventilation system type.
- Option 2 requires implementing one strategy applicable to the project's ventilation system type. If multiple ventilation system types are used (i.e., mixed mode), only one strategy needs to be attempted. For example, if a space is both naturally and mechanically ventilated, the project team could select carbon dioxide monitoring and implement this strategy by installing monitors that operate whenever the space is operating in mechanical ventilation mode. Similarly, if the project has both naturally and mechanically ventilated spaces, it could also select carbon dioxide monitoring and implement this strategy by installing monitors in all mechanically ventilated spaces.

TABLE 2. Ventilation systems and credit requirements

Option 1. Enhanced IAQ strategies					
	Entryway systems	Interior cross-contamination prevention	Filtration	Natural ventilation design calculations	Mixed-mode design calculations
Mechanically ventilated space	REQUIRED	REQUIRED	REQUIRED	N/A	N/A
Naturally ventilated space	REQUIRED	N/A	N/A	REQUIRED	N/A
Mixed-mode system	REQUIRED	REQUIRED	REQUIRED	REQUIRED	REQUIRED
Option 2. Additional enhanced IAQ strategies					
	Exterior contamination prevention	Increased ventilation	Carbon dioxide monitoring	Additional source control and monitoring	Natural ventilation room-by-room calculations
Mechanically ventilated space	SELECT 1 OF 4				N/A
Naturally ventilated space	SELECT 1 OF 3	N/A	N/A	SELECT 1 OF 3	
Mixed-mode system	SELECT 1 OF 4		N/A	SELECT 1 OF 4	

STEP 3. COMPLY WITH APPROPRIATE STRATEGY REQUIREMENTS

For each strategy required for a given space's ventilation system, follow the appropriate set of steps. Prepare a narrative indicating the system type and strategies pursued, detailing how compliance was achieved.

Option 1. Enhanced IAQ Strategies

ENTRYWAY SYSTEMS

STEP 1. IDENTIFY APPLICABLE ENTRIES

Identify all regularly used exterior entrances to the building (see *Further Explanation, Regularly Used Exterior Entrances*). Projects that do not have direct access to the exterior are exempt from this requirement.

STEP 2. INCORPORATE PERMANENT ENTRYWAY SYSTEMS INTO THE DESIGN

Determine which type of permanent entryway system will be installed and incorporate into the project drawings and specifications (see *Further Explanation, Selecting a Permanent Entryway System*). Indicate the compliant entryways on project plans.

STEP 3. IMPLEMENT MAINTENANCE STRATEGY

Determine how the entryway systems will be maintained on a weekly basis. Consider modifying standard operating procedures, cleaning programs, and vendor requirements to include entryway maintenance.

INTERIOR CROSS-CONTAMINATION PREVENTION

STEP 1. IDENTIFY ALL SPACES NEEDING INTERIOR CROSS-CONTAMINATION PREVENTION

Identify spaces where hazardous gases or chemicals may be handled or used, as indicated in the credit requirements.

- Open garages are exempt from this requirement.
- Include housekeeping and laundry areas even if green cleaning policies are adopted.
- Copying and printing rooms with convenience printers and copiers only may be excluded. The definition of convenience printers and copiers is left to the discretion of the design team; convenience machines are generally small units shared by many office personnel for short printing and copying jobs.

STEP 2. DEVELOP CONTAMINANT CONTROL DESIGN

Work with the architect and mechanical designer to develop a contaminant control design for all spaces needing interior cross-contamination prevention and incorporate strategies into the project drawings and specifications.

- Include self-closing doors and either deck-to-deck partitions or a hard-lid ceiling for each space, as indicated in the credit requirements.
- Design the exhaust system such that each space has negative pressure, as indicated in the credit requirements. Use the exhaust rates from EQ Prerequisite Minimum Indoor Air Quality Performance or 0.50 cfm per square foot, whichever is greater (see *Further Explanation, Exhaust Rates for Interior Cross-Contamination Prevention*).
- Additional ductwork and exhaust fans may be needed to provide the required ventilation. Possible strategies to achieve the necessary ventilation economically include stacking all high-pollutant source areas and locating rooms with hazardous material adjacent to outside walls and each other.

FILTRATION MEDIA

STEP 1. SPECIFY COMPLIANT FILTRATION MEDIA

Identify all HVAC equipment that supplies outdoor air to occupied spaces and specify outdoor air filtration media that meet the credit requirements for minimum efficiency reporting value (MERV) ratings or filtration class. All outdoor air supplied to occupied spaces must be filtered.

- Ensure that specified air-handling equipment is designed to accommodate the required filter media. Otherwise, customization—resizing ductwork, increasing fan capacity to maintain air delivery despite the added resistance of MERV 13 (F7) filtration, or other modifications to system design—may be required.

- Mixed return and outdoor air can also be filtered with MERV 13 (F7) or higher, but this is not required.
- If the project design includes a dedicated outdoor air system with local distribution systems, the filtration requirement only applies to the dedicated outdoor air system.

STEP 2. REPLACE FILTRATION BEFORE OCCUPANCY

Replace all filters after completion of construction but before occupancy.

NATURAL VENTILATION DESIGN CALCULATIONS

STEP 1. REVIEW STANDARD

Review the basic forms of ventilation strategy presented in Chartered Institution of Building Service Engineers Applications (CIBSE) Manual AM10, Natural Ventilation in Non-Domestic Buildings, Section 2.4: single-sided ventilation, single opening, double opening, cross-ventilation, stack ventilation, double-skin facade ventilation, mechanically assisted strategies, and night ventilation. Identify which ventilation strategies apply to the project.

STEP 2. CONFIRM RULES OF THUMB FOR ESTIMATING EFFECTIVENESS OF NATURAL VENTILATION

Use the rules of thumb or guidance from CIBSE AM10 as applicable to the project. Prepare diagrams and narratives to explain how each applicable rule of thumb or guidance was considered. The documentation should supplement the natural ventilation calculations for EQ Prerequisite Minimum Indoor Air Quality Performance.

MIXED-MODE VENTILATION DESIGN CALCULATIONS

STEP 1. REVIEW STANDARD

Review the mixed-mode design strategies presented in Chartered Institution of Building Service Engineers (CIBSE) Applications Manual AM13, Mixed-Mode Ventilation, Section 2.1: contingency design, complementary design, and zone design. Identify which mixed-mode strategy applies to the project. If the complementary design is selected, also identify the operational strategy based on CIBSE AM13, Section 2.2.

Use CIBSE AM13, Figure 2.1, as the iteration strategy to optimize the mixed mode system.

STEP 2. CONFIRM THAT DESIGN FOLLOWS APPROPRIATE MIXED-MODE STRATEGIES

Use the guidance and strategies from CIBSE AM13 (Section 2.1, Section 2.2, and Figure 2.1) as applicable to the project. Prepare diagrams and narratives to explain how the guidance was considered. The documentation should supplement that prepared for EQ Prerequisite Minimum Indoor Air Quality Performance and requirement D (natural ventilation design calculations) in this credit.

Option 2. Additional Enhanced IAQ Strategies

Determine which strategy the project will implement, based on Table 1.

EXTERIOR CONTAMINATION PREVENTION

STEP 1. DESIGN OUTDOOR AIR INTAKES TO MINIMIZE AND CONTROL ENTRY OF POLLUTANTS

The exterior contaminant prevention applies to all outdoor air intakes that serve the project space. Consider locating outdoor air intakes away from nearby sources. Air intakes located one-third of the way up the side of the building tend to work best.[1] Locate air intakes away from loading docks, at ground level near roadways, below grade in areaways, or on roofs near exhausts.[2] ASHRAE 62.1–2010, Table 5-1, lists minimum separation distances for air intakes (see *Further Explanation, International Tips*).

1. *Spengler, J.D., J.M. Samet, and J.F. McCarthy, Indoor Air Quality Handbook* (*New York: McGraw-Hill, 2001*).
2. *Ibid.*

STEP 2. SELECT MODELING TOOL

Determine which modeling tool, of the list in the credit requirements, will be used to verify compliance with pollution concentration requirements. Consider whether the software can accurately capture expected meteorological conditions, potential pollutant plumes, and contaminant concentrations at the project's outdoor air intakes.

STEP 3. COMPLETE LEVEL 1 SCREENING

Model contaminant travel at worst-case meteorological conditions. Worst-case conditions should be based on the wind speed and direction, with a direct line of sight from each pollutant source to the project building.

Once worst-case conditions have been identified, perform a simulation to determine whether concentrations for the pollutants regulated by National Ambient Air Quality Standards (NAAQS) at outdoor air intakes are below the allowable annual average, eight-hour or 24-hour average where an annual standard does not exist, or the rolling three-month average. If all pollutant concentrations are well below the required thresholds, no further modeling is required.

STEP 4. COMPLETE LEVEL 2 SCREENING

If the Level 1 screening indicates that pollutant concentrations are barely compliant or noncompliant, perform a Level 2 screening to reassess pollutant concentrations. Use more detailed inputs pertaining to atmospheric processes, building geometry, and emissions concentrations. If the precise composition of chemical exhaust from a source is unpublished, document how the team arrived at its components and concentrations.

The Level 2 screening should confirm one of the following outcomes:

- The concentrations for the pollutants regulated by NAAQS at outdoor air intakes are below the allowable annual average, eight-hour or 24-hour average where an annual standard does not exist, or the rolling three-month average.
- The indoor concentrations for the pollutants regulated by NAAQS are below 2.5% of the allowable annual average, eight-hour or 24-hour average where an annual standard does not exist, or the rolling three-month average. Indoor analyses may require a different modeling technique than that used in the Level 1 dispersion analysis. If the Level 2 screening indicates that pollutant concentrations are noncompliant, consider modifying air filtration or the locations of the outdoor air intakes.

INCREASED VENTILATION

STEP 1. DETERMINE VOLUME OF OUTDOOR AIR REQUIRED

Use the ventilation standard or code and the calculation methodology selected for EQ Prerequisite Minimum Indoor Air Quality Performance to determine the 30% increase.

- Follow the prerequisite's steps for mechanical ventilation systems to determine the amount of outdoor air that must be supplied by each ventilation system. To meet the credit requirements, the system must deliver 30% more outdoor air to the occupied spaces at all times the space is occupied. For multiple-zone recirculating systems, this will likely increase the required outdoor air intake for the system by more than 30%.
- For projects that use ASHRAE 62.1–2010, see *Further Explanation, Determining Increased Ventilation Rate*.
- Exhaust rates are excluded from the credit requirements.

STEP 2. REVISE DESIGN TO MEET OUTDOOR AIR REQUIREMENTS, IF NECESSARY

See EQ Prerequisite Minimum Indoor Air Quality Performance for recommended modifications for specific mechanical ventilation system types.

CARBON DIOXIDE (CO_2) MONITORING

STEP 1. IDENTIFY DENSELY OCCUPIED SPACES

Review ventilation calculations developed for EQ Prerequisite Minimum Indoor Air Quality Performance or the project's furniture plans to identify all spaces with an occupant density greater than 25 people per 1,000 square feet (93 square meters).

STEP 2. DESIGN THE CO_2 MONITORING SYSTEM

Incorporate CO_2 sensors into the design for each densely occupied space.

- CO_2 sensors must be installed in the breathing zone as defined in the credit requirements. CO_2 sensors installed in return air ducts cannot be used to meet the requirements of this credit.
- Determine CO_2 concentration setpoint(s) using the methods in ASHRAE 62.1–2010, Appendix C. See ASHRAE 62.1–2010 User's Manual, Appendix A, for calculations and examples.
- Configure the CO_2 monitoring system to generate an alarm if the differential CO_2 concentration exceeds the setpoint by more than 10%. Alarms may be audible or visual indicators to space occupants or building automation system alerts. CO_2 sensors may be incorporated into the HVAC control system, for example, to open zone VAV dampers when the setpoint is exceeded. However, this is not required.

STEP 3. INSTALL AND COMMISSION CO_2 SENSORS

During construction, install CO_2 sensors per the design. Include CO_2 sensors in the commissioning process for EA Prerequisite Fundamental Commissioning and Verification.

ADDITIONAL SOURCE CONTROL AND MONITORING

STEP 1. DETERMINE POTENTIAL CONTAMINANT SOURCES

List potential indoor air contaminants that may be present in the project spaces. Consider typical substances found in the particular building types, and review activities and processes that will occur. Substances might include cleaning supplies, laboratory chemicals, or materials required for manufacturing.

STEP 2. IDENTIFY PRIORITY CONTAMINANTS AND EXPOSURE LIMITS

From the list of potential sources, identify the priority contaminants—those that pose the greatest risk to occupants' health. For each priority contaminant, identify a reference standard and an exposure limit.

STEP 3. DESIGN AND INSTALL MONITORING SYSTEM

Install a permanent monitoring system to continuously monitor concentrations of priority contaminants. Configure the system to generate an alarm when unusual or unsafe concentrations occur.

- Retain documentation that describes how alarm setpoints were established.
- Include the contaminant monitoring system in the commissioning process for EA Prerequisite Fundamental Commissioning and Verification.

STEP 4. DEVELOP AND IMPLEMENT MATERIALS HANDLING PLAN

Develop a materials handling plan to limit human exposure to priority contaminants and ensure that the monitoring system is effective. For example, a materials handling plan may require that a particular solvent be stored and used in a single room that is properly ventilated and equipped with sensors connected to an alarm.

NATURAL VENTILATION ROOM-BY-ROOM CALCULATIONS

STEP 1. DETERMINE REQUIRED FLOW RATES

Follow CIBSE AM10, Section 4.1, to determine the desired airflow rates.

STEP 2. DETERMINE OPENING SIZES

Follow CIBSE AM10, Sections 4.1.2, 4.1.3, 4.1.4, 4.2, and 4.3, as applicable, to determine whether the design will produce sufficient airflow rates and to optimize opening sizes, locations, and characteristics. These sections offer many calculation options. All options are acceptable, provided inputs and results are justified and reasonable.

STEP 3. CONFIRM COMPLIANCE

Create a table of all naturally ventilated spaces in the project, opening characteristics, desired flow rates, and calculated flow rates. Indicate how seasonal conditions and different wind conditions were considered.

Determine the free area of natural ventilation openings and the required opening area. Confirm that natural ventilation openings meet or exceed the sizes calculated for all spaces. The documentation should supplement that developed for EQ Prerequisite Minimum Indoor Air Quality Performance and Option 1, requirement D (natural ventilation design calculations) in this credit.

FURTHER EXPLANATION

CALCULATIONS

See the referenced standards for all calculations.

REGULARLY USED EXTERIOR ENTRANCES

See *Definitions* to help in identifying regularly used entrances.

For renovation or additions where the scope of the project does not include an exterior entrance, entryway systems do not need to be installed. However, if the project scope includes an entrance that would qualify as a regularly used exterior entrance, the team must ensure that appropriate entryway systems are also installed.

SELECTING A PERMANENT ENTRYWAY SYSTEM

Permanent entryway systems must catch and hold dirt particles and prevent contamination of the building interior. Acceptable permanent entryway systems include the following:

- Permanently installed grates
- Grilles
- Slotted systems that allow for cleaning underneath
- Rollout mats
- Carpet tile specifically designed for entryway system or similar use
- Other materials manufactured for use as an entryway system or similar that performs at least as well as the above systems

Typical building carpeting is not an acceptable permanent entryway system.

Consider permanent entryway systems that have solid backings. A nonporous backing captures dirt and moisture and helps prevent contaminants from collecting underneath. Consider permanent entryway systems made with mold- and mildew- resistant materials.

The permanent entryway system should be at least 10 feet (3 meters) long. Exceptions to the 10-foot (3-meter) distance are allowed if the team submits documentation verifying that the proposed entryway system performs at least as well as a full-length system. The selected product should be appropriate for the project's climate. Areas with high precipitation, for example, may need to install more absorbent mats to prevent occupants from slipping.

Evaluate maintenance requirements when selecting the permanent entryway system. All permanent entryway systems must be maintained on a weekly basis.

EXHAUST RATES FOR INTERIOR CROSS-CONTAMINATION PREVENTION

In general, exhaust rates are prescribed by the ventilation standard or code used in EQ Prerequisite Minimum Indoor Air Quality Performance. However, if this standard or code does not set a requirement for a particular space type, a minimum exhaust rate of 0.5 cubic feet per minute (cfm) per square foot (2.54 liters per second, l/s, per square meter) must be used.

ASHRAE 62.1–2010, Table 6-4, lists numerous spaces whose exhaust requirements exceed the 0.5 cfm per square foot (2.54 l/s per square meter) rate. Exhaust rates for these spaces must be maintained at all times, even when the building is not occupied.

If supply air is being provided to the room, the exhaust rate must be sufficient to create a negative pressure with respect to adjacent spaces when the doors to the room are closed.

No recirculation of the air from these rooms is permitted.

DETERMINING INCREASED VENTILATION RATES

When using ASHRAE 62.1–2010, use the following process to determine the 30% increase in ventilation for the breathing zone:

Single-zone or 100% outdoor air system. Calculate the required outdoor intake flow using the ventilation rate procedure and multiple the result by 1.3.

Multiple-zone recirculating system. At the system level, multiply the uncorrected outdoor air requirements for the system, V_{ou}, by 1.3. Multiply the outdoor airflow (V_{bz}) in the critical zone's breathing zone by 1.3. Recalculate the system ventilation efficiency, Ev, based on the revised values for V_{ou} and critical zone V_{bz}. This will likely increase the required outdoor air intake for the system (V_{ot}) by more than 30%.

INTERNATIONAL TIPS

For Option 2, local guidelines for maximum concentrations of pollutants at air intakes may be followed, provided they are at least as stringent as the U.S. EPA guideline.

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
Entryway systems: scaled floor plans showing locations and measurements	X	
Interior cross-contamination prevention: list of rooms, areas, exhaust rate, separation method	X	
Filtration: mechanical schedules highlighting MERV or class ratings for all units that supply outdoor air	X	
Natural ventilation design: calculations and narrative demonstrating appropriate strategies per referenced standard	X	
Mixed mode design: calculations and narrative demonstrating appropriate strategies per referenced standard	X	
Exterior contamination prevention: narrative describing type of modeling; model output reports highlighting contaminant levels and required thresholds		X
Increased ventilation: confirmation (calculations are documented under EQ Prerequisite Minimum Indoor Air Quality Performance)		X
Carbon dioxide monitoring: controls drawing sample showing CO_2 monitors and densely occupied space		X
Additional source control and monitoring: description of likely air contaminants and how they were identified, description of materials handling plan, plans showing installed monitoring system		X
Natural ventilation: room-by-room calculations, narrative, and diagrams demonstrating effective natural ventilation per referenced standard		X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. Increased filtration and increased ventilation affect energy consumption. Consider incorporating energy efficiency measures, such as dedicated outdoor air systems, economizers, and demand-controlled ventilation, to reduce or eliminate potential energy penalties.

EQ Prerequisite Minimum Indoor Air Quality Performance. The ventilation system referenced in the related prerequisite must be consistent with this credit.

CHANGES FROM LEED 2009

- Portions of IEQ Credit 1 Outdoor Air Delivery Monitoring, IEQ Credit 2 Increased Ventilation, and IEQ Credit 5 Indoor Chemical and Pollutant Source Control have been combined into a single credit.
- Meeting the requirements of interior cross-contamination prevention no longer requires a calculation of a minimum pressure differential. However, the exhaust rates from the ventilation standard in EQ Prerequisite Minimum Indoor Air Quality Performance must be used. For spaces that do not have a requirement from this standard, a minimum exhaust rate of 0.5 cubic feet per minute per square foot (2.54 liters per second per square meter) must be used.
- Additional options regarding naturally ventilated spaces have been included.
- An option for filtration media requirements, CEN Standard EN 779–2002, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance, has been added.

REFERENCED STANDARDS

ASHRAE Standard 52.2–2007: ashrae.org

CEN Standard EN 779–2002: www.cen.eu/

ASHRAE Standard 62.1–2010: ashrae.org

Chartered Institution of Building Services Engineers (CIBSE) Applications Manual AM10, March 2005: cibse.org

Chartered Institution of Building Services Engineers (CIBSE) Applications Manual 13–2000: cibse.org

National Ambient Air Quality Standards (NAAQS): epa.gov/air/criteria.html

EXEMPLARY PERFORMANCE

Achieve both Option 1 and Option 2 and incorporate an additional Option 2 strategy.

DEFINITIONS

densely occupied space an area with a design occupant density of 25 people or more per 1,000 square feet (93 square meters)

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

regularly occupied space an area where one or more individuals normally spend time (more than one hour per person per day on average) seated or standing as they work, study, or perform other focused activities inside a building. The one-hour timeframe is continuous and should be based on the time a typical occupant uses the space. For spaces that are not used daily, the one-hour timeframe should be based on the time a typical occupant spends in the space when it is in use.

regularly used exterior entrance a frequently used means of gaining access to a building. Examples include the main building entrance as well as any building entryways attached to parking structures, underground parking garages, underground pathways, or outside spaces. A typical entrances, emergency exits, atriums, connections between concourses, and interior spaces are not included.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Low-Emitting Materials

This credit applies to:

Commercial Interiors (1-3 points)
Retail (1-3 points)
Hospitality (1-3 points)

INTENT

To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment.

REQUIREMENTS

This credit includes requirements for product manufacturing as well as project teams. It covers volatile organic compound (VOC) emissions into indoor air and the VOC content of materials, as well as the testing methods by which indoor VOC emissions are determined. Different materials must meet different requirements to be considered compliant for this credit. The building interior and exterior are organized in seven categories, each with different thresholds of compliance. The building interior is defined as everything within the waterproofing membrane. The building exterior is defined as everything outside and inclusive of the primary and secondary weatherproofing system, such as waterproofing membranes and air- and water-resistive barrier materials.

OPTION 1. PRODUCT CATEGORY CALCULATIONS

Achieve the threshold level of compliance with emissions and content standards for the number of product categories listed in Table 2.

TABLE 1. Thresholds of compliance with emissions and content standards for 7 categories of materials

Category	Threshold	Emissions and content requirements
Interior paints and coatings applied on site	At least 90%, by volume, for emissions; 100% for VOC content	• General Emissions Evaluation for paints and coatings applied to walls, floors, and ceilings • VOC content requirements for wet applied products
Interior adhesives and sealants applied on site (including flooring adhesive)	At least 90%, by volume, for emissions; 100% for VOC content	• General Emissions Evaluation • VOC content requirements for wet applied products
Flooring	100%	• General Emissions Evaluation
Composite wood	100% not covered by other categories	• Composite Wood Evaluation
Ceilings, walls, thermal, and acoustic insulation	100%	• General Emissions Evaluation
Furniture	At least 90%, by cost	• Furniture Evaluation

TABLE 2. Points for number of compliant categories of products

Compliant categories	Points
3	1
5	2
6	3

OPTION 2. BUDGET CALCULATION METHOD

If some products in a category do not meet the criteria, project teams may use the budget calculation method (Table 3).

TABLE 3. Points for percentage compliance, under budget calculation method

Percentage of total	Points
≥ 50% and < 70%	1
≥ 70% and < 90%	2
≥ 90%	3

The budget method organizes the building interior into six assemblies:

- flooring;
- ceilings;
- walls;
- thermal and acoustic insulation;
- furniture; and

Walls, ceilings, and flooring are defined as building interior products; each layer of the assembly, including paints, coatings, adhesives, and sealants, must be evaluated for compliance. Insulation is tracked separately.

Determine the total percentage of compliant materials according to Equation 1.

EQUATION 1. Total percentage compliance

$$\text{Total \% compliant for projects with furniture} \quad \left\{ \frac{(\text{\% compliant walls} + \text{\% compliant ceilings} + \text{\% compliant flooring} + \text{\% compliant insulation}) + (\text{\% compliant furniture})}{5} \right\}$$

EQUATION 2. System percentage compliant

$$\text{Flooring, walls, ceilings, insulation \% compliant} = \left\{ \frac{\left(\text{compliant surface area of layer 1} + \text{compliant surface area of layer 2} + \text{compliant surface area of layer 3} + \ldots\right)}{\left(\text{total surface area of layer 1} + \text{total surface area of layer 2} + \text{total surface area of layer 3} + \ldots\right)} \right\} \times 100$$

EQUATION 3. Furniture systems compliant, using ANSI/BIFMA evaluation

$$\text{\% compliant for furniture} = \left\{ \frac{0.5 \times \text{cost compliant with §7.6.1 of ANSI/BIFMA e3-2011} + \text{cost compliant with §7.6.2 of ANSI/BIFMA e3-2011}}{\text{total furniture cost}} \right\} \times 100$$

Calculate surface area of assembly layers based on the manufacturer's documentation for application.

If 90% of an assembly meets the criteria, the system counts as 100% compliant. If less than 50% of a assembly meets the criteria, the assembly counts as 0% compliant.

Manufacturers' claims. Both first-party and third-party statements of product compliance must follow the guidelines in CDPH SM V1.1–2010, Section 8. Organizations that certify manufacturers' claims must be accredited under ISO Guide 65.

Laboratory requirements. Laboratories that conduct the tests specified in this credit must be accredited under ISO/IEC 17025 for the test methods they use.

Emissions and Content Requirements

To demonstrate compliance, a product or layer must meet all of the following requirements, as applicable.

Inherently nonemitting sources. Products that are inherently nonemitting sources of VOCs (stone, ceramic, powder-coated metals, plated or anodized metal, glass, concrete, clay brick, and unfinished or untreated solid wood flooring) are considered fully compliant without any VOC emissions testing if they do not include integral organic-based surface coatings, binders, or sealants.

General emissions evaluation. Building products must be tested and determined compliant in accordance with California Department of Public Health (CDPH) Standard Method v1.1–2010, using the applicable exposure scenario. The default scenario is the private office scenario. The manufacturer's or third-party certification must state the exposure scenario used to determine compliance. Claims of compliance for wet-applied products must state the amount applied in mass per surface area.

Manufacturers' claims of compliance with the above requirements must also state the range of total VOCs after 14 days (336 hours), measured as specified in the CDPH Standard Method v1.1:

- 0.5 mg/m³ or less;
- between 0.5 and 5.0 mg/m³; or
- 5.0 mg/m³ or more.

Projects outside the U.S. may use products tested and deemed compliant in accordance with either (1) the CDPH standard method (2010) or (2) the German AgBB Testing and Evaluation Scheme (2010). Test products either with (1) the CDPH Standard Method (2010), (2) the German AgBB Testing and Evaluation Scheme (2010), (3) ISO 16000-3: 2010, ISO 16000-6: 2011, ISO 16000-9: 2006, ISO 16000-11:2006 either in conjunction with AgBB, or with French legislation on VOC emission class labeling, or (4) the DIBt testing method (2010). If the applied testing method does not specify testing details for a product group for which the CDPH standard method does provide details, use the specifications in the CDPH standard method. U.S. projects must follow the CDPH standard method.

Additional VOC content requirements for wet-applied products. In addition to meeting the general requirements for VOC emissions (above), on-site wet-applied products must not contain excessive levels of VOCs, for the health of the installers and other tradesworkers who are exposed to these products. To demonstrate compliance, a product or layer must meet the following requirements, as applicable. Disclosure of VOC content must be made by the manufacturer. Any testing must follow the test method specified in the applicable regulation.

- All paints and coatings wet-applied on site must meet the applicable VOC limits of the California Air Resources Board (CARB) 2007, Suggested Control Measure (SCM) for Architectural Coatings, or the South Coast Air Quality Management District (SCAQMD) Rule 1113, effective June 3, 2011.
- All adhesives and sealants wet-applied on site must meet the applicable chemical content requirements of SCAQMD Rule 1168, July 1, 2005, Adhesive and Sealant Applications, as analyzed by the methods specified in Rule 1168. The provisions of SCAQMD Rule 1168 do not apply to adhesives and sealants subject to state or federal consumer product VOC regulations.
- For projects outside the U.S., all paints, coatings, adhesives, and sealants wet-applied on site must either meet the technical requirements of the above regulations, or comply with applicable national VOC control regulations, such as the European Decopaint Directive (2004/42/EC), the Canadian VOC Concentration Limits for Architectural Coatings, or the Hong Kong Air Pollution Control (VOC) Regulation.
- If the applicable regulation requires subtraction of exempt compounds, any content of intentionally added exempt compounds larger than 1% weight by mass (total exempt compounds) must be disclosed.
- If a product cannot reasonably be tested as specified above, testing of VOC content must comply with ASTM D2369-10; ISO 11890, part 1; ASTM D6886-03; or ISO 11890-2.
- For projects in North America, methylene chloride and perchloroethylene may not be intentionally added in paints, coatings, adhesives, or sealants.

Composite Wood Evaluation. Composite wood, as defined by the California Air Resources Board, Airborne Toxic Measure to Reduce Formaldehyde Emissions from Composite Wood Products Regulation, must be documented to have low formaldehyde emissions that meet the California Air Resources Board ATCM for formaldehyde requirements for ultra-low-emitting formaldehyde (ULEF) resins or no added formaldehyde resins.

Salvaged and reused architectural millwork more than one year old at the time of occupancy is considered compliant, provided it meets the requirements for any site-applied paints, coatings, adhesives, and sealants.

Furniture evaluation. New furniture and furnishing items must be tested in accordance with ANSI/BIFMA Standard Method M7.1–2011. Comply with ANSI/BIFMA e3-2011 Furniture Sustainability Standard, Sections 7.6.1 and 7.6.2, using either the concentration modeling approach or the emissions factor approach. Model the test results using the open plan, private office, or seating scenario in ANSI/BIFMA M7.1, as appropriate. USGBC-approved equivalent testing methodologies and contaminant thresholds are also acceptable. For classroom furniture, use the standard school classroom model in CDPH Standard Method v1.1. Documentation submitted for furniture must indicate the modeling scenario used to determine compliance.

Salvaged and reused furniture more than one year old at the time of use is considered compliant, provided it meets the requirements for any site-applied paints, coatings, adhesives, and sealants.

BEHIND THE INTENT

Many types of chemicals, both engineered and naturally occurring, are present everywhere. Volatile organic compounds (VOCs) are chemicals that are released into the air from numerous materials—some of them natural, humanmade, plant-based, and from animals, including people. Prolonged exposure to high concentrations of some VOCs has been linked to a wide range of chronic health problems such as asthma, chronic obstructive pulmonary disease, and cancer. Short-term exposure to VOCs can also cause acute reactions, such as eye, nose, and throat irritation.

Some VOCs are present in the natural environment; however, higher concentrations of VOCs are typically found indoors, where reduced air ventilation and numerous sources of VOCs may exist. Although completely eliminating exposure to all VOCs is impossible, specifying low-emitting and nonemitting products will significantly reduce the strength and quantity of VOC exposure indoors.

Project teams should specify products that meet the compliance thresholds established by recognized standards, or choose products classified as inherently nonemitting (see *Further Explanation, About the Referenced Standards*). Ideally, all interior building materials—from furniture and furnishings to thermal and acoustic insulation and the interior finishes of all floors, walls, and ceilings—would be compliant. This credit, however, uses a holistic systems approach that rewards teams for partial compliance, recognizing compliance of product assemblies even if some of their elements do not meet the applicable standard.

This credit addresses each layer of wall, flooring, and ceiling interior finish—a methodology that is conservatively protective of occupants, given that the emissions from layers that are not directly exposed to air are tested separately.

Air concentration measurements from chamber testing are a much better predictor of emissions over time than VOC content limits. However, chamber emissions testing is generally more expensive, less widely adopted for wet-applied products, and unable to evaluate emissions generated at the time of application. The credit still limits VOC for on-site wet-applied products, in part to avoid environmental damage (e.g., smog formulation) and in part to protect the people who apply these products or are exposed to them during installation.

STEP-BY-STEP GUIDANCE

STEP 1. RESEARCH AND SPECIFY LOW- OR NONEMITTING FINISHES AND FURNITURE

Review project documents to identify all applicable products and specify them as low- or nonemitting.

Research products that meet the requirements by having one or more of the following characteristics:

- The product is inherently nonemitting. Examples of nonemitting products are stone, ceramic, powder-coated metals, plated or anodized metal, glass, concrete, clay brick, and unfinished or untreated solid wood flooring, provided they do not include integral organic-based surface coatings, binders, or sealants (see *Further Explanation, Inherently Nonemitting Materials*).
- The manufacturer has self-declared the product's compliance and provides appropriate documentation, as outlined in the credit requirements.
- The product has third-party certification of compliance.

In most cases, turning to third-party certification to recognized guidelines, such as California Department of Public Health (CDPH) Standard Method v1.1, is the easiest way to find and specify products; in other cases, self-declared compliance to a standard, such as South Coast Air Quality Management District (SCAQMD) Rule 1113, is widespread and sufficient. Check that the appropriate version of the testing method was used to test the product Check the USGBC website for an up-to-date listing of certification programs that test to the referenced standards (see *Further Explanation, Testing Standards*).

Provide the contractor with detailed specifications to ensure that the team has the information needed to meet the credit requirements. The design team should specifically call out products that have been researched and confirm that they meet the credit requirements.

Request the specific documentation that will be required for the certification review, such as material safety data sheets (MSDS), third-party certificates, and test reports from subcontractors; this will help in procuring compliant products. Certificates must state the testing methodology and the model as appropriate. The units must be stated and be consistent with those as required. For wet-applied products, the manufacturer must state each product's classification and application according to the referenced standard's definitions or be otherwise justified; how it's used in the project does not count as justification. For example, a defined roof coating is not a carpet adhesive simply because it was used this way on the project. If the product is classified as a roof coating under SCAQMD, it must meet the appropriate limit for roof coatings.

Specifying only compliant products is the easiest way to ensure that the credit requirements are met and the building will have the lowest possible emissions. But Option 2 allows project teams to substitute a noncompliant product if necessary.

The credit requirements need to be met for all products and materials installed within the waterproofing membrane (see *Definitions*).

STEP 2. PERFORM CONSTRUCTION SUBMITTAL REVIEWS

During construction, coordinate a review of the construction submittals to ensure that selected products meet the credit requirements and do not exceed the allocated VOC emissions.

- Because meeting these credit requirements is not typical for all construction teams and suppliers, conducting a LEED-specific preconstruction meeting to review the credit requirements in detail and stress their importance will aid in successful product procurement.
- Any product substitutions should be carefully reviewed by the design team and contractor for compliance with credit requirements. Such lists are good resources for design teams and contractors to consult when sourcing products that may meet the requirements of this credit. Some manufacturers have a list of LEED compliant products on their websites.

STEP 3. SELECT ONE OPTION

Based on the research performed and products purchased in each category identified in the credit requirements, determine which option is more appropriate for the project.

- Option 1 is simpler but less flexible, since partial credit (i.e., less than the minimum percentage compliance required) in one category cannot be combined with partial credit in another category. If the minimum percentage compliance cannot be attained in a category, project teams must use Option 2.
- Option 2 offers a budget calculation method that categorizes building interior products and materials into six "assemblies." If at least 50% of an assembly is compliant, partial credit for that assembly can be combined with partial credit from another assembly to earn points, which ensures that teams can receive partial credit for specifying compliant low-emitting products or materials in each assembly category if full compliance is not readily achievable.
- Option 2 may also allow the project to achieve more points and demonstrate higher overall compliance, even if the Option 1 requirements are also feasible.

Option 1. Product Category Calculations

STEP 1. IDENTIFY ALL APPLICABLE PRODUCTS

List all specified interior paints, coatings, adhesives, sealants, flooring, composite wood, ceilings, walls, thermal and acoustic insulation, and furniture.

- During the construction submittal review process, obtain manufacturer documentation confirming compliance for each product category. All products must comply with each applicable threshold requirement. If two requirements exist, the product must comply with both requirements.
- The most effective way to track this credit is for one team member to keep a running list of products and their compliance information (e.g., VOC content, emissions testing, emissions percentage by volume), with manufacturers' documentation.
- Furniture must be included, regardless of who specified or provided it.
- Adhesives, sealants, paints, and coatings used on site with flooring products are considered interior adhesives and sealants or interior paints and coatings, as appropriate. The flooring itself must meet the requirements of the flooring product category.
- For wet-applied product categories, 90% of products must meet emissions criteria and 100% must meet VOC content criteria.
- To demonstrate the project's overall attainment of 100% of the VOC content criteria, compare the

baseline case and the design case in a VOC content budget. If the design (or actual) level is less than the baseline, the credit requirement is satisfied. The values used in the comparison calculation are the g/L of VOCs contained in the product. To determine the budget, multiply the volume of the product used by the threshold VOC level for the baseline case from the appropriate referenced standard; use the actual product VOC level for the design case. If a product with high VOC levels is applied unintentionally, use the VOC budget approach to determine whether compliance can nevertheless be attained.

- **Example.** SCAQMD Rule 1113 sets the allowable VOC content limit for faux finishing coatings—trowel-applied coatings at 350 g/L. A subcontractor mistakenly used 50 liters of a faux finish coating with 450 g/L VOC content. The project team must now create a budget for all paints and coatings installed in the project to offset this product, which does not meet the Rule 1113 limits.

TABLE 4. SCAQMD Rule 1113

Regulation	Product type	General emissions criteria met?	Volume installed (l)	Allowable VOC content	Actual VOC content	VOC budget	
						Baseline case (g)	Design case (g)
SCAQMD Rule 1113	Faux finishing coatings—trowel-applied coatings	YES	50	350	450.00	17,500	22,500
SCAQMD Rule 1113	Clear wood finishes—sanding sealers	YES	55	275	150	15,125	8,250
						VOC budget baseline case total (g)	**32,625**
						VOC budget design case total (g)	**30,750**

STEP 2. PERFORM BUDGET CALCULATION METHOD (AS NECESSARY)

A different budget may be used if threshold requirements cannot be achieved for the material categories specified in the credit requirements. That is, if 100% of the product category does not meet the requirements, use the budget calculation method in Option 2.

Option 2. Budget Calculation Method

STEP 1. IDENTIFY ASSEMBLIES

Break out assembly components for each category (flooring, ceilings, walls, insulation, and furniture).

- For each product in an assembly, calculate the surface area for typical wall, ceiling, and floor areas (see *Further Explanation, Building Products and Systems*).
- Identify products that are full-spread, such as paint or carpet adhesive, according to the manufacturer's documentation for application.

STEP 2. CALCULATE TOTAL PERCENTAGE COMPLIANCE

Use Equation 1 in the credit requirements to calculate the total percentage compliance. Generate take-offs and review estimates from subcontractors to calculate the surface area for each product. Equations 2 and 3 may be required to generate values for Equation 1.

For assemblies, use the following guidelines:

- If all layers of an assembly are compliant, the entire surface area (square footage or square meters) counts. Not-full-spread, wet-applied products are included in the definition of interior finish if they are installed on site.
- If some layers of an assembly are noncompliant, calculate the weighted average using Equation 2.
- At least 50% of an assembly must be compliant to contribute to credit compliance: if less than 50% of the assembly is compliant, it counts as 0%; if 90% of the assembly meets the criteria, it counts as 100% compliant.

If some furniture is noncompliant, calculate the percentage of compliance using Equation 3.

FURTHER EXPLANATION

CALCULATIONS

See calculations in the credit requirements.

ABOUT THE REFERENCED STANDARDS

As VOC emissions test methods and related criteria have advanced, the choices in standards have significantly improved. In the very early days of LEED, only proprietary criteria and incomplete standards were available, which did not promote competition between laboratories or provide consistent comparisons between products. However, after much research and work in this area, qualified laboratories, manufacturers, and third-party certification organizations are now available to support the choice of safe interior materials (see *Further Explanation, Testing Standards*).

The science behind these credit criteria is complex. Compliance with the credit requires testing agencies to measure millionths of a gram of a chemical compound in a cubic meter of air under tightly controlled laboratory conditions, and then equate these measurements to standard building conditions to correlate the results with real-world conditions.

Selection of the referenced standards included consideration of the following factors:

- Leadership and scientific basis of target criteria (necessary for market transformation)
- Rigor of the standards (specificity, consistency, repeatability across competing assessors)
- Standard development process (proprietary business interest, open balanced consensus)
- Market adoption (balanced with other factors but high enough to ensure credit success)
- Harmonization with best practices (necessary for efficiency and economical application)

When multiple, competing criteria exist, purchasers find it difficult to make meaningful comparisons among products and materials. If compliance with all cited standards were required, manufacturers (and ultimately customers) would pay for duplicative tests and evaluations, wasting precious time and resources. Thus, harmonization on baseline standards is essential for market clarity and efficiency.

INHERENTLY NONEMITTING MATERIALS

Naturally occurring materials and products that are made from inorganic materials (e.g., granite) emit either very low or no VOCs. USGBC recognizes that such products do not need to undergo testing to prove they do not emit VOCs. For the purposes of this credit, untreated and unfinished solid wood (not engineered wood) flooring can also be considered nonemitting even though such flooring will likely emit some amount of formaldehyde naturally. This applies only to flooring materials, not to wood paneling or cabinetry.

TESTING STANDARDS

CDPH Standard Method v1.1

This credit uses the California Department of Public Health (CDPH) Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers, v. 1.1–2010, for the emissions testing and requirements of all products and materials except furniture. The method, widely recognized as a leadership standard for its stringent scientific criteria and detailed specificity, was developed through an open, consensus process. It uses the chronic reference exposure levels established by the California Office of Environmental Health Hazard Assessment, which include some of the most stringent criteria in use. It also adopted and incorporated the first edition of the ANSI/BIFMA M7.1 standard test method for furniture.

There is no total volatile organic compound (TVOC) pass-fail requirement in the CDPH standard, which focuses on measuring and limiting individual VOCs. However, this credit requires manufacturers using the CDPH standard to also disclose the range of TVOC for each product, a requirement intended to provide greater transparency for project teams, especially when they are comparing similar materials. Though TVOC alone is a crude measurement not suitable for health-based determinations of acceptability, it is useful as a general indicator in combination with individual VOC measurements, since higher TVOC may suggest the need for additional investigation.

CARB ATCM composite wood formaldehyde regulation

This credit uses the California Air Resources Board (CARB) 93120 Airborne Toxic Control Measure (ATCM) for formaldehyde emissions from composite wood products. It provides a way to determine the compliance of composite wood materials used in products not covered by full VOC testing in other categories. CARB 93120 ATCM is required in California but widely used internationally.

This credit uses not the minimum requirements of the CARB 93120 ATCM but the more stringent requirements for ultra-low-emitting formaldehyde (ULEF) resins or no added formaldehyde based resins, as defined in the CARB ATCM. These criteria are some of the strongest available for formaldehyde emissions from composite wood.

Although composite wood compliance with the CARB formaldehyde criteria is beneficial, chamber testing for a broader range of individual VOCs emitted from assembled products that include composite wood in combination with other components can provide a better determination of a product's potential effect on indoor air quality. Therefore, the composite wood criteria of this credit do not apply to composite wood covered by the full VOC testing of other categories.

ANSI/BIFMA standards

This credit requires that all furniture VOC emissions testing be conducted in accordance with the ANSI/BIFMA M7.1–2011 Standard Test Method for Determining VOC Emissions from Office Furniture Systems, Components and Seating. The second edition of this standard incorporates important advances that include defining an emissions factor approach for compliance, refining the mathematical estimation procedures for nonmeasured time points, and adding specific, highly detailed surface area calculation requirements to ensure consistency.

This credit also requires furniture to comply with the low-emitting requirements in the ANSI/BIFMA e3–2011 Furniture Sustainability Standard. This standard includes both the historical VOC emissions requirements for furniture from earlier versions of LEED and the health-based requirements from the 2010 version of the CDPH standard, both as concentration limits and as maximum emissions factors. These emissions factor limits effectively increase the stringency of the standard and make it easier for furniture component suppliers to modify their products for compliance.

International standards

Recognizing the need for additional compliance options for projects outside the U.S., this credit also references select international standards, which can be used only under specific conditions because of the complicated nature of air quality standards.

The German AgBB Testing and Evaluation Scheme (2010) is a leading industry standard that can be used for this credit, with some limitations. The AgBB standard does not represent a European consensus but does share common attributes with several European counterparts. It addresses six times more individual VOC requirements than the CDPH standard, and it specifies TVOC and total semivolatile organic compound (TSVOC) limits for all nonregulated substances. However, the standard has limitations, including the following:

- The formaldehyde limit value of 10 $\mu g/m^3$ at 28 days must also be met when using the AgBB alternative, as specified for class A+ in French compulsory VOC emissions class labeling.
- The AgBB requirements use different exposure scenario conditions than CDPH. Because VOC emissions from building materials generally decrease over time, the point in time for determining compliance is critical. The more time there is for off-gassing to occur, the easier it may be to meet the standard, even though in many cases the difference is minor (most emissions decay within the first week). CDPH requires compliance at 14 days; the full AgBB requirements apply at three or 28 days, which this credit does not take into account.

Similarly, this credit allows the use of the ISO 16000 series standards when combined with the AgBB standard, the cited French legislation (Decree no 2011-321 and arrêté of 19 April 2011), or the DIBT method (German Institute for Building Technology, *Principles of Health Assessment of Construction Products in Indoor Environments,* 2010 dibt.de/de/data/Aktuelles_Ref_II_4_6.pdf). The ISO 16000 series standards do not contain enough detail to be cited alone for testing in this credit. The same requirements for formaldehyde also apply in each of these cases.

Referenced mass VOC regulatory standards

The U.S. regulatory system for adhesives and sealants captures a limited range of listed product categories and excludes small packages intended for consumer use. The leading CARB and SCAQMD regulations are well ahead of other state and national regulations. Historically, CARB has developed the suggested control measure (SCM) coatings regulatory framework later adopted by some U.S. states and Canada. SCAQMD created a widely cited regulatory system for sealants and adhesives packaged and designed for commercial applications.

This credit includes requirements for all product categories found in the referenced standards. Product categories that are not listed do not need to be tracked. The credit incorporates various district, state, and national regulations limiting the overall VOC content in coatings, sealants, and adhesives. These regulatory limits serve as a minimum requirement, in addition to emissions testing standards listed in the general emissions requirements.

Because of divergent regulatory development processes, the coatings categories, category definitions, and VOC limits vary between CARB SCM and SCAQMD Rule 1113. Suppliers should provide information on the proper categorization of their materials consistent with definitions in the referenced regulations.

For projects outside the U.S., existing national VOC regulations may serve as the credit requirement. The Canadian VOC Concentration Limits for Architectural Coatings and the Hong Kong Air Pollution Control (VOC) Regulation are examples of local regulations deemed equivalent to the CARB SCM and SCAQMD Rule 1113. Project teams should contact USGBC to determine additional equivalent regulations. Establishing parity or a direct comparison with cited U.S. regulations is difficult, given varying definitions of product categories, the VOC status of specific solvents, and varying applications of the less-water and exempt-solvent approaches.

Information on any VOC compounds exempt from regulation is required for credit compliance. Cited regulatory limits do not include the VOC content of colorants added to coatings at the point of sale. Pretinted flat, nonflat, industrial maintenance coatings and stains include the VOC content of all ingredients, including colorants.

BUILDING PRODUCTS AND SYSTEMS

Use Table 5 to calculate the surface area for each layer in a building system. For all building systems listed in the table, salvaged and reused items more than one year old at the time of occupancy do not require testing.

TABLE 5. Building products and systems

Building system	Includes	Exceptions	Calculations
Insulation (thermal and acoustic)	Includes following (whether part of building interior or exterior): • Thermal and acoustical boards, batts, rolls, blankets • Sound attenuation fire blankets • Loose fill insulation • Spray foam insulation (open and closed cell)	Insulation on interior or exterior of HVAC ductwork may be excluded (because of lack of modeling scenarios)	Total area of insulation is based on installed planar areas of each insulation type, irrespective of placement of insulation (e.g., exterior or interior wall use). Total area of insulation for project is sum of planar areas of all types of insulation in defined scope. Percentage of compliant insulation is calculated based on percentage of compliant insulation surface area. If insulation system comprises more than one component, all components identified in spreadsheet matrix must be compliant for system to qualify for full credit. Otherwise, use Equation 2 to determine credit percentage. Example of multicomponent insulation system is insulation board bonded to structural components with adhesive.
Flooring	Includes all finished flooring: • Subflooring • Fluid and trowel-applied adhesives and grout (full spread only) • Engineered wood • Resilient flooring • Carpeting • Mineral-based tile	Testing not required: • Mineral-based finished flooring without integral organic-based modifiers, or topically applied film-forming or penetrating coatings such as tile, terrazzo, and masonry • Associated site-applied adhesives, grouts, and sealers must be meet requirements for adhesives and sealants. • Untreated and unfinished solid wood flooring	Total finished floor area for project is sum of areas of all flooring. Percentage of compliant flooring is calculated based on percentage of compliant floor area. If flooring system comprises more than one component, all components identified in spreadsheet matrix must be compliant for system to qualify for full credit. Flooring systems generally comprise multiple components; identify all components in spreadsheet matrix. This includes all site-applied products and materials such as adhesives, underlays, grouting, stains, and sealers. Examples of multicomponent flooring systems are carpet with cushion, resilient flooring with flooring adhesive, wood flooring with site-applied finish, cut stone flooring with site-applied sealer, tile with adhesive and grout, and concrete finish consisting of stain, sealer and top coat.

TABLE 5. (CONTINUED) Building products and systems

Ceilings	• Overhead structural elements (exposed, finished, unfinished) • Direct-applied ceiling systems • Suspended systems (including canopies and clouds) • Glazed skylights • Examples include painted drywall and plaster, acoustical suspension systems, specialty systems (plastic, metal, wood), and painted or otherwise finished structural elements • When it is unclear what is wall versus ceiling, project teams may classify elements either way, as they deem appropriate	Testing not required: • Exposed concrete • Exposed metal structural elements • Factory-finished metal ceiling products • Glazing • Ceiling systems considered architectural woodwork must comply with prescriptive material requirements specified for built-in cabinetry • Bare concrete or metal structural elements; tile, masonry and cut stone without integral organic-based coatings and sealants; transition strips	Total ceiling area for project is ceiling plan area for project plus areas of additional finished ceiling planes. Percentage of compliant ceiling is calculated based on percentage of compliant ceiling area. If ceiling system comprises more than one component, all components identified in USGBC's low-emitting materials calculator must be compliant for system to qualify for full credit. Examples of multicomponent ceiling systems are drywall panel with skim coat, primer and finish paint; manufactured wood coffer applied with adhesive; and any ceiling surface with site-applied paint or coating.
Walls	• Generally vertical structural elements (exposed, finished, unfinished) • All finish wall treatments • Interior columns • Exterior and interior wall glazing • Doors • Partial-height vertical surfaces (e.g., transoms, bulkheads, pony walls, knee walls, and similar structures normally constructed and finished on-site) • Architectural woodwork applied to walls • Built-in cabinetry • Floor-to-ceiling, moveable. demountable wall systems and partitions • When it is unclear what is wall versus ceiling, project teams may classify elements either way, as they deem appropriate.	• Office furniture system partitions (e.g., partial-height or floor-to-ceiling cubicle panels that are manufactured off-site) are addressed under Furniture and furnishings Testing not required: • Bare concrete or metal structural elements; tile, masonry and cut stone without integral organic-based coatings and sealants; factory-finished metal wall products; and glazing. • Plaster and stucco without >1% organic additives • Wall systems considered to be architectural woodwork must comply with prescriptive material requirements specified for built-in cabinetry (see below) • Salvaged and reused architectural woodwork is available for credit without any requirements other than those associated with site-applied paints, coatings, adhesives, sealants	Total wall area for project is total interior surface area of all elements within scope of wall systems category. Because of potential complexity of area calculations for large projects, wall surface areas may be estimated as for painting. Percentage of compliant wall systems is calculated based on percentage of compliant wall area. If wall system is comprises more than one component, all components identified in spreadsheet matrix must be compliant for system to qualify for full credit. Examples of multicomponent wall systems are drywall panel and acoustic panel applied with adhesive, drywall panel with primer and finish paint coats, and movable wall system with wood frame, wood door, and fabric-covered acoustic panels.
Built-in cabinetry (subcategory of wall systems in Option 2)	Includes all furniture-like items built on site that are typically procured by general contractor at earlier stage than furniture and furnishings • Examples: cabinets, other storage units, shelving, product-display units, integrated or built-in reception desks and seating		Total emitting surface area of built-in cabinetry is the area exposed to interior For built-in cabinetry, compliance is determined based on following prescriptive construction criteria intended to limit sources of indoor VOC contaminants: • Products with composite woods constituting all or portion of product (e.g., countertops, cabinetry with composite wood cores and internal components) must be constructed with composite wood documented to have low formaldehyde emissions (compliant to CARB ATCM limits for no added formaldehyde or ultra-low formaldehyde emitting). Materials with no defined category under ATCM must follow requirements for particleboard. Built-in cabinetry constructed of inherently nonemitting materials (e.g., metal with factory-applied powder coating or plating) are eligible for credit without testing. • Site-applied finishes must comply with VOC content limits and VOC emissions limits for paints and coatings. • Site-applied adhesives must comply with VOC content limits for adhesives and sealants.

TABLE 5. (CONTINUED) Building products and systems

Furniture and Furnishings	All stand-alone furniture items purchased for project • Examples: individual and group seating; open-plan and private office workstations; desks and tables of all types; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted, visual display products (e.g., markerboards and tackboards, excluding electronic display products); and miscellaneous items (e.g., easels, mobile carts, freestanding screens, and movable partitions) • Movable partitions include office furniture system cubicle panels that are typically integrated with work surfaces, desks, and storage furniture.	• Salvaged and reused furniture more than one year old at time of occupancy is available for credit without any IAQ testing • Office accessories (e.g., desk-top blotters, trays, tape dispensers, waste baskets, work tools normally hung on office cubicle panels, monitor arms, and all electrical items such as desk lamps and small appliances) are excluded	Total amount of stand-alone furniture for project and the relative contributions of these products is based on purchase costs (i.e., excluding labor for installation). To achieve full credit, 50% or more of total stand-alone furniture costs must be compliant for project to earn credit for this category. Product compliance of 90% or more is treated as 100%. Furniture and furnishing items must be tested following ANSI/BIFMA Standard Method M7.1–2011. Compliance must be determined based on BIFMA e3–2011 Furniture Sustainability Standard, Sections 7.6.1 and 7.6.2 using either concentration modeling approach or emission factor approach. Model test results using open plan, private office, or seating scenario in ANSI/BIFMA M7.1 as appropriate. USGBC-approved equivalent testing methodologies and contaminant thresholds are also acceptable. For classroom furniture, use standard school classroom model in CDPH Standard Method v1.1. Documentation submitted for furniture must indicate modeling scenario used to determine compliance. To be compliant, furniture must comply with Section 7.6.1 or Section 7.6.2 of BIFMA e3–2011.

DEFINITION OF BUILDING INTERIOR AND EXTERIOR

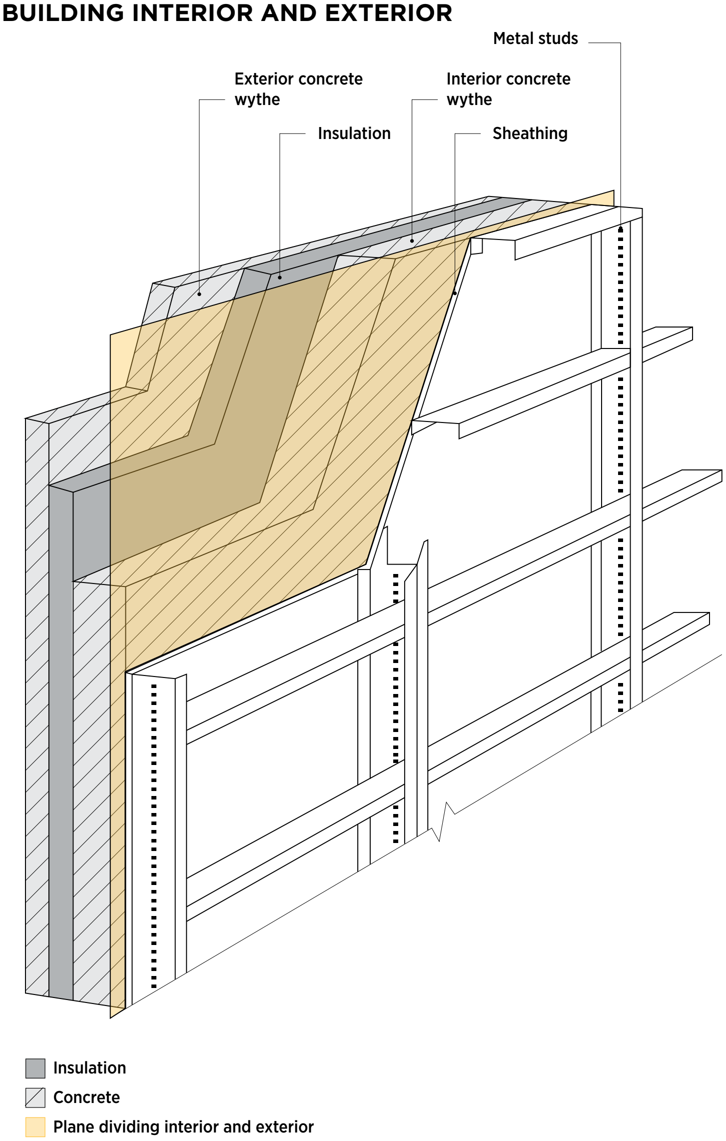


Figure 1. Insulated concrete panel

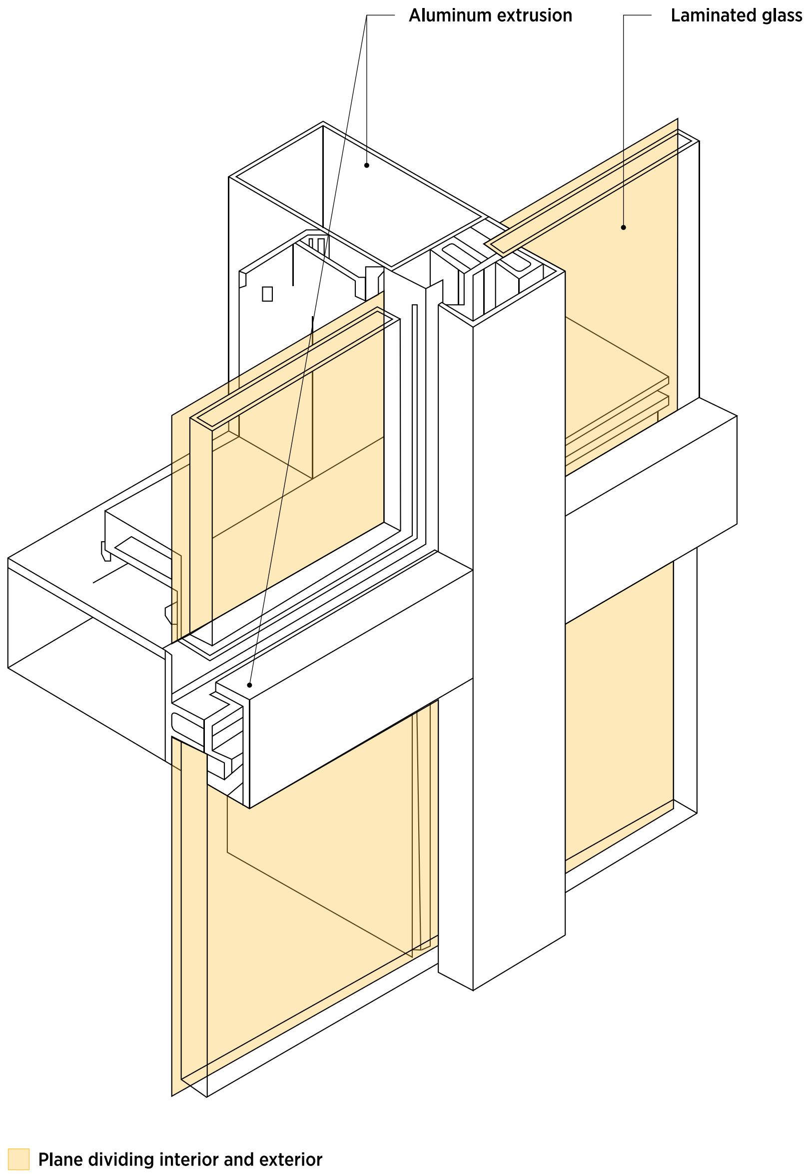


Figure 2. Curtain wall assembly

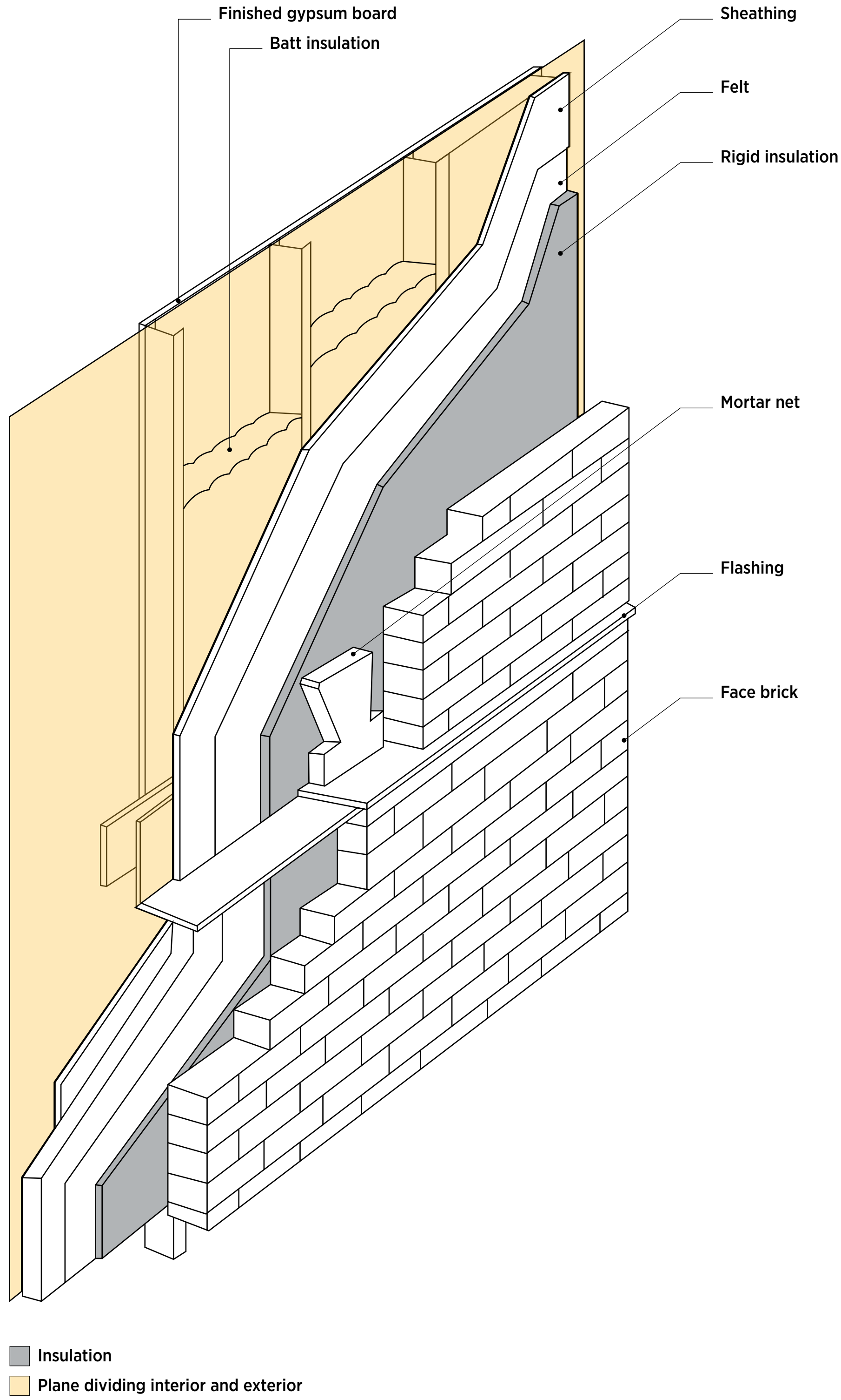


Figure 3. Metal stud masonry wall

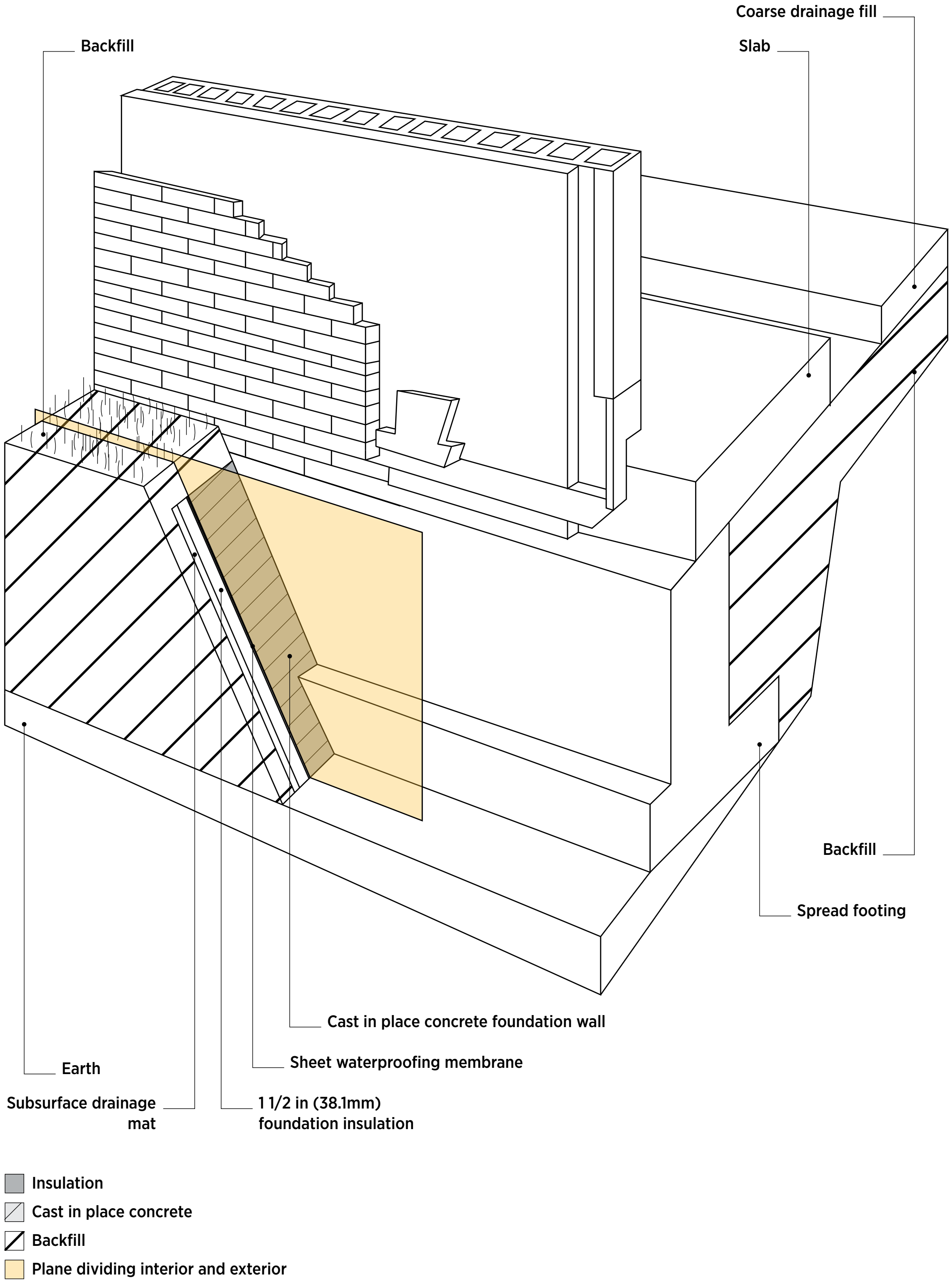


Figure 4. Cast in place concrete foundation wall

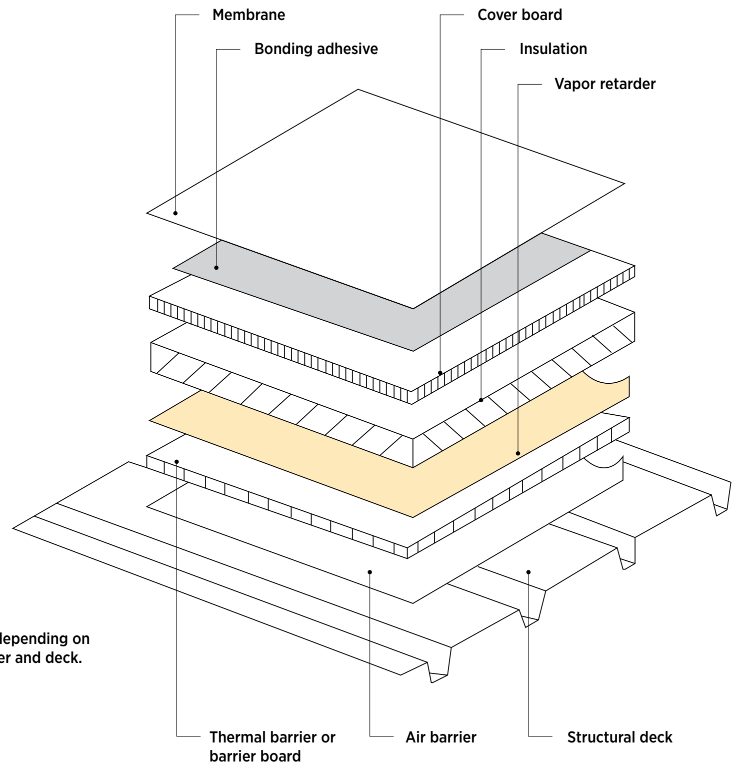


Figure 5. EPDM roof assembly

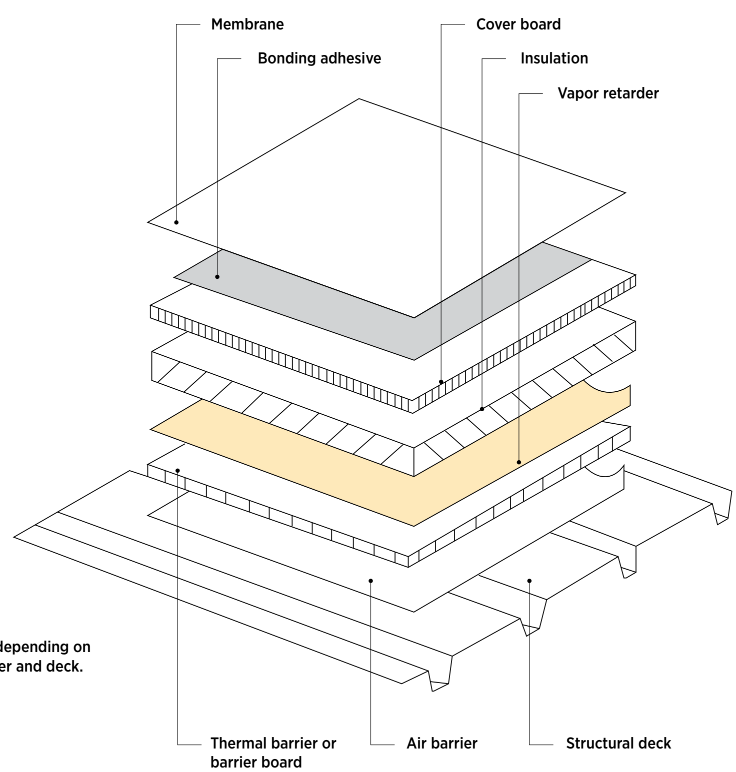


Figure 6. TPO roof assembly

CAMPUS

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

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

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2
USGBC low-emitting materials calculator	X	X
Product information (e.g., MSDS, third-party certifications, testing reports)	X	X

RELATED CREDIT TIPS

EQ Credit Indoor Air Quality Assessment. Using products with low emissions can significantly improve indoor air quality. Each product category pursued increases the chance of passing the indoor air quality testing limits for the related credit.

CHANGES FROM LEED 2009

- Former individual credit paths have been combined into one credit, with a scaled point system for each path earned.
- Compliance of interior finishes may be demonstrated in assemblies with multiple layers in combination, or in each system individually.
- Consideration of furniture emissions has been included for all rating systems.
- New referenced standards have been added to address international projects and new product requirements.
- Ceilings are now included in the requirements.
- Emissions from insulation are now included.
- Emissions requirements for on-site wet-applied, full-spread products measured via chamber tests in air are now included. VOC content limits for on-site, wet-applied products are still required.

REFERENCED STANDARDS

CDPH Standard Method v1.1–2010: cal-iaq.org

ISO 17025: iso.org

ISO Guide 65: iso.org

AgBB–2010: umweltbundesamt.de/produkte-e/bauprodukte/agbb.htm

ISO 16000 parts 3, 6, 7, 11: iso.org

South Coast Air Quality Management District (SCAQMD) Rule 1168: aqmd.gov

South Coast Air Quality Management District (SCAQMD) Rule 1113: aqmd.go

European Decopaint Directive: ec.europa.eu/environment/air/pollutants/stationary/paints/paints_legis.htm

Canadian VOC Concentration Limits for Architectural Coatings:
ec.gc.ca/lcpe-cepa/eng/regulations/detailReg.cfm?intReg=117

Hong Kong Air Pollution Control Regulation:
epd.gov.hk/epd/english/environmentinhk/air/air_maincontent.html

CARB 93120 ATCM: arb.ca.gov/toxics/compwood/compwood.htm

ANSI/BIFMA M7.1 Standard Test Method for Determining VOC Emissions from Office Furniture Systems, Components and Seating: bifma.org

ANSI/BIFMA e3–2011 Furniture Sustainability Standard: bifma.org

EXEMPLARY PERFORMANCE

Option 1. Earn all points and reach 100% of products.

Option 2. Reach 100% of products.

DEFINITIONS

building exterior a structure's primary and secondary weatherproofing system, including waterproofing membranes and air- and water-resistant barrier materials, and all building elements outside that system

building interior everything inside a structure's weatherproofing membrane

furniture and furnishings the stand-alone furniture items purchased for the project, including individual and group seating; open-plan and private-office workstations; desks and tables; storage units, credenzas, bookshelves, filing cabinets, and other case goods; wall-mounted visual-display products (e.g., marker boards and tack boards, excluding electronic displays); and miscellaneous items, such as easels, mobile carts, freestanding screens, installed fabrics, and movable partitions. Hospitality furniture is included as applicable to the project. Office accessories, such as desktop blotters, trays, tape dispensers, waste baskets, and all electrical items, such as lighting and small appliances, are excluded.

interior floor finish all the layers applied over a finished subfloor or stairs, including stair treads and risers, ramps, and other walking surfaces. Interior finish excludes building structural members, such as beams, trusses, studs, or subfloors, or similar items. Interior finish also excludes nonfull spread wet coatings or adhesives.

interior wall and ceiling finish all the layers comprising the exposed interior surfaces of buildings, including fixed walls, fixed partitions, columns, exposed ceilings, and interior wainscoting, paneling, interior trim or other finish applied mechanically or for decoration, acoustical correction, surface fire resistance, or similar purposes

INDOOR ENVIRONMENTAL QUALITY CREDIT

Construction Indoor Air Quality Management Plan

This credit applies to:

Commercial Interiors (1 point)
Retail (1 point)
Hospitality (1 point)

INTENT

To promote the well-being of construction workers and building occupants by minimizing indoor air quality problems associated with construction and renovation.

REQUIREMENTS

Develop and implement an indoor air quality (IAQ) management plan for the construction and preoccupancy phases of the building. The plan must address all of the following.

During construction, meet or exceed all applicable recommended control measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008, Chapter 3.

Protect absorptive materials stored on-site and installed from moisture damage.

Do not operate permanently installed air-handling equipment during construction unless filtration media with a minimum efficiency reporting value (MERV) of 8, as determined by ASHRAE 52.2–2007, with errata (or equivalent filtration media class of F5 or higher, as defined by CEN Standard EN 779–2002, Particulate Air Filters for General Ventilation, Determination of the Filtration Performance), are installed at each return air grille and return or transfer duct inlet opening such that there is no bypass around the filtration media. Immediately before occupancy, replace all filtration media with the final design filtration media, installed in accordance with the manufacturer's recommendations.

Prohibit the use of tobacco products inside the building and within 25 feet (7.5 meters) of the building entrance during construction.

BEHIND THE INTENT

Construction activities adversely affect indoor air quality (IAQ) when they generate dust, toxic substances, or other contaminants, which can cause health problems not only for construction workers but also those who occupy the building long after construction is complete. Incorporating IAQ best practices during construction has many benefits. One is the protection of building occupants from airborne pollutants associated with the construction. Another is the protection of construction workers from toxins and dust during build-out. A less obvious one, finally, is the benefit gained when building material and HVAC equipment last longer and perform better over time.

This credit requires teams to develop and implement a construction IAQ management plan that follows the Sheet Metal and Air Conditioning National Contractors' Association (SMACNA) IAQ guidelines. The SMACNA standard identifies major sources of construction-related indoor air pollution and spells out best practices for controlling them.

By implementing SMACNA IAQ strategies, projects will capture dust and other airborne pollutants, keep contaminants and toxic substances out of building systems, and prevent mold and other damage to building materials. Additionally, projects must protect absorptive material from moisture damage, prohibit smoking during construction inside the building and near entrances, and ensure that any permanent air handlers operated during construction meet filtration requirements.

STEP-BY-STEP GUIDANCE

STEP 1. INTEGRATE SMACNA CONTROL MEASURES INTO PROJECT DRAWINGS AND SPECIFICATIONS

Include compliance with SMACNA guidelines and other credit requirements in the project drawings and specifications (see *Further Explanation, SMACNA Guidelines*).

- Consider how the requirements and guidelines may affect design decisions. If used during construction, the air-handling equipment must be designed to accommodate MERV 8 or higher filters. Finishes such as paints and coatings specified by the design team must be consistent with SMACNA guidelines, regardless of whether those materials will contribute to other LEED credits.
- Include SMACNA requirements in project specifications. For example, specify that air handlers and ducts be delivered to the site prewrapped in plastic, to avoid having to protect equipment after delivery.
- Review the credit requirements and SMACNA guidelines in detail with all pertinent members of the design and construction team, specifically, the construction manager, general contractor, and mechanical subcontractor(s).

STEP 2. DEVELOP INDOOR AIR QUALITY PLAN

Before construction begins, develop an IAQ management plan that meets or exceeds the credit requirements. The IAQ plan is typically prepared by the general contractor or construction manager. It includes IAQ management practices implemented during construction and preoccupancy phases and describes how each requirement in the SMACNA guidelines and credit requirements will be addressed and managed on the job site. The plan should adhere to the SMACNA guidelines and cover the following additional items:

- Specify procedures for protecting stored and installed absorptive materials from moisture damage.
- Highlight the no-smoking policy. Prohibit the use of tobacco products inside the building and within 25 feet (7.5 meters), or more if required by the local jurisdiction, of the building entrance at all times during construction. Consider prohibiting smoking on the entire job site.
- Indicate whether air handlers will be operated during construction, and specify compliant filtration procedures for permanent equipment that will be used.

A detailed checklist instead of an IAQ management plan is also acceptable.

STEP 3. IMPLEMENT INDOOR AIR QUALITY PLAN

Ensure that the IAQ management plan is in place before starting above-ground construction, storing materials on site, or roughing in mechanical systems. Take photographs of each IAQ measure for documentation.

The following best practices support successful implementation of the plan:

- Identify the key players and someone responsible for implementing the plan, such as the HVAC installer and the general contractor. Make sure they understand the requirements of the plan and help champion its goals.
- Include the IAQ management plan requirements in contract agreements with subcontractors.
- As subcontractors are selected and deployed on site, familiarize them with the plan and how it will affect their daily activities. Hold a subcontractors' orientation meeting to review the plan requirements as a group.
- Include construction IAQ progress check-ins as a regular item in weekly subcontractor meetings and safety meetings.
- Provide a copy of the plan on site, preferably posted in an accessible area. Translate the plan into the languages spoken by subcontractors and their crews.
- General contractors, construction managers, and owners should verify that the IAQ management plan is being followed on job walks, ideally daily, so that issues can be addressed with subcontractors as necessary. Creating a checklist of major items for easy reference is often effective.
- Decide whether air handlers need to be used during construction. If so, substituting stand-alone temporary air handlers or heaters may make it easier to meet the HVAC protection requirement. If permanent air handlers are used during construction, record the filtration media used to meet the documentation requirements.
- Annotate photographs to indicate each IAQ measure depicted and its general location.
- Provide photographs of the methods employed to protect stored and installed absorptive materials from moisture damage during construction and preoccupancy.

FURTHER EXPLANATION

SMACNA GUIDELINES

The following SMACNA guidelines apply to teams seeking credit.

HVAC protection. Keep contaminants out of the HVAC system. Do not run permanently installed equipment if possible, or maintain proper filtration if it is used.

- If conditioning is required during construction, use supplementary HVAC units instead of permanently installed equipment if possible.
- If permanently installed HVAC system must be used during construction, install filtration to protect the return (negative pressure) side of the system. Replace these filters regularly during construction.
- Seal all ductwork, registers, diffusers, and returns with plastic when stored on site or not in service. Seal unfinished runs of ductwork at the end of each day.
- Replace all filtration media before occupancy.
- Do not store materials in mechanical rooms, to reduce potential debris and contamination to mechanical systems.

Source control. Keep sources of contaminants out of the building and have a plan to eliminate any that are introduced.

- Use low-toxicity and low-VOC materials to the greatest extent possible.
- Develop protocols for the use of any high-toxicity materials. Isolate areas where high-toxicity materials are being installed and use temporary ventilation for that area.

- Prevent exhaust fumes (from idling vehicles, equipment, and fossil-fueled tools) from entering the building.
- Enforce the no-smoking job site policy.
- Protect stored materials from moisture because absorbent materials exposed to moisture during construction can mold and degenerate long after installation. Store materials in dry conditions indoors, under cover, and off the ground or floor.
- If materials are improperly exposed to moisture, replace the material and consider testing air quality before occupancy to make sure no mold contamination has occurred.

Pathway interruption. Prevent circulation of contaminated air when cutting concrete or wood, sanding drywall, installing VOC-emitting materials, or performing other activities that affect IAQ in other work spaces.

- Isolate areas of work to prevent contamination of other spaces, whether they are finished or not. Seal doorways, windows, or tent off areas as needed using temporary barriers, such as plastic separations. Provide walk-off mats at entryways to reduce introduced dirt and pollutants.
- Depressurize the work area to allow a differential between construction areas and clean areas. Exhaust to the outdoors using 100% outdoor air, if possible.
- Use dust guards and collectors on saws and other tools.

Housekeeping. Maintaining a clean job site results in fewer IAQ contaminants to manage.

- Maintain good job site housekeeping on a daily basis. Use vacuum cleaners with high-efficiency particulate filters and use sweeping compounds or wetting agents for dust control when sweeping.
- Keep materials organized to improve job site safety as well as indoor air quality.

Scheduling. Sequence construction activities to reduce air quality problems in new construction projects. For major renovations, coordinate construction activities to minimize or eliminate disruption of operations in occupied areas.

- Keep trades that affect IAQ physically isolated on site and separated from each other by the construction schedule. For example, schedule drywall finishing and carpet installation for different days or different sections of the building. Consider after-hours or weekend work if practical.
- Install absorptive-finish materials after wet-applied materials have fully cured whenever possible. For example, install carpet and ceiling tile after paints and stains are completely dry.
- If applicable, plan adequate time to conduct a flush-out and/or perform IAQ testing before occupancy, in compliance with EQ Credit Indoor Air Quality Assessment (see *Related Credit Tips*).
- Remove all temporary filtration media and replace them with new filters before occupancy.

INTERNATIONAL TIPS

In countries where filters with MERV ratings are not available, filtration media must be Class F5 or higher, as defined by CEN Standard EN 779–2002. Filtration media with a minimum dust spot efficiency of 30% or higher and greater than 90% arrestance on a particle size of 3–10 µg are also acceptable.

CAMPUS

Group Approach

All project spaces may be documented as one. One master indoor air quality management plan is allowed. The plan should include building specific guidelines if necessary. Photo documentation must include a sampling for all buildings.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects
IAQ management plan or detailed checklist, highlighting nonsmoking policy	X
Narrative describing protection measures for absorbent materials	X
Annotated photographs of each IAQ measures	X
Record of filtration media	X

RELATED CREDIT TIPS

EQ Credit Enhanced Indoor Air Quality Strategies. The related credit builds on the best practices implemented during construction to maintain optimal indoor air quality. Both credits have filtration requirements; however, the related credit requires MERV 13 filtration (or Class F7 filters for projects outside the U.S.) to be installed immediately before occupancy, whereas this credit does not specify a rating for filtration installed before occupancy.

EQ Credit Low-Emitting Materials. Both the related credit and this credit's SMACNA source control strategies require the use of low-VOC and low-toxicity materials. Although earning one credit does not necessarily mean that all requirements are met for the other, implementing a comprehensive strategy of using low-VOC and low-toxicity materials can contribute to earning both credits.

EQ Credit Indoor Air Quality Assessment. A single IAQ management plan can be developed for both this credit and the related credit. Teams may pursue the assessment credit without pursuing this credit.

CHANGES FROM LEED 2009

The use of tobacco products during construction is now explicitly prohibited inside the building and within 25 feet (7.5 meters) (or greater, if required by the local jurisdiction) of the building entrance.

REFERENCED STANDARDS

Sheet Metal and Air Conditioning National Contractors Association (**SMACNA**) **IAQ Guidelines for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008** (**Chapter 3**)**:** smacna.org

ASHRAE 52.2–2007 (**with errata but without addenda**)**:** ashrae.org

CEN standard EN 779–2002: cen.eu

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Indoor Air Quality Assessment

This credit applies to:

Commercial Interiors (1-2 points)
Retail (1-2 points)
Hospitality (1-2 points)

INTENT

To establish better quality indoor air in the building after construction and during occupancy.

REQUIREMENTS

Select one of the following two options, to be implemented after construction ends and the building has been completely cleaned. All interior finishes, such as millwork, doors, paint, carpet, acoustic tiles, and movable furnishings (e.g., workstations, partitions), must be installed, and major VOC punch list items must be finished. The options cannot be combined.

OPTION 1. FLUSH-OUT (1 POINT)

Path 1. Before Occupancy
Install new filtration media and perform a building flush-out by supplying a total air volume of 14,000 cubic feet of outdoor air per square foot (4 267 140 liters per second of outdoor air per square meter) of gross floor area while maintaining an internal temperature of at least 60°F (15°C) and no higher than 80°F (27°C) and relative humidity no higher than 60%.

OR

Path 2. During Occupancy
If occupancy is desired before the flush-out is completed, the space may be occupied only after delivery of a minimum of 3,500 cubic feet of outdoor air per square foot (1 066 260 liters per second of outdoor air per square meter) of gross floor area while maintaining an internal temperature of at least 60°F (15°C) and no higher than 80°F (27°C) and relative humidity no higher than 60%.

Once the space is occupied, it must be ventilated at a minimum rate of 0.30 cubic foot per minute (cfm) per square foot of outdoor air (1.5 liters of outside air per second per square meter) or the design minimum outdoor air rate determined in EQ Prerequisite Minimum Indoor Air Quality Performance, whichever is greater. During each day of the flush-out period, ventilation must begin at least three hours before occupancy and continue during occupancy. These conditions must be maintained until a total of 14,000 cubic feet per square foot of outdoor air (4 270 cubic meters of outdoor air per square meter) has been delivered to the space.

OR

OPTION 2. AIR TESTING (2 POINTS)

After construction ends and before occupancy, but under ventilation conditions typical for occupancy, conduct baseline IAQ testing using protocols consistent with the methods listed in Table 1 for all occupied spaces.
Use current versions of ASTM standard methods, EPA compendium methods, or ISO methods, as indicated. Laboratories that conduct the tests for chemical analysis of formaldehyde and volatile organic compounds must be accredited under ISO/IEC 17025 for the test methods they use. Retail projects may conduct the testing within 14 days of occupancy.

Demonstrate that contaminants do not exceed the concentration levels listed in Table 1.

TABLE 1. Maximum concentration levels, by contaminant and testing method

Contaminant	Maximum concentration	Maximum concentration (Healthcare only)	ASTM and U.S. EPA methods	ISO method
Formaldehyde	27 ppb	16.3 ppb	ASTM D5197; EPA TO-11 or EPA Compendium Method IP-6	ISO 16000-3
Particulates (PM10 for all buildings; PM2.5 for buildings in EPA nonattainment areas, or local equivalent)	PM10: 50 micrograms per cubic meter PM2.5: 15 micrograms per cubic meter	20 micrograms per cubic meter	EPA Compendium Method IP-10	ISO 7708
Ozone (for buildings in EPA nonattainment)	0.075 ppm	0.075 ppm	ASTM D5149 - 02	ISO 13964
Total volatile organic compounds (TVOCs)	500 micrograms per cubic meter	200 micrograms per cubic meter	EPA TO-1, TO-15, TO-17, or EPA Compendium Method IP-1	ISO 16000-6
Target chemicals listed in CDPH Standard Method v1.1, Table 4-1, except formaldehyde	CDPH Standard Method v1.1–2010, Allowable Concentrations, Table 4-1	CDPH Standard Method v1.1–2010, Allowable Concentrations, Tble 4-1	ASTM D5197; EPA TO-1, TO-15, TO-17	ISO 16000-3, 16000-6
Carbon monoxide (CO)	9 ppm; no more than 2 ppm above outdoor levels	9 ppm; no more than 2 ppm above outdoor levels	EPA Compendium Method IP-3	ISO 4224

ppb = parts per billion; ppm = parts per million; µg/cm = micrograms per cubic meter

Conduct all measurements before occupancy but during normal occupied hours, with the building ventilation system started at the normal daily start time and operated at the minimum outdoor airflow rate for the occupied mode throughout the test.

For each sampling point where the concentration exceeds the limit, take corrective action and retest for the noncompliant contaminants at the same sampling points. Repeat until all requirements are met.

BEHIND THE INTENT

Many building materials contain substances that are hazardous to human health, and construction activity can introduce contaminants into the indoor environment. Harmful substances include formaldehyde and volatile organic compounds (VOCs) from building materials. Dust, ozone, and fine particulate matter generated by construction activity, diesel engines, or unfiltered outdoor air can also be harmful. Reducing indoor air contaminants has significant human health benefits and typically improves occupants' comfort, lowers absenteeism, and increases productivity.

Testing airborne pollutant levels is the best way to demonstrate that source control strategies have been effectively and properly implemented. For VOCs, this credit follows the California Department of Public Health Standard Method v1.1, which is widely recognized by the industry for its science-based best practices and rigorous, well-established testing procedures.

An alternative to testing that can improve indoor air quality is a building flush-out, an effective method to disperse off-gassed compounds and other contaminants left behind at the end of construction. The threshold for duration of building flush-out is based on a typical mechanical ventilation system. A typical ventilation system supply airflow rate is 0.7 cubic feet per minute per square foot. Therefore, if a system operates at 100% outdoor air continuously for two weeks, the cubic feet of outdoor air per square foot of floor area is calculated as follows:

$$\text{14,112 cu ft of outdoor air/ft}^2\text{ of floor area} = \left\{ 0.7 \left(\frac{\text{cfm}}{\text{ft}^2}\right) \times 14 \text{ days} \times \left(\frac{\text{24 hours}}{\text{day}}\right) \times \left(\frac{\text{60 mins}}{\text{hr}}\right) \right\}$$

In SI units,

$$\text{4 294 080 lps of outdoor air/sq meter of floor area} = \left\{ 3.55 \left(\frac{\text{lps}}{\text{m}^2}\right) \times 14 \text{ days} \times \left(\frac{\text{24 hours}}{\text{day}}\right) \times \left(\frac{\text{60 mins}}{\text{hr}}\right) \times \left(\frac{\text{60 sec}}{\text{min}}\right) \right\}$$

This demonstrates that two weeks of flush-out provides adequate time for removing contaminants from the construction process.

STEP-BY-STEP GUIDANCE

STEP 1. ASSESS OPTIONS

Develop a plan for the preferred option. Teams can change to a different option later if, for example, they run out of time to complete a flush-out. Options 1 and 2 cannot be combined to meet the credit requirements.

- Option 1 may be feasible if the project's schedule allows time for a flush-out. Work with the mechanical engineer to estimate the flush-out duration before the construction schedule is established (see *Further Explanation, Calculations,* and *Considerations for Flush-Out*).
- Option 2 can typically be completed in less time than a flush-out, but the cost of air quality testing must be factored into the project's budget.

STEP 2. SPECIFY LOW-EMITTING PRODUCTS AND MATERIALS

Use the requirements of the source control credits in this credit category, such as EQ Credit Low-Emitting Materials and EQ Credit Construction Indoor Air Quality Management Plan, as guidance during selection and installation of products and materials.

By incorporating low-emitting products, the project team can reduce the contaminant load before the flush-out and position the project for good test results. However, project teams are not required to achieve EQ Credit Low-Emitting Materials to meet the requirements of this credit.

STEP 3. INSTALL FINISHES, FURNITURE, AND FURNISHINGS

Install all finishes, furniture, and furnishings before performing tests or beginning a flush-out.

- All owner-provided furniture must be installed in residential projects.
- All punch list items that would generate VOCs or other contaminants must be completed.
- Testing and balancing of the HVAC system must be completed.

STEP 4. CLEAN BUILDING

Consider thoroughly cleaning the building, including the ductwork before testing or beginning a flush-out.

- Use low-emitting cleaning products to prevent high short-term VOC levels that may affect test results.
- Use vacuum cleaners with HEPA filtration to capture particulates.

Option 1. Flush-out

STEP 1. SELECT PATH 1 OR PATH 2

Path 1 is preferable if the schedule permits, since it exposes occupants to lower levels of potential toxins; Path 2 is acceptable if the schedule does not allow time for Path 1 (see *Further Explanation, Examples 1–4*).

- For Path 2, begin the flush-out three hours before daily occupancy and continue throughout the occupied portion of the day.
- For Path 2, ensure that outdoor air volume is at least 0.30 cubic feet per minute per square foot (1.5 liters per second per square meter) or the design minimum outdoor air rate, whichever is greater.

STEP 2. CALCULATE REQUIRED VOLUME

Use the gross square footage (or square meters) to calculate the total cubic feet (or liters) of air required. The area used must be consistent with the area reported in other credits. Every space in the building must be flushed out (see *Further Explanation, Calculations*).

STEP 3. DETERMINE DURATION OF FLUSH-OUT

Determine the rate of outdoor air the HVAC system can provide and calculate the duration of flush-out with the required volume calculated in Step 1 (see *Further Explanation, Calculations*).

- If a shorter duration is desired, or if the HVAC system is unable to provide at least 0.3 cubic feet per minute per square foot (1.5 liters per second per square meter) for an occupied flush-out, supplemental units may be used.
- Ventilation fans without supplemental cooling or heating, or temporary, supplemental HVAC units (installed in window or door openings) may be used, provided the outdoor conditions are within the required temperature and humidity constraints at all times during the flush-out. See the credit requirements.
- Commissioning can occur during the flush-out, provided none of the commissioning procedures introduce contaminants into the space and none of the flush-out procedures circumvent the commissioning process. Complete testing and balancing of the HVAC system after the flush-out is complete.
- If even partial construction work occurs during the flush-out (e.g., repainting a room) the flush-out must be started again from the beginning for that space.
- If multiple, discrete HVAC systems operate independently, the team may flush out portions of the building as work is completed in each area served by a given system.

STEP 4. REPLACE OR INSTALL FILTERS

If the permanent HVAC system will be used to perform the flush-out procedure, first replace used filters.

- Replace the used HVAC filtration media with new media. Filter selection has implications for other credits (see *Related Credit Tips*).
- Remove any temporary filters or duct coverings installed as part of the construction indoor air quality management plan.

STEP 5. COMPLETE FLUSH-OUT

Complete the flush-out, following the requirements for Path 1 or Path 2.

STEP 6. PREPARE FLUSH-OUT REPORT

Provide a flush-out report with the following information.

- Base the duration calculations on the capacity of all HVAC units used and indicate which are permanent and which temporary; capacity should take into account the volume of outdoor air and temperature and humidity allowances.
- Describe the flush-out procedure and include a log of dates, hours, and recorded temperature and humidity.
- If the amount of outdoor air is more than has been designed in EQ Prerequisite Minimum Indoor Air Quality Performance or more than shown on the mechanical schedules, include a narrative explaining how the additional air was provided to the building.

Option 2. Air Testing

STEP 1. DETERMINE AIR-TESTING LOCATIONS

Select testing locations with the least ventilation but the greatest concentration of VOCs and other contaminants. Testing must be completed by an appropriately accredited professional. Use current versions of ASTM or ISO methods. The number of testing locations depends on the size of the building and number of ventilation systems but must include all occupied spaces. If sampling is used, all space types must be represented (e.g., office and classroom). Use the following methodology to determine how many air testing locations are required.

- Test at least one location per ventilation system for each occupied space type. There must be a minimum of one test per floor. The locations selected for testing must represent the worst-case zones where the highest concentrations of contaminants of concern are likely to occur.
- For offices, retail, and hospitality projects, test areas no larger than 5,000 square feet (465 square meters). For large open spaces (e.g., ballrooms in hospitality), a limit of 50,000 square feet (4 654 square meters) may be used. If there is evidence that the air in the space is well mixed and sources of contaminants of concern are uniform, project teams may test a single location in that space.
- Determine whether the project includes spaces (e.g., offices) that are identical in their construction, finishes, configuration, square footage, and HVAC systems. Project teams may sample identical spaces by testing one in seven. If the sampled space fails the test, all seven must be tested.

STEP 2. PERFORM TEST

Ensure that the following procedures are followed at all test locations. If a location fails the test, take corrective action (e.g. clean and flush out the space) and retest. The duration of any flush-out between tests is at the discretion of the project team.

- The measurement equipment must be positioned in the breathing zone, between 3 and 6 feet (900 and 1 800 millimeters) above the floor.
- The test must occur during normal occupied hours, with the HVAC system starting at the normal start time and delivering outdoor air at the minimum rate.
- The gravimetric method must be used for testing.

STEP 3. PREPARE INDOOR AIR QUALITY TESTING REPORT

Develop an IAQ testing report that includes the following:

- Narrative describing procedures and how locations were determined
- Dates and results of each test

FURTHER EXPLANATION

CALCULATIONS

Option 1, Path 1. Flush-Out before Occupancy

EQUATION 1. Flush-out outdoor air volume

$$\text{Cubic feet of outdoor air needed prior to occupancy} = \text{Area (ft}^2) \times 14{,}000 \text{ cfm}$$

$$\text{Liters of outdoor air needed prior to occupancy} = \text{Area (m}^2) \times 4\,267\,140 \text{ lps}$$

Option 1, Path 2. Flush-Out during Occupancy

EQUATION 2. Flush-out outdoor air volume before occupancy

$$\text{Cubic feet of outdoor air needed prior to occupancy} = \text{Area (ft}^2) \times 3{,}500 \text{ cfm of outdoor air}$$

$$\text{Liters of outdoor air needed prior to occupancy} = \text{Area (m}^2) \times 1\,066\,260 \text{ lps}$$

EQUATION 3. Flush-out outdoor air volume during occupancy

$$\text{Cubic feet of outdoor air needed during occupancy to complete flush-out} = \text{Area (ft}^2) \times 10{,}500 \text{ cfm}$$

$$\text{Liters of outdoor air needed during occupancy to complete flush-out} = \text{Area (m}^2) \times 3\,200\,880 \text{ lps}$$

Options 1 and 2

EQUATION 4. Flush-out duration

$$\text{Duration (Days)} = \left\{ \frac{(\text{Area (ft}^2) \times 14{,}000 \text{ cfm})}{(\text{Air handler capacity} \div 1440 \text{ minutes/day})} \right\}$$

$$\text{Duration (Days)} = \left\{ \frac{(\text{Area (m}^2) \times 4\,267\,140 \text{ lps})}{(\text{Air handler capacity} \div 86{,}400 \text{ seconds/day})} \right\}$$

EXAMPLES

The figures below assume that air handlers are capable of delivering 100% outdoor air while maintaining 60–80°F (15–27°C) and 60% relative humidity 24 hours per day.

Example 1. Option 1, Path 1, flush-out before occupancy calculation (IP)

TABLE 2. Option 1, Path 1 (IP)

	Net Office Area (ft^2)	Total Outdoor Air Required (cfm/ft^2)	Volume of air required before occupancy (ft^3)	Air handler OA Capacity (cfm)	Duration of preoccupancy flush-out (minutes)	Duration of preoccupancy flush-out (days)
Space type 1	50,000	14,000	700,000,000	15,000	46,667	32.4
Space type 2	10,000	14,000	140,000,000	4,000	35,000	24.3
Space type 3	5,000	14,000	70,000,000	5,000	14,000	9.7

Example 2. Option 1, Path 1, flush-out before occupancy calculation (SI)

TABLE 3. Option 1, Path 1 (SI)

	Net office area (m^2)	Total outdoor air required (lps/m^2)	Volume of air required before occupancy (liters)	Air handler outdoor air capacity (lps)	Duration of preoccupancy flush-out (seconds)	Duration of preoccupancy flush-out (days)
Space type 1	4 645	4 267 140	19 820 865 300	7 079	2 799 953	32.4
Space type 2	929	4 267 140	3 964 173 060	1 888	2 099 668	24.3
Space type 3	464	4 267 140	1 979 952 960	2 360	838 963	9.7

Example 3. Option 1, Path 2, flush-out during occupancy calculation (IP)

TABLE 4. Option 1, Path 2 (IP)

	Net office area (ft^2)	Total outdoor air required before occupancy (cfm/ ft^2)	Volume of air required before occupancy (ft^3)	Air handler outdoor air capacity (cfm)	Duration of preoccupancy flush-out (minutes)	Duration of preoccupancy flush-out (days)	Total outdoor air required to complete flush-out (cfm/sf)	Volume of air required to complete flush-out (cf)	Minimum outdoor air delivery rate postoccupancy (cfm)	Time to complete flush-out at min. delivery rate (minutes)	Time to complete flush-out at min. delivery rate (days)
Space type 1	50,000	3,500	175,000,000	15,000	11,667	8.1	10,500	525,000,000	15,000 (0.3 cfm/ ft^2)	35,000	24.3
Space type 2	10,000	3,500	35,000,000	4,000	8,750	6.1	10,500	105,000,000	4,000*	26,250	18.2
Space type 3	5,000	3,500	17,500,000	5,000	3,500	2.4	10,500	52,500,000	5,000*	10,500	7.3

* Minimum rate required in Prerequisite Minimum Indoor Air Quality Performance

Example 4. Option 1, Path2, flush-out during occupancy calculation (SI)

TABLE 5. Option 1, Path 2 (SI)

	Net office area (m^2)	Total outdoor air required before occupancy (lps/m^2)	Volume of air required before occupancy (liters)	Air handler outdoor air capacity (lps)	Duration of preoccupancy flush-out (seconds)	Duration of preoccupancy flush-out (days)	Total outdoor air required to complete flush-out (lps/m^2)	Volume of air required to complete flush-out (liters)	Minimum outdoor air delivery rate postoccupancy (lps)	Time to complete flush-out at min. delivery rate (seconds)	Time to complete flush-out at min. delivery rate (days)
Space type 1	4 645	1 066 260	4 952 777 700	7 079	699 644	8.1	3 200 880	14 868 087 600	7 079	2 100 309	24.3
Space type 2	929	1 066 260	990 555 540	1 888	524 659	6.1	3 200 880	2 973 617 520	1 888*	1 575 009	18.2
Space type 3	464	1 066 260	494 744 640	2 360	209 638	2.4	3 200 880	1 485 208 320	2 360*	629 326	7.3

* Minimum rate required in EQ Prerequisite Minimum Indoor Air Quality Performance

CONSIDERATIONS FOR FLUSH-OUT

Before committing to a flush-out, check with the mechanical engineer to confirm that proposed mechanical systems are capable of providing outdoor air at the required rate. Flush-out during occupancy requires at least 0.3 cubic feet per minute per square foot (1.5 liters per second per square meter) of outdoor air.

Systems that meet ASHRAE 62.1–2010 airflow rates and provide a fixed volume of outdoor air may not be able to provide sufficient outdoor air, or the flush-out could take a long time.

For systems that can provide a sufficient volume of outdoor air, confirm that heating and cooling equipment can handle the additional load from increased outdoor air during times of peak heating and cooling. The equipment must be able to maintain an internal temperature between 60°F (15°C) and 80°F (27°C), with a relative humidity no higher than 60%.

Buildings with air-side economizers may be able to provide the required outdoor air during the free cooling season, reducing the energy required to provide the increased outdoor air, assuming it can be provided at a constant volume.

INTERNATIONAL TIPS

To address PM2.5 and ozone (see Table 1 of the credit requirements), use an equivalent to the U.S. EPA standards for nonattainment areas. If no equivalent exists, consider the project to be in a nonattainment area.

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	Option 1, Path 1	Option 1, Path 2	Option 2
Flush-out report	X	X	
IAQ testing report			X

RELATED CREDIT TIPS

EQ Prerequisite Minimum Indoor Air Quality Performance. Projects that pursue Option 1, Path 2 (flush-out during occupancy), must use the greater of the minimum outdoor air rate determined for this prerequisite or 0.30 cubic feet per minute per square foot (1.5 liters per second per square meter) for the occupied portion of the flush-out.

EQ Credit Enhanced Indoor Air Quality Strategies. Projects that pursue Option 1 must install new MERV 13 or Class F7 filters before the flush-out to meet the requirements of this credit. Using comprehensive strategies will improve indoor air quality, increase the effectiveness of a flush-out, and increase the likelihood of passing the air quality tests.

EQ Credit Low-Emitting Materials. Specifying low-emitting products and materials will improve indoor air quality, increase the effectiveness of a flush-out, and increase the likelihood of passing the air quality tests.

EQ Credit Construction Indoor Air Quality Management. For projects that pursue Option 1, new filters that meet the appropriate specifications and were installed immediately before the flush-out also satisfy the requirements of this credit. Proper attention to contaminants during construction will improve overall indoor air quality, increase the effectiveness of a flush-out, and increase the likelihood of passing the air quality tests.

CHANGES FROM LEED 2009

- Options can no longer be combined.
- An upper interior temperature limit is now identified in Option 1.
- Testing is now required for an expanded list of contaminants in Option 2.

REFERENCED STANDARDS

ASTM D5197–09e1 Standard Test Method for Determination of Formaldehyde and Other Carbonyl Compounds in Air (Active Sampler Methodology): astm.org/Standards/D5197.htm

ASTM D5149–02(2008) Standard Test Method for Ozone in the Atmosphere: Continuous Measurement by Ethylene Chemiluminescence: astm.org/Standards/D5149

ISO 16000-3, Indoor air–Part 3: Determination of formaldehyde and other carbonyl compounds in indoor air and test chamber air—Active sampling method: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51812

ISO 16000-6, Indoor air–Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS or MS-FID: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=52213

ISO 4224 Ambient air—Determination of carbon monoxide—Nondispersive infrared spectrometric method: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=32229

ISO 7708 Air quality—Particle size fraction definitions for health-related sampling: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=14534

ISO 13964 Air quality—Determination of ozone in ambient air—Ultraviolet photometric method: iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=23528

US EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air, IP-1: Volatile Organic Compounds, IP-3: Carbon Monoxide and Carbon Dioxide, IP-6: Formaldehyde and other aldehydes/ketones, IP-10 Volatile Organic Compounds: nepis.epa.gov

US EPA Compendium of Methods for the Determination of Inorganic Compounds in Ambient Air, TO-1: Volatile Organic Compounds, TO-11: Formaldehyde, TO-15: Volatile Organic Compounds, TO-17: Volatile Organic Compounds: epa.gov/ttnamti1/airtox.html

California Department of Public Health, Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources using Environmental Chambers, v1.1–2010: cal-iaq.org/separator/voc/standard-method

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Thermal Comfort

This credit applies to:

Commercial Interiors (1 point)
Retail (1 point)
Hospitality (1 point)

INTENT

To promote occupants' productivity, comfort, and well-being by providing quality thermal comfort.

REQUIREMENTS

Meet the requirements for both thermal comfort design and thermal comfort control.

Thermal Comfort Design

OPTION 1. ASHRAE STANDARD 55-2010

Design heating, ventilating, and air-conditioning (HVAC) systems and the building envelope to meet the requirements of ASHRAE Standard 55–2010, Thermal Comfort Conditions for Human Occupancy, with errata or a local equivalent.

For natatoriums, demonstrate compliance with ASHRAE HVAC Applications Handbook, 2011 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions, with errata.

OR

OPTION 2. ISO AND CEN STANDARDS

Design HVAC systems and the building envelope to meet the requirements of the applicable standard:

- ISO 7730:2005, Ergonomics of the Thermal Environment, analytical determination and interpretation of thermal comfort, using calculation of the PMV and PPD indices and local thermal comfort criteria; and
- CEN Standard EN 15251:2007, Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings, addressing indoor air quality, thermal environment, lighting, and acoustics, Section A2.

Thermal Comfort Control

Provide individual thermal comfort controls for at least 50% of individual occupant spaces. Provide group thermal comfort controls for all shared multioccupant spaces.

Thermal comfort controls allow occupants, whether in individual spaces or shared multioccupant spaces, to adjust at least one of the following in their local environment: air temperature, radiant temperature, air speed, and humidity.

HOSPITALITY ONLY

Guest rooms are assumed to provide adequate thermal comfort controls and are therefore not included in the credit calculations.

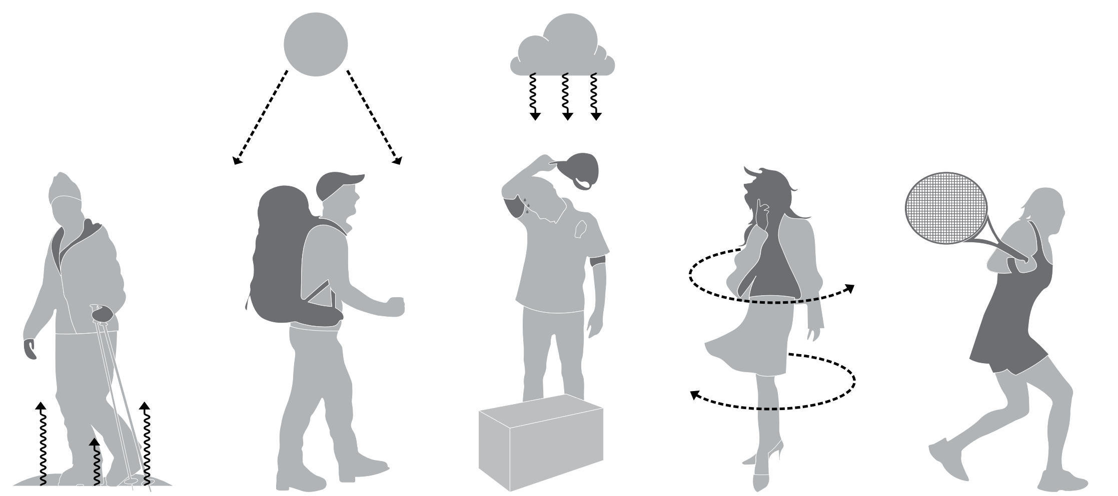
RETAIL ONLY

Meet the above requirements for at least 50% of the individual occupant spaces in office and administrative areas.

BEHIND THE INTENT

A large body of laboratory and field research has demonstrated how thermal conditions inside buildings directly affect people's satisfaction and performance.[1] Often associated only with air temperature, thermal comfort is a complex amalgam of six primary factors (Figure 1), all of which are influenced by building design and operation. An effective thermal comfort strategy considers all six concurrently, meaning that close collaboration among the owner, architect, and engineer is critical to achieving this credit.

Figure 1. Primary factors that affect thermal comfort



Modifying one or more of the six comfort factors can greatly improve occupants' perception of the thermal environment while still supporting energy reduction goals. Working closely with the owner during design, the project team can maximize comfort by coordinating design with operational policies. For example, a flexible dress code that permits seasonally appropriate clothing can allow design air temperatures to be adjusted upward during the cooling season and downward during the heating season without affecting occupants' perception of comfort.

Occupants who are able to modify their thermal environment through thermal controls will perceive more comfort regardless of conditioning strategy, and they may exhibit additional satisfaction and productivity. Indoor environment quality surveys administered by the Center for the Built Environment have shown significant increases in satisfaction among occupants who have individual control of a thermostat or an operable window.[2] Likewise, research from the International Centre for Indoor Environment and Energy suggests that giving occupants +/–5°F (3°C) of local temperature control can result in productivity gains of 2.7% to 7%.[3]

The referenced standards for this credit use two indices: predicted mean vote (PMV) and predicted percentage of dissatisfied (PPD). The PMV was developed by placing test subjects in climate chambers and asking them to rate their level of comfort on a seven-point thermal sensation scale. The scale runs from plus 3 (too hot) to minus 3 (too cold), with zero representing neutral. The PPD index is then determined; it predicts the percentage of people who are likely to be dissatisfied with a given thermal condition. The referenced standards for this credit also use field-based research as the basis of the adaptive model, which relates indoor design temperatures or acceptable temperature ranges to outdoor meteorological or climatological parameters.[4]

1. *Fisk, W. 2001. "Estimates of Potential Nationwide Productivity and Health Benefits from Better Indoor Environments: An Update." In Spengler, J., J. Samet, and J. McCarthy. Indoor Air Quality Handbook. New York: McGraw Hill, 4.1–4.31.*
2. *Huizenga, C., S. Abbaszadeh, L. Zagreus, and E. Arens. 2006. "Air Quality and Thermal Comfort in Office Buildings: Results of a Large Indoor Environmental Quality Survey." In Proceedings of Healthy Buildings 2006, vol. III, Lisbon, Portugal, pp. 393–397.*
3. *Wyon, D. 1996. "Individual Microclimate Control: Required Range, Probable Benefits, and Current Feasibility." In Proceedings of Indoor Air 1996: Seventh International Conference of Indoor Air Quality and Climate, vol. 1, Nagoya, Japan, pp.1067–1072.*
4. *ASHRAE Standard 55–2010, Thermal Environmental Conditions for Human Occupancy.*

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH THERMAL COMFORT GOALS

Work with the owner to understand expectations for the indoor thermal environment, the level of control that occupants should have, and characteristics of the occupant population.

- Determine whether a tightly controlled environment is required or whether some variation in indoor conditions is acceptable.
- Determine whether occupants would see natural conditioning as a workplace benefit.
- Consider including factors and design criteria related to occupants in the owner's project requirements (OPR) for commissioning activities.
- Thermal comfort needs for natatoriums are unique (see *Further Explanation, Natatoriums*).

STEP 2. SELECT CONDITIONING SYSTEM

Based on the thermal comfort goals, determine the best conditioning approach for the project (see *Further Explanation, Thermal Comfort Conditioning Approaches*). Consider any limitations of the base building systems.

- Consider whether the project is a candidate for natural conditioning. Examine the climate by season, including temperature, humidity, and air quality, to determine optimal times of the year for natural conditioning.
- Identify program areas that could be designed to accommodate cross or stack ventilation and consider ways they could be organized to create microclimates to expand annual hours of natural conditioning (see *Further Explanation, Criteria for Occupant-Controlled Naturally Conditioned Spaces*).

STEP 3. SELECT COMFORT CONTROLS

Determine the best thermal comfort controls for the conditioning system(s) selected, based on the type of project and occupant's activities (see *Further Explanation, Rating System Variations* and *Project Type Variations*).

- Consider thermal comfort controls that allow occupants to control air temperature, radiant temperature, air speed, and humidity.
- Examples of eligible thermal comfort controls include thermostats, ceiling fans, adjustable underfloor diffusers, task-mounted controls (such as plug-in desktop fans, humidifiers, or dehumidifiers), and operable windows. Examples of ineligible thermal comfort controls include a ceiling diffuser without an accessible control, and a thermostat with a fixed setpoint that cannot be adjusted by occupants.
- Zone the conditioning system to ensure that at least 50% of individual occupant spaces have individual thermal comfort controls. Additional controls may be appropriate for some projects but are not required by this credit.
- Provide at least one group thermal comfort control in each shared multioccupant space. Meeting spaces that can be subdivided (e.g., a convention hall with movable walls) must be designed such that each group of occupants can control their area.

STEP 4. SELECT THERMAL COMFORT STANDARD

Decide which standard or set of standards is suited to the project. Either option is appropriate for common space types, such as offices, educational buildings, hospitals, hotels and restaurants, and retail buildings. For other building types, see *Further Explanation, Project Type Variations*.

- Option 1 is suitable for most U.S. project teams, who are likely to be familiar with ASHRAE Standard 55-2010. This option allows project teams to use the same standard for both mechanically and naturally conditioned spaces.
- Option 2 relies on two international standards, ISO 7730–2005 and EN 15251–2007, to document mechanically and naturally conditioned spaces, respectively.

Both options are based on the same comfort models.

Option 1. ASHRAE Standard 55–2010

STEP 1. SELECT ANALYSIS METHOD(S)

Select the methodology from ASHRAE Standard 55–2010 that will be used for the thermal comfort analysis.

- For mechanically conditioned spaces, select one or more of the following from Section 5.2, Methods for Determining Acceptable Conditions in Occupied Spaces:
  - Section 5.2.1, Graphic Comfort Zone Method for Typical Indoor Environments
  - Section 5.2.1.2, Computer Model Method for General Indoor Application
  - Section 5.2.3.1, Graphic Elevated Air Speed Method
  - Section 5.2.3.2, SET Method

  Section 5.2.4 must also be followed for potential sources of local discomfort.
- For naturally conditioned spaces, select Section 5.3, Optional Method for Determining Acceptable Thermal Conditions in Naturally Conditioned Spaces. The optional method is available only for spaces that meet certain criteria (see *Further Explanation, Criteria for Occupant-Controlled Naturally Conditioned Spaces*). Spaces that do not meet these criteria must follow one of the mechanically conditioned spaces methods.

For mixed-mode spaces, each seasonal conditioning strategy must be documented separately. For example, demonstrate heating season compliance using Section 5.2 and cooling season compliance using Section 5.3.

STEP 2. PERFORM ANALYSIS

If using Section 5.2, perform the analysis as described in the standard.

- Estimate occupants' personal factors, such as clothing and activity levels.
- Using the owner's comfort expectations, energy goals, and occupancy factors, set seasonal comfort criteria for operative temperature, humidity, and air speed for each programmed area. Refer to ASHRAE 55–2010, Appendices A and B, for recommended values.
- Calculate the effects of any likely local discomfort sources, such as radiant temperature asymmetry, vertical air temperature difference, floor surface temperature, and drafts, as described in Section 5.2.4. Confirm that dissatisfaction is within the allowable ranges listed in Table 5.2.4.

This analysis may be an iterative process in which thermal conditions are revised or refined to meet the ASHRAE requirements. By using the standard in this way, project teams can ensure that the thermal conditions meet the credit requirements before they begin detailed design work.

If using Section 5.3, perform the analysis as described in the standard.

- Calculate mean monthly outdoor temperature for the project's location, as described in the ASHRAE standard, for times of the year when natural conditioning is used.
- Use Figure 5.3 to establish the upper and lower operative temperature limits of the comfort zone. It may be helpful to plot mean monthly outdoor temperatures, comfort zone boundaries, and design operative temperatures on Figure 5.3.
- Compare indoor operative temperatures with the comfort zone boundaries.

STEP 3. DESIGN PROJECT'S CONDITIONING SYSTEMS

Design the project's conditioning systems to provide the acceptable comfort conditions identified in the previous step. Additionally, verify that all spaces at risk for discomfort, such as locations close to entrances prone to drafts or west-facing walls that may retain heat, have been addressed.

ASHRAE 55–2010, Section 6.1, requires the design to be within the acceptable comfort range at all combinations of conditions that are expected to occur, including variations in internal loads and the exterior environment, and at both full- and partial-load conditions. Systems that cannot maintain comfort under all conditions (e.g., a constant-volume rooftop unit with a single compressor may have problems controlling humidity levels) do not meet the credit requirements (see *Further Explanation, Examples*).

Option 2. ISO 7730–2005 and EN 15251–2007

STEP 1. SELECT ANALYSIS METHOD(S)

Select the methodology that will be used for the thermal comfort analysis.

- For mechanically conditioned spaces, select ISO 7730–2005.
- For naturally conditioned spaces, select EN 15251–2007, Annex A.2, Acceptable Indoor Temperatures for Design of Buildings without Mechanical Cooling Systems. The EN method is available only for spaces that meet certain criteria (see *Further Explanation, Criteria for Occupant-Controlled Naturally Conditioned Spaces*). Spaces that do not meet these criteria must follow ISO.

For mixed-mode spaces, each seasonal conditioning strategy must be documented separately. For example, demonstrate heating season compliance using ISO 7730 and cooling season compliance using EN 15251.

STEP 2. SELECT BUILDING CATEGORY

Identify the space category and comfort threshold for the project based on the selected standard's classifications.

- The ISO and EN standards set different ranges of comfort acceptability for specific building types and occupant populations (Table 1).
- Category B (ISO) and Category II (EN) are appropriate for most new buildings.

TABLE 1. Comparison of comfort acceptability ranges, ISO 7730–2005 and EN 15251–2007

Category		Description	Allowable predicted mean vote	Allowable predicted percentage dissatisfied
ISO 7730– 2005	EN 15251– 2007			
A	I	Recommended for spaces occupied by very sensitive and fragile persons with special requirements (very young children, elderly, ill)	–0.2 < PMV < 0.2	<6%
B	II	Suitable for most new buildings and renovations	–0.5 < PMV < 0.5	<10%
C	III	Suitable for existing buildings	–0.7 < PMV < 0.7	<15%
	IV	Values other than above; acceptable for only part of year	PMV < –0.7 or PMV > 0.7	>15%

PMV = predicted mean vote (index of thermal comfort)

PPD = predicted percentage (of people) dissatisfied

Source: This excerpt is adapted and modified from ISO 7730:2005 and EN 15251:2007 with the permission of ANSI on behalf of ISO.

STEP 3. PERFORM ANALYSIS

If using ISO 7730-2005, perform the analysis as described in the standard.

- Estimate occupants' personal factors, such as clothing and activity levels.
- Using the owner's comfort expectations, energy goals, and occupancy factors, set seasonal comfort criteria for operative temperature, humidity, and air speed for various programmed areas. Refer to ISO 7730–2005, Appendices A and C, for recommended values.
- Use the simplified look-up tables provided in ISO 7730–2005, Annex E, to determine PMV for spaces with 50% relative humidity and minimal difference between air and mean radiant temperature. For spaces that do not meet Annex E criteria, calculate PMV as described in Section 4.1 or Annex D.
- Confirm that PMV falls within the allowable range for general thermal comfort for appropriate building category (Table 1).
- Calculate the effects of any likely local discomfort sources, such as draughts, vertical air temperature difference, floor surface temperature, and radiant temperature asymmetry, as described in ISO 7730–2005, Section 6, and Annex A, Section A.3, and confirm that dissatisfaction is within the allowable ranges listed in Annex A, Table A1.

This analysis may be an iterative process in which thermal conditions are revised or refined to meet the ISO requirements. By using the standard in this way, project teams can ensure that design criteria meet the credit requirements before they begin detailed design work.

If using EN 15251–2007, perform the analysis as described in the standard.

- Calculate running mean outdoor temperatures for the project's location, as described in Section 3.11 of the EN standard, for times of the year when natural conditioning is used.
- Use Figure A1 or the equations in Section A.2 of the EN standard to establish the upper and lower operative temperature limits of the comfort zone. It may be helpful to plot running mean outdoor temperatures, comfort zone boundaries, and design operative temperatures on Figure A1.
- Compare design operative temperatures with the comfort zone boundaries.

STEP 4. DESIGN PROJECT'S CONDITIONING SYSTEMS

Design the project's conditioning systems to provide the acceptable comfort conditions identified in the previous step. Additionally, verify that all spaces at risk for discomfort, such as locations close to entrances prone to drafts or west-facing walls that may retain heat, have been addressed.

ISO 7730–2005, Section A.2, requires the mechanical conditioning system design to maintain the specified comfort ranges "at all locations within the occupied zone of a space ... at all times." Systems that cannot maintain comfort under all conditions (e.g., a constant-volume rooftop unit with a single compressor may have problems controlling humidity levels) do not meet the credit requirements (see *Further Explanation, Examples*).

FURTHER EXPLANATION

CALCULATIONS

All calculations are found in the referenced standards.

THERMAL COMFORT CONDITIONING APPROACHES

There are three basic approaches to conditioning for thermal comfort: mechanical, natural, and a combination.

Mechanical conditioning is the use of mechanical systems, such as chillers and boilers, to supply cooling or heating to a space. Comfort is based on the predicted mean vote (PMV) model, which is the result of laboratory-based controlled climate chamber research in which test subjects assigned comfort values to different conditions. PMV assumes relatively consistent comfort conditions with minimal adjustment for seasonal variations. Occupants of mechanically conditioned spaces have come to expect a tightly controlled indoor thermal environment and a narrow band of indoor conditions.

Natural conditioning is the use of zero-energy strategies, such as cross or stack natural ventilation paths, passive solar heating, and thermal mass, to moderate exterior conditions. The thermal comfort zone is determined using the adaptive comfort model, which accounts for outdoor climate as well changes in occupants' expectations, clothing adjustments and use of controls, such as operable windows. Occupants of naturally conditioned spaces typically expect a broader comfort zone and accept more variation in comfort conditions, both of which can facilitate lower-energy solutions than are possible with mechanical conditioning alone.

Mixed-mode conditioning combines mechanical and natural conditioning systems, which may be used concurrently or on an alternating basis (within a working day or seasonally) in the same space, or may be used independently in different spaces in the same building.

CRITERIA FOR OCCUPANT-CONTROLLED NATURALLY CONDITIONED SPACES

The referenced standards, ASHRAE 55–2010, Section 5.3, and EN 15251–2007, Section A.2, set the following requirements for when the occupant-controlled naturally conditioned spaces (or adaptive) method may be used:

- Occupants' metabolic rate is between 1.0 and 1.3 metabolic equivalent of task (MET).
- Occupants are free to adapt their clothing to the indoor and/or outdoor thermal conditions.

- User-controlled operable windows are present.
- No mechanical cooling is installed.
- Running mean outdoor temperatures are within the ranges specified in the standards at times of year when natural conditioning is used.
- The natural conditioning comfort model cannot be applied to times of the year when the heating system is operating.

EXAMPLES

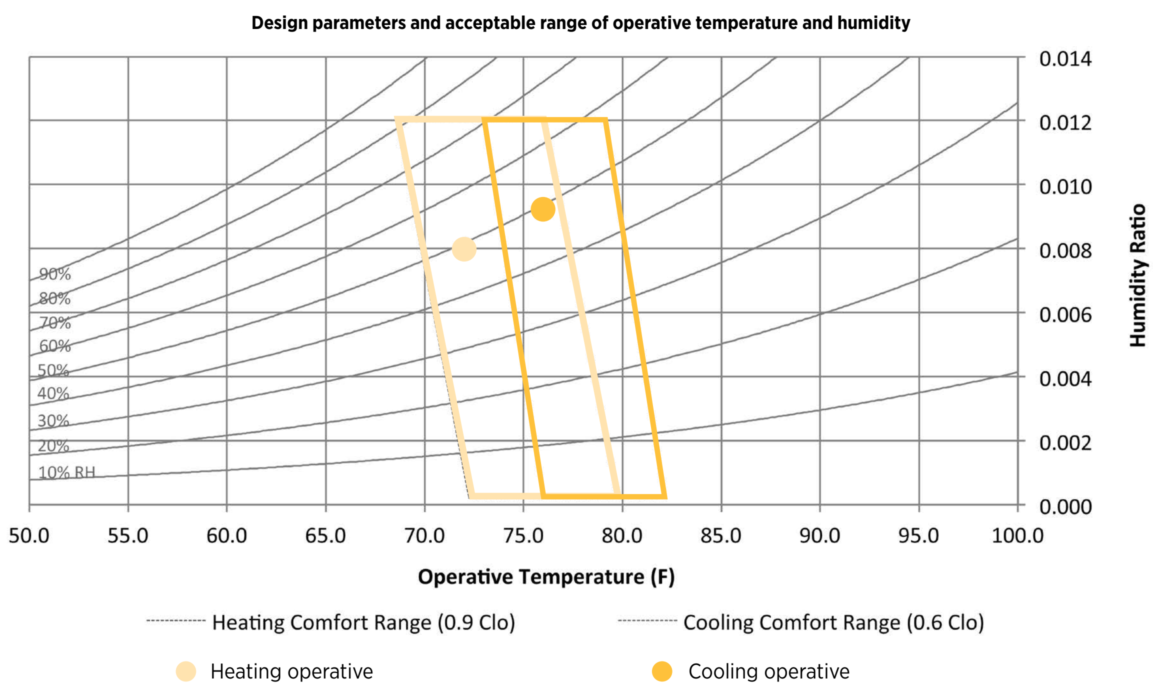
Example 1. Option 1, mechanically conditioned , graphic method

An office space is cooled with an underfloor air system and heated by perimeter fin tube radiators. The metabolic rate for the space is 1.1, per ASHRAE Appendix A. The clothing insolation (clo) is calculated as 0.9 when the outdoor environment is cool and 0.6 when the outdoor environment is warm, per garment insulation values from ASHRAE 55–2010, Appendix A, Table B2.

The project team has decided to determine compliance using the graphic method, described in ASHRAE 55–2010, Section 5.2.1.1. The design air speeds (less than 40 feet per minute), clothing insulation levels (0.5–1.0 clo), and occupant metabolic rate1.0–1.3 MET) are all within the specified ranges for this method.

The comfort zone boundaries are calculated using the ASHRAE equations for T_{max}, I_{cl}, T_{min}, I_{cl}, and I_{cl}. The design parameters and comfort zone boundaries are plotted on a psychometric chart (Figure 2). The team has determined that any local thermal discomfort effects are unlikely. Because the space's operative temperature and humidity levels fall within the comfort zone in heating and cooling modes, the project achieves the credit.

Figure 2. Supporting documentation for Example 1



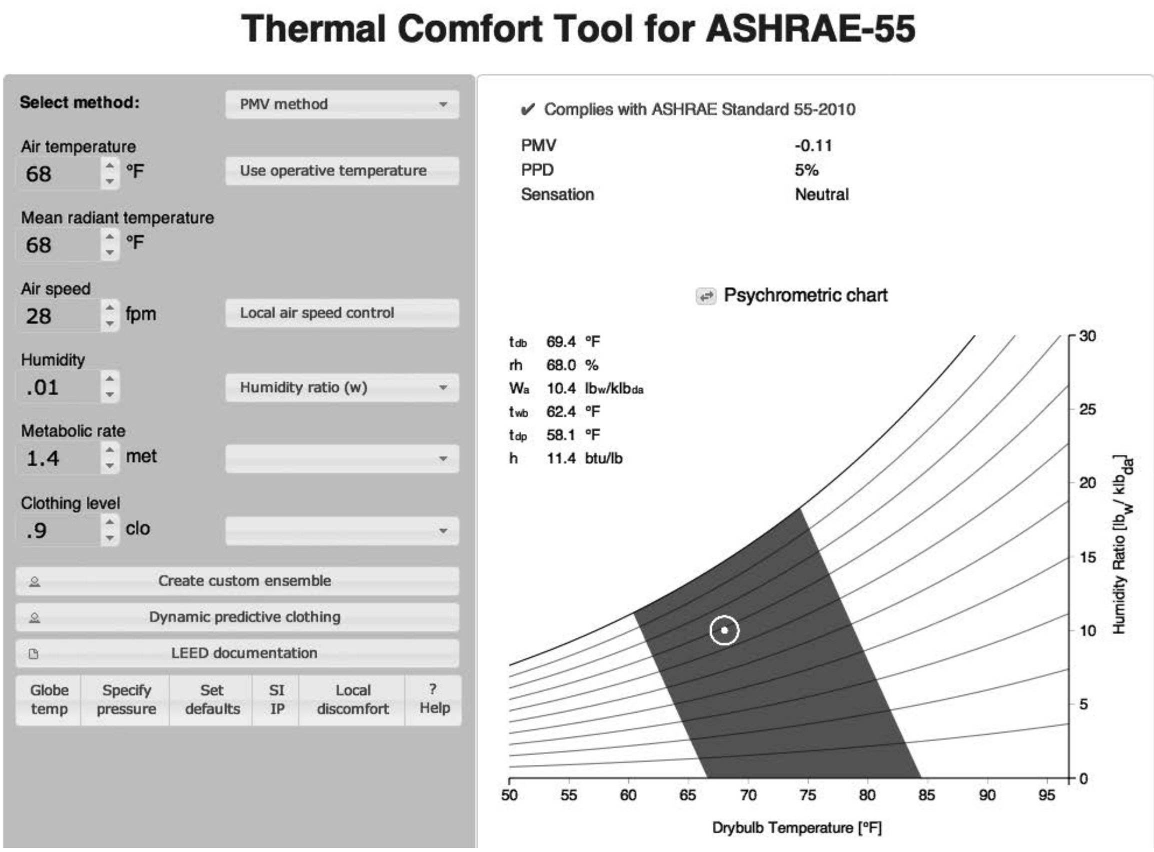
Example 2. Option 1, mechanically conditioned, computer model method

An office's file room is heated and cooled by a fan coil unit. Because the occupants of this space will be standing and filing, the expected metabolic rate is 1.4 MET, per ASHRAE 55–2010, Appendix A. The clo is calculated as in Example 1.

The project team is determining compliance using the computer model method, described in ASHRAE 55–2010, Section 5.2.1.2, because the activity level exceeds the upper metabolic limit of the graphic method (1.3 MET) but falls below the 2.0 limit for computer model method.

The design parameters are entered into the Center for the Built Environment (CBE) Thermal Comfort Tool for ASHRAE-55, which performs the required PMV and PPD calculation. The results from the tool (Figure 3) indicate that the room's operative temperature and humidity levels comply with the standard, and the project meets the credit requirements.

Figure 3. Supporting documentation for Example 2. Hoyt Tyler, Schiavon Stefano, Piccioli Alberto. 2013, CBE Thermal Comfort Tool for ASHRAE-55. Center for the Built Environment, University of California Berkeley, http://cbe.berkeley.edu/comforttool/



Example 3. Option 1, naturally conditioned, adaptive method

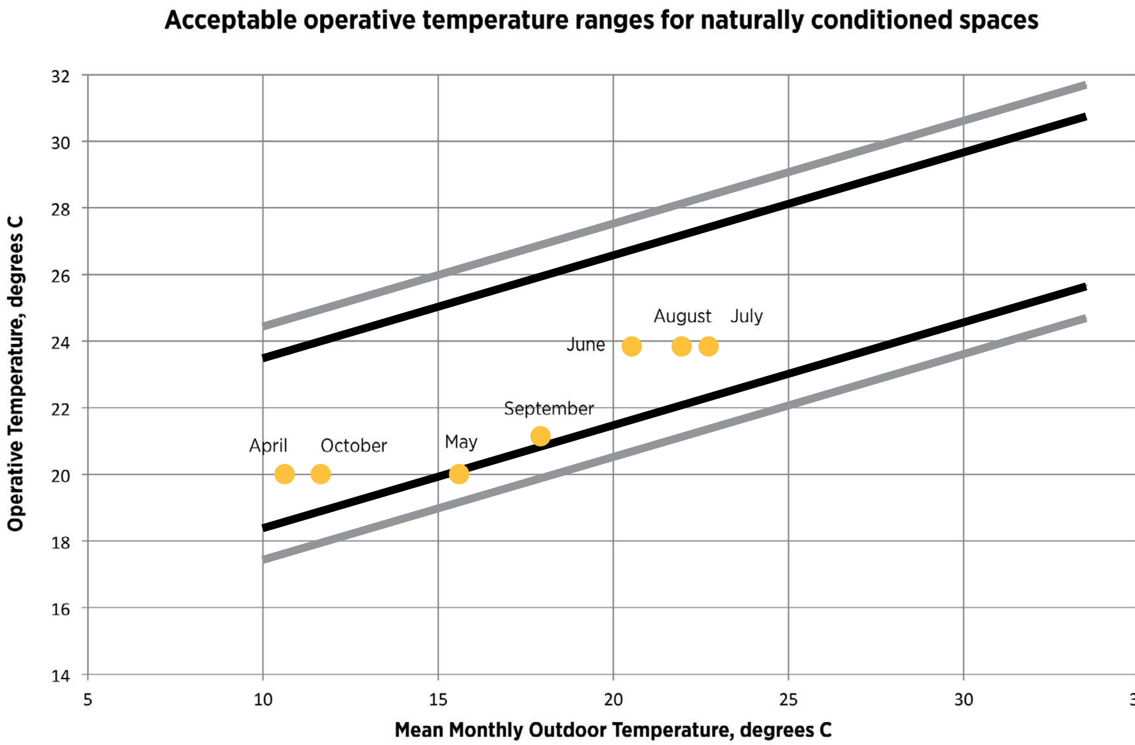
An open office space is naturally cooled with occupant-controlled operable windows and does not have any mechanical cooling system installed. Heating is provided by fin tube radiators.

The project team has decided to determine compliance for the cooling period (April through October) using the adaptive method, described in ASHRAE 55–2010, Section 5.3, Optional Method for Determining Acceptable Thermal Conditions in Naturally Conditioned Spaces.

The average monthly outdoor temperatures and design operative temperatures are plotted on Figure 5.3, found in Section 5.3 of the standard (Figure 4).

The project team must also determine compliance for the mechanically conditioned heating period (November through March) and uses the CBE Thermal Comfort Tool for ASHRAE-55, as described in Example 2.

Figure 4. Supporting documentation for Example 3



The project team must also determine compliance for the mechanically conditioned heating period (November through March) and uses the ASHRAE Thermal Comfort tool, as described in Example 2.

Example 4. Option 2

A classroom is naturally cooled via operable windows that are manually operated by teachers and students. The heating system consists of a hydronic radiant panel supplied with hot water from a central boiler system and controlled by a local thermostat in each classroom.

The project team has decided to determine compliance for the cooling period using the adaptive method, described in EN 15251–2007, Annex A, Section A.2, and will determine compliance for the mechanically conditioned heating period using ISO 7730–2005, Table E.3.

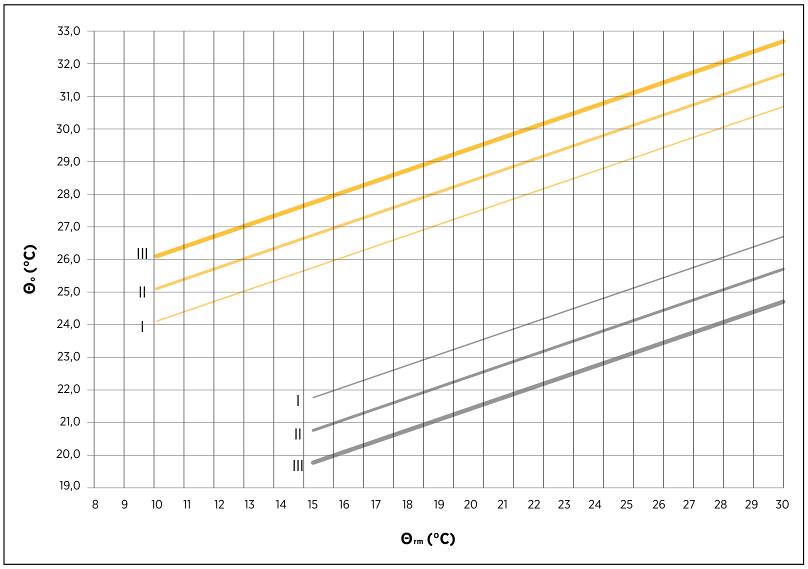
The project team creates a summary table for the design parameters (Table 2).

TABLE 2. Summary table for Example 4

	Space type	Activity level (MET)	Operative temperature (°C)	Mean monthly outdoor temperature (°C)	Relative humidity (%)	Air speed (m/s)
Cooling	Classroom	1.2	25.5	20	N/A	1
Heating	Classroom	1.2	22.2	N/A	50	0.15

The average mean monthly outdoor temperature and design operative temperature is plotted on Figure A1 in Annex A of the EN standard (Figure 5).

Figure 5. Supporting documentation for naturally conditioned period for Example 4. This excerpt is adapted and modified from ISO 7730:2005 and EN 15251:2007 with the permission of ANSI on behalf of ISO.



The design parameters were compared with the ISO 7730–2005 Annex E lookup table, Table E.3 (Figure 6), and the PMV was determined to be –0.40. This is within the acceptable range for a Category B building, which is –0.5<PMV<+0.5.

Figure 6. Supporting documentation for mechanically conditioned period for Example 4. This excerpt is adapted and modified from ISO 7730:2005 and EN 15251:2007 with the permission of ANSI on behalf of ISO.

Table E.3 — Activity level: 69,6 W/m² (1,2 met)

Clothing		Operative temperature	Relative air velocity							
			m/s							
clo	m² · K/W	°C	< 0,10	0,10	0,15	0,20	0,30	0,40	0,50	1,00
0	0	25	−1,33	−1,33	−1,59	−1,92				
		26	−0,83	−0,83	−1,11	−1,40				
		27	−0,33	−0,33	−0,63	−0,88				
		28	0,15	0,12	−0,14	−0,36				
		29	0,63	0,56	0,35	0,17				
		30	1,10	1,01	0,84	0,69				
		31	1,57	1,47	1,34	1,24				
		32	2,03	1,93	1,85	1,78				
0,25	0,039	23	−1,18	−1,18	−1,39	−1,61	−1,97	−2,25		
		24	−0,79	−0,79	−1,02	−1,22	−1,54	−1,80	−2,01	
		25	−0,42	−0,42	−0,64	−0,83	−1,11	−1,34	−1,54	−2,21
		26	−0,04	−0,07	−0,27	−0,43	−0,68	−0,89	−1,06	−1,65
		27	0,33	0,29	0,11	−0,03	−0,25	−0,43	−0,58	−1,09
		28	0,71	0,64	0,49	0,37	0,18	0,03	−0,10	−0,54
		29	1,07	0,99	0,87	0,77	0,61	0,49	0,39	0,03
		30	1,43	1,35	1,25	1,17	1,05	0,95	0,87	0,58
0,50	0,078	18	−2,01	−2,01	−2,17	−2,38	−2,70			
		20	−1,41	−1,41	−1,58	−1,76	−2,04	−2,25	−2,42	
		22	−0,79	−0,79	−0,97	−1,13	−1,36	−1,54	−1,69	−2,17
		24	−0,17	−0,20	−0,36	−0,48	−0,68	−0,83	−0,95	−1,35
		26	0,44	0,39	0,26	0,16	−0,01	−0,11	−0,21	−0,52
		28	1,05	0,98	0,88	0,81	0,70	0,61	0,54	−0,31
		30	1,64	1,57	1,51	1,46	1,39	1,33	1,29	1,14
		32	2,25	2,20	2,17	2,15	2,11	2,09	2,07	1,99
0,75	0,116	16	−1,77	−1,77	−1,91	−2,07	−2,31	−2,49		
		18	−1,27	−1,27	−1,42	−1,56	−1,77	−1,93	−2,05	−2,45
		20	−0,77	−0,77	−0,92	−1,04	−1,23	−1,36	−1,47	−1,82
		22	−0,25	−0,27	−0,40	−0,51	−0,66	−0,78	−0,87	−1,17
		24	0,27	0,23	0,12	0,03	−0,10	−0,19	−0,27	−0,51
		26	0,78	0,73	0,64	0,57	0,47	0,40	0,34	0,14
		28	1,29	1,23	1,17	1,12	1,04	0,99	0,94	0,80
		30	1,80	1,74	1,70	1,67	1,62	1,58	1,55	1,46
1,00	0,155	16	−1,18	−1,18	−1,31	−1,43	−1,59	−1,72	−1,82	−2,12

For the heating period, the project reviews the potential for local discomfort effects, as required by the ISO standard, and determines that draft rate, vertical air distribution, and warm and cool floors are not likely. Radiant asymmetry was considered likely, however, so the team must perform additional calculations.

Radiant asymmetry was calculated to be 10°C from warm walls and 5°C from cool walls. Figure 4 from Section 6.5, ISO 7730–2005 provides the associated percentages dissatisfied, <2% and <1%, respectively. The team compares percentages dissatisfied with the local discomfort limits listed in ISO 7730–2005, Annex A, Table A.1 and sees that they are well below the 5% limit for Category B buildings.

Alternatively, the project could have compared the radiant temperature asymmetry with Annex A, Table A.4, which shows that for a Category B building, the radiant temperature asymmetry must be below 23°C for warm walls and below 10°C for cool walls.

Example 5. Thermal comfort controls

A project consists of a library that has private offices, open library space with reference desks, meeting rooms, and a children's storytime room. All spaces are regularly occupied. The project develops a table to summarize the controls for each space (Table 3).

TABLE 3. Summary table for Example 5

Space type	Occupancy	Spaces	Spaces with controls	Type of control
Private office	Individual occupant	16	12	Operable window
Reference desk	Individual occupant	6	2	Adjustable underfloor diffuser
Meeting rooms	Multioccupant	8	8	Thermostat
Storytime room	Multioccupant	2	2	Operable window
Percentage of individual occupant spaces with controls			64% (=14/22)	
Percentage of multioccupant spaces with controls			100% (=10/10)	

The project team earns the credit because the percentage of individual occupant spaces with controls is above 50% and all multioccupant spaces have controls.

RATING SYSTEM VARIATIONS

Hospitality

The thermal comfort design and thermal comfort control requirements are the same as those in *Step-by-Step Guidance* with the exception of guest rooms, which are assumed to have individual thermal comfort controls and are therefore excluded from the controls requirements of this credit.

Retail

The thermal comfort design requirements are the same as those in *Step-by-Step Guidance*. The thermal comfort control requirements are the same as those in *Step-by-Step Guidance* but apply only to individual occupant spaces in office and administrative areas. All other spaces may be excluded.

PROJECT TYPE VARIATIONS

Gymnasiums, Fitness Areas, and Other Spaces with High Metabolic Rates

ASHRAE 55–2010, Normative Appendix A, permits use of a time-weighted average metabolic rate over a period of an hour or less. Any space with a rate of 2.0 MET or less must be addressed using standard compliance methods.

Although the ASHRAE standard does not apply where the time-averaged metabolic rate is above 2.0 MET, thermal comfort in these spaces must still be addressed. For spaces with a rate above 2.0 MET, address how the project meets the intent of the credit. ISO 7730–2005 addresses metabolic rates up to 4.0 MET.

Kitchens
Many kitchens are not conditioned, not cooled, or are only indirectly cooled and may have difficulties achieving the requirements of ASHRAE 55–2010 or ISO 7730–2005. For kitchens that cannot meet the requirements of these standards, address how the project meets the intent of the credit.

Apparatus Bays in Fire Stations
Typically, these spaces are not designed for human occupancy and thus would not have to meet the credit requirements. However, if these spaces are designed for human occupancy, the project must meet thermal comfort criteria. The requirements for LEED BD+C: Warehouses and Distribution Centers may be applied to meet the credit requirements for such spaces. Design each regularly occupied bulk storage, regularly occupied sorting and/or regularly occupied distribution area to include one or more of the following systems:

- Radiant flooring
- Circulating fans
- Passive systems, such as nighttime air, heat venting, or wind flow
- Localized active cooling (refrigerant or evaporative-based systems) or heating systems
- Localized, hard-wired fans that provide air movement for occupants' comfort

Vehicle Repair Facilities
The requirements for LEED BD+C: Warehouses and Distribution Centers may be applied to earn the credit (see Apparatus Bays in Fire Stations, above). This space type, which is not typically cooled, also includes military buildings where trucks, tanks, aircraft, and other vehicles are being serviced.

Natatoriums
Discuss with the owner how the natatorium will be used and the associated activity levels. Design the space to meet the thermal comfort design requirements in the ASHRAE HVAC Applications Handbook, 2011 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions. Calculate internal loads and rates of evaporation and verify that the design criteria will result in acceptable comfort. Retain all activity levels and factors, evaporation rates, and design calculations for credit documentation.

Residential
The thermal comfort design requirements are the same as those in *Step-by-Step Guidance*. The thermal comfort control requirements are the same as those in *Step-by-Step Guidance*, except the entire residential unit only needs one thermal comfort control.

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	Thermal comfort design		Thermal comfort controls
	Option 1	Option 2	
Description of weather data used to determine operative temperatures, relative humidity, and outdoor temperatures	X		
Plots or calculation results verifying that design parameters meet ASHRAE Standard 55–2010 for 80% acceptability (e.g., psychometric chart; PMV or PPD calculations; ASHRAE Thermal Comfort Tool results; copy of ASHRAE 55–2010, Figure 5.2.4.1, Figure 5.2.4.3, or Figure 5.2.4.4; or predicted worst-case indoor conditions for each month on copy of Figure 5.3)	X		
Documentation to verify thermally conditioned spaces meet ISO 7730 or EN 15251, as applicable (e.g., for ISO, calculations based on Sections 4.1 and 6 or Annex H, computer program results based on Annex D, tables based on Annex E, or copy of Figures 2, 3, 4, A.1, A.2; for EN, documentation of worst-case indoor conditions for each month on copy of Figure A1)		X	
Floor plans or drawings indicating all individual and shared multioccupant spaces.			X
List of spaces by type, quantity, and controls.			X

PMV = predicted mean vote (index of thermal comfort)

PPD = predicted percentage of dissatisfied (people)

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance. Any plug-in devices that are claimed as thermal controls must be included in Option 1 of the related prerequisite.

EQ Prerequisite Minimum Indoor Air Quality Performance. The requirements for natural conditioning (ASHRAE 55–2010) are different from those for natural ventilation (ASHRAE 62.1–2010). The former standard does not specify a minimum window size or any location or proximity requirements. The latter specifies minimum window or ventilation opening area as well as maximum distance from the ventilation opening that may be considered naturally ventilated. Refer to ASHRAE 62.1–2010, Section 6.4, for additional information. Adjustable diffusers used to provide thermal control (whether floor, wall, or ceiling mounted) can affect the supply air flow of ventilation and should be coordinated with the ventilation design under the related prerequisite.

EQ Credit Enhanced Indoor Air Quality Strategies. Natural ventilation and mixed mode systems must meet additional requirements of CISBE AM10 and AM13 to earn the related credit.

EQ Credit Interior Lighting. The quantity of individual occupant spaces and shared multioccupant spaces for this credit must be consistent with the quantity in the related credit.

CHANGES FROM LEED 2009

- This thermal comfort credit combines the LEED 2009 credits Controllability of Systems: Thermal Comfort (IEQ Credit 6.2, IEQ Credit 6) and Thermal Comfort: Design (IEQ Credit 7.1, IEQ Credit 7) into a single credit.
- The referenced standard has been updated to ASHRAE 55–2010. Refer to ASHRAE Journal (June 2011) for an explanation of changes from the 2004 version of the standard: ashrae.org/resources--publications/periodicals/ashrae-journal/.
- International standards have been included to provide more relevant compliance options for non-U.S. projects.
- The requirements for natatoriums are now applicable to all rating systems, not just Schools.

REFERENCED STANDARDS

ASHRAE Standard 55–2010, Thermal Environmental Conditions for Human Occupancy: ashrae.org

ASHRAE HVAC Applications Handbook, 2011 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions: ashrae.org

ISO 7730–2005 Ergonomics of the thermal environment, Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria: iso.org

EuropeanStandard EN 15251: 2007, Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics: cen.eu

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

individual occupant space an area where an occupant performs distinct tasks. Individual occupant spaces may be within multioccupant spaces and should be treated separately where possible.

nonregularly occupied space an area that people pass through or an area used for focused activities an average of less than one hour per person per day. The one-hour timeframe is continuous and should be based on the time a typical occupant uses the space. For spaces that are not used daily, the one-hour timeframe should be based on the time a typical occupant spends in the space when it is in use.

occupant control a system or switch that a person in the space can directly access and use. Examples include a task light, an open switch, and blinds. A temperature sensor, photo sensor, or centrally controlled system is not occupant controlled.

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

regularly occupied space an area where one or more individuals normally spend time (more than one hour per person per day on average) seated or standing as they work, study, or perform other focused activities inside a building. The one-hour timeframe is continuous and should be based on the time a typical occupant uses the space. For spaces that are not used daily, the one-hour timeframe should be based on the time a typical occupant spends in the space when it is in use.

shared multioccupant space a place of congregation, or where occupants pursue overlapping or collaborative tasks

unoccupied space an area designed for equipment, machinery, or storage rather than for human activities. An equipment area is considered unoccupied only if retrieval of equipment is occasional.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Interior Lighting

This credit applies to:

Commercial Interiors (1-2 points)
Retail (2 points)
Hospitality (1-2 points)

INTENT

To promote occupants' productivity, comfort, and well-being by providing high-quality lighting.

REQUIREMENTS

COMMERCIAL INTERIORS, HOSPITALITY

Select one or both of the following two options.

OPTION 1. LIGHTING CONTROL (1 POINT)

For at least 90% of individual occupant spaces, provide individual lighting controls that enable occupants to adjust the lighting to suit their individual tasks and preferences, with at least three lighting levels or scenes (on, off, midlevel). Midlevel is 30% to 70% of the maximum illumination level (not including daylight contributions).

For all shared multioccupant spaces, meet all of the following requirements.

- Have in place multizone control systems that enable occupants to adjust the lighting to meet group needs and preferences, with at least three lighting levels or scenes (on, off, midlevel).
- Lighting for any presentation or projection wall must be separately controlled.
- Switches or manual controls must be located in the same space as the controlled luminaires. A person operating the controls must have a direct line of sight to the controlled luminaires.

HOSPITALITY ONLY
Guest rooms are assumed to provide adequate lighting controls and are therefore not included in the credit calculations.

AND/OR

OPTION 2. LIGHTING QUALITY (1 POINT)

Choose four of the following strategies.

A. For all regularly occupied spaces, use light fixtures with a luminance of less than 2,500cd/m² between 45 and 90 degrees from nadir.
Exceptions include wallwash fixtures properly aimed at walls, as specified by manufacturer's data, indirect uplighting fixtures, provided there is no view down into these uplights from a regularly occupied space above, and any other specific applications (i.e. adjustable fixtures).

B. For the entire project, use light sources with a CRI of 80 or higher. Exceptions include lamps or fixtures specifically designed to provide colored lighting for effect, site lighting, or other special use.

C. For at least 75% of the total connected lighting load, use light sources that have a rated life (or L70 for LED sources) of at least 24,000 hours (at 3-hour per start, if applicable).

D. Use direct-only overhead lighting for 25% or less of the total connected lighting load for all regularly occupied spaces.

E. For at least 90% of the regularly occupied floor area, meet or exceed the following thresholds for area-weighted average surface reflectance: 85% for ceilings, 60% for walls, and 25% for floors.

F. If furniture is included in the scope of work, select furniture finishes to meet or exceed the following thresholds for area-weighted average surface reflectance: 45% for work surfaces, and 50% for movable partitions.

G. For at least 75% of the regularly occupied floor area, meet a ratio of average wall surface illuminance (excluding fenestration) to average work plane (or surface, if defined) illuminance that does not exceed 1:10. Must also meet strategy E, strategy F, or demonstrate area-weighted surface reflectance of at least 60% for walls.

H. For at least 75% of the regularly occupied floor area, meet a ratio of average ceiling illuminance (excluding fenestration) to work surface illuminance that does not exceed 1:10. Must also meet option E, option F, or demonstrate area-weighted surface reflectance of at least 85% for ceilings.

RETAIL

For at least 90% of the individual occupant spaces in office and administrative areas, provide individual lighting controls.

In sales areas, provide controls that can reduce the ambient light levels to a midlevel (30% to 70% of the maximum illumination level not including daylight contributions).

BEHIND THE INTENT

Studies of lighting in buildings have shown that workers are more comfortable and productive in an environment that is carefully illuminated and where lighting controls are provided for individual and group needs.[1] Also, high-quality lighting helps eliminate distractions, creates visual interest and a sense of place, supports interaction and communication, contributes to occupants' well-being, and reduces health problems.[2] This credit rewards lighting quality that dramatically improves occupants' comfort and productivity.[3]

The credit encourages lighting quality in multiple ways.

- Minimizing light fixture luminance (strategy A) helps reduce disability and discomfort glare; the threshold, 2,500 candela per square meter, was selected because research by the Light Right Consortium found that above that level, glare became objectionable.
- Using light sources with a color rendering index above 80 (strategy B) helps approximate natural light.
- Using light sources with long lamp life (strategy C) can lengthen the period over which the integrity of the lighting design is maintained; it also reduces maintenance costs and lowers material and resource inputs. A lamp life of 24,000 hours promotes the use of longer-life fluorescents.
- Designing spaces with less direct-only overhead lighting (strategy D) helps minimize glare, reduces the perceived brightness of the direct luminaires, and reduces contrast between ceiling and luminaire.
- Specifying surfaces with high reflectance (strategies E and F) helps make the space brighter through reflection, minimizing the difficulty of viewing light documents on dark surfaces; the specific surface reflectance values for ceilings, walls, and floors are above the standard industry assumptions of 80, 50, and 20, respectively, as recommended in the latest edition of the Illuminating Engineering Society (IES) Lighting Handbook[4].
- Designing for an illuminance ratio less than 1:10 (strategies G and H) minimizes the amount of contrast that occupants experience between their work surface and the ceiling and wall surfaces around them; the 1:10 illuminance ratio represents one log scale difference in lighting levels (human eyes are logarithmic, but illuminance is linear).

Research on lighting and visual performance is cited in *Further Explanation, Additional Lighting Resources*.

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH LIGHTING NEEDS

Work with the owner to understand occupants' lighting needs and desires.

- Document the types of tasks that will occur in each space and the tools and equipment that occupants will use regularly, and determine appropriate light levels for tasks.
- Identify the level of control that occupants should have and the characteristics of the occupant population.

STEP 2. SELECT OPTION(S)

Determine which option(s) are appropriate for the project. All projects except Retail projects may earn one or both options.

- Option 1 requires lighting controls for 90% of the individual occupant spaces and 100% of shared multioccupant spaces. Standard on-off switches are not acceptable; at least three lighting levels or scenes must be provided. Project teams that are familiar with previous versions of LEED may prefer this option, and it is easier to implement in later phases of design than Option 2.

1. *Lighting Quality and Office Work: A Field Simulation Study, lrc.rpi.edu/researchAreas/pdf/LRAlbanyStudyReport.pdf (accessed June 11, 2013).*
2. *Federal Lighting Guide, eere.energy.gov/femp/pdfs/light_controls.pdf (accessed June 11, 2013).*
3. *Veitch, J.A., et al., "Lighting Appraisal, Well-Being, and Performance in Open-Plan Offices: A Linked Mechanisms Approach," Lighting Research and Technology 40(2) (June 2008): 133-151.*
4. *DiLaura, David, Kevin Houser, Richard Mistrick, and Gary Steff, eds., The Lighting Handbook, 10th edition (New York: Illuminating Engineering Society of North America, 2011).*

- Option 2 offers eight strategies (Table 1), of which four must be implemented to meet the requirements. The first four strategies (A–D) are based on characteristics of the lighting fixtures, light sources, and luminaires. The second four strategies (E–H) are based on characteristics of the surfaces in the project and the illuminance levels that fall on those surfaces. This option requires attention during early design phases because achievement depends on luminaire selection and configuration and architectural surface specifications.

For Retail projects, see *Further Explanation, Rating System Variations*.

TABLE 1. Option 2. Lighting quality strategies

Strategy	Scope	Exceptions, exclusions
A. Light fixture luminance	All light fixtures located in regularly occupied spaces	• Wallwash fixtures properly aimed at walls, as specified by manufacturer • Indirect uplighting fixtures, provided there is no view down into these uplights from regularly occupied space above • Any other specific applications (e.g., adjustable fixtures)
B. Color rendering index (CRI)	All light fixtures	• Lamps or fixtures specifically designed to provide colored lighting for effect • Site lighting • Any other special use
C. Lamp life	75% connected lighting load	—
D. Direct-only overhead lighting	25% connected lighting load	—
E. Surface reflectance: ceilings, walls, floors	90% of regularly occupied floor area	—
F. Surface reflectance: furnishings	All furniture used for work surfaces	—
G. Surface illuminance ratio: wall to work surface	75% regularly occupied floor area	—
H. Surface illuminance ratio: ceiling to work surface	75% regularly occupied floor area	—

STEP 3. COMPLY WITH OPTION REQUIREMENTS

For the option(s) selected, follow the appropriate set of steps to confirm compliance.

Option 1. Lighting Control

Identify all individual occupant and shared multioccupant spaces in the project (see *EQ Overview*).

- Design lighting controls for individual and multioccupant spaces to meet the credit requirements for Option 1. Task lighting may be used to meet the credit requirements for individual occupant spaces. Task lights are not required to be hardwired.
- All lighting controls must provide at least three lighting levels or scenes: including on, off, and a midlevel, defined as 30% to 70% of the maximum illumination level (not including daylight contributions). Daylight does not qualify as a separate lighting level.
- For multioccupant spaces that can be subdivided by movable walls or partitions, provide the required lighting controls for each subdivision of the space.
- Tabulate all individual and multioccupant spaces and their respective lighting controls. Confirm that at least 90% of individual occupant spaces and 100% of multioccupant spaces meet credit requirements. The percentage of compliant individual occupant spaces is based on the number of spaces, not floor area.

Option 2. Lighting Quality

Option 2. Lighting Quality, Strategy A

Identify all regularly occupied spaces in the project and all light fixtures in these spaces (see *EQ Overview*). The following fixtures may be excluded:

- Wallwash fixtures properly aimed at walls, as specified by manufacturer's data
- Indirect uplighting fixtures, provided there is no view down into these uplights from a regularly occupied space above
- Any other specific applications (e.g., adjustable fixtures)

For the light fixtures, review luminaires cutsheets, Illuminating Engineering Society (IES) photometric files, or other documentation to identify luminance between 45 degrees and 90 degrees from nadir and select products that meet the credit requirements. The luminance must be below 2,500 candela per square meter.

Compile documentation that confirms compliance with the credit requirements for luminance.

Option 2. Lighting Quality, Strategy B

Specify all light sources to meet the credit requirements for color rendering index (CRI).

- The following light sources may be excluded: lamps or fixtures specifically designed to provide colored lighting for effect, site lighting, and lamps or fixtures designed for some other special use.
- For the light sources, determine the CRI, not to be confused with correlated color temperature (CCT), which refers to the spectrum of warm to cool. A light source can have a high or low CRI regardless of its CCT.
- Compile documentation that confirms compliance with the credit requirements for the lighting's CRI.

Option 2. Lighting Quality, Strategy C

Specify all light sources to meet the credit requirements for lamp life.

- Calculate the total connected lighting load for all lighting in the project, in watts or kilowatts. Refer to the lighting power calculations prepared for EA Prerequisite Minimum Energy Performance and tabulate luminaire quantities and wattages to determine the total connected load. For guidance on determining connected lighting load, see ASHRAE 90.1–2010, Sections 9.1.3 and 9.1.4. Plug-in lighting is included in the calculation for connected load.
- For lamp life, review luminaire cutsheets or other documentation. Lamp life depends on the type of source. For traditional light sources, the lamp life is based on the time at which 50% of the test samples have burned out. For LED light sources, the lamp life criterion L70 is based on the time at which the light source has a 30% reduction in light output. Review the IES Lighting Handbook for more information on lamp life.
- Calculate the amount of connected lighting load with compliant light source; it must be 75% or greater.

Compile documentation that confirms compliance with the credit requirements for lamp life.

Option 2. Lighting Quality, Strategy D

Specify a combination of direct-only overhead lighting and other lighting. Minimize the use of direct-only overhead lighting to meet the credit requirements for strategy D.

- Identify all regularly occupied spaces in the project and the total connected lighting load associated with these spaces (see *EQ Overview*). Refer to the lighting power calculations prepared for EA Prerequisite Minimum Energy Performance and tabulate luminaire quantities and wattages to determine the total connected load. For guidance on determining connected lighting load, see ASHRAE 90.1–2010, Sections 9.1.3 and 9.1.4. Plug-in lighting is included in the calculation for connected load.
- Determine the connected lighting load that is associated with direct-only overhead lighting; it must be 25% or less.

Compile documentation that confirms compliance with the credit requirements for overhead lighting.

Option 2. Surface Reflectance (Strategies E and F)

Select or specify high-reflectance finish materials as applicable to the strategy pursued: ceilings, walls, and floors for strategy E, and work surfaces and movable partitions for strategy F.

- Before construction begins, review manufacturers' cutsheets to identify reflectance, typically expressed as a fraction or percentage LR (light reflectance) or LRV (light reflectance value). If manufacturers' data do not include reflectance, measure the reflectance of product samples (before construction) or the installed product (postconstruction) using the methodology described in IES

Lighting Handbook, Section 9.12.2, Measuring Reflectance and Transmittance. Or use reflectance charts, such as Lighting Guide 11, Surface Reflectance and Colour.[5]

- For strategy E, 10% of the regularly occupied floor area may be excluded.
- For strategy F, work surfaces include desks or other table surfaces where individuals perform tasks. The surface area for movable partitions is limited to opaque surfaces of the partition; transparent or partially transparent surfaces are not included in the calculation.
- Use Equation 1 to calculate the average surface reflectance for walls, ceilings, and floors (strategy E) and work surfaces and movable partitions (strategy F).

EQUATION 1. Average surface reflectance

$$\text{Weighted average of surface reflectances} = \left\{ \frac{\left(\text{reflectance of surface 1} \times \text{surface area of surface 1}\right) + \left(\text{reflectance of surface 2} \times \text{surface area of surface 2}\right) + \ldots + \left(\text{reflectance of surface n and surface area of surface n}\right)}{\text{total surface area}} \right\}$$

Confirm that the average surface reflectance of the specified surfaces meets or exceeds the values in the credit requirements.

Option 2. Illuminance (Strategies G and H)

Develop a lighting design strategy to minimize the ratio of wall surface illuminance (strategy G) or ceiling surface illuminance (strategy H) to work surface illuminance. Consider the following design strategies:

- Specify ceiling and wall finishes that are light colored or have high surface reflectance.
- Design the lighting system to intentionally light the walls or ceiling.
- Consider luminaires that throw 20% to 30% of light on ceiling or wall, such as direct-indirect lighting.
- Arrange luminaires to provide wall wash.

Use lighting calculation software or measurements to determine the average illuminance levels on work, wall, and ceiling surfaces for each regularly occupied space. If illuminance values vary widely throughout the space, either subdivide or use the predominant illuminance level. Work surfaces include desks or other table surfaces where individuals perform tasks. Where work surfaces are not specified, calculate the illuminance at a height of 30 inches (750 millimeters) above the finished floor. Alternatively, calculate illuminance at the height where most visual tasks are expected to be performed. For existing building projects or after construction is complete, the illuminance may be measured. The illuminance of a given surface is measured with a light meter, with the sensor facing away from the surface for which the measurement is being taken.

Use Equation 2 (for Strategy G) and Equation 3 (for Strategy H) to calculate an illuminance ratio for each regularly occupied space. Determine the percentage of regularly occupied area that achieves an illuminance ratio of 1:10 or less, it must be at least 75%.

EQUATION 2. Wall to work plane illuminance ratio

$$\text{Illuminance ratio} = 1{:}\left\{ \frac{\text{average work surface illuminance}}{\text{average wall surface illuminance}} \right\}$$

EQUATION 3. Ceiling to work plane illuminance ratio

$$\text{Illuminance ratio} = 1{:}\left\{ \frac{\text{average work surface illuminance}}{\text{average ceiling illuminance}} \right\}$$

Spaces where similar ratios of wall surface or ceiling surface illuminance to work surface illuminance are expected can be assessed through a single representative calculation.

Compile documentation that confirms compliance with the credit requirements for illuminance, As applicable, include confirmation that one of the following has also been met: strategy E, strategy F, area-weighted surface reflectances of at least 60% for walls, or area-weighted surface reflectances of at least 85% for ceilings.

5. *cibseknowledgeportal.co.uk (accessed June 11, 2013).*

FURTHER EXPLANATION

CALCULATIONS

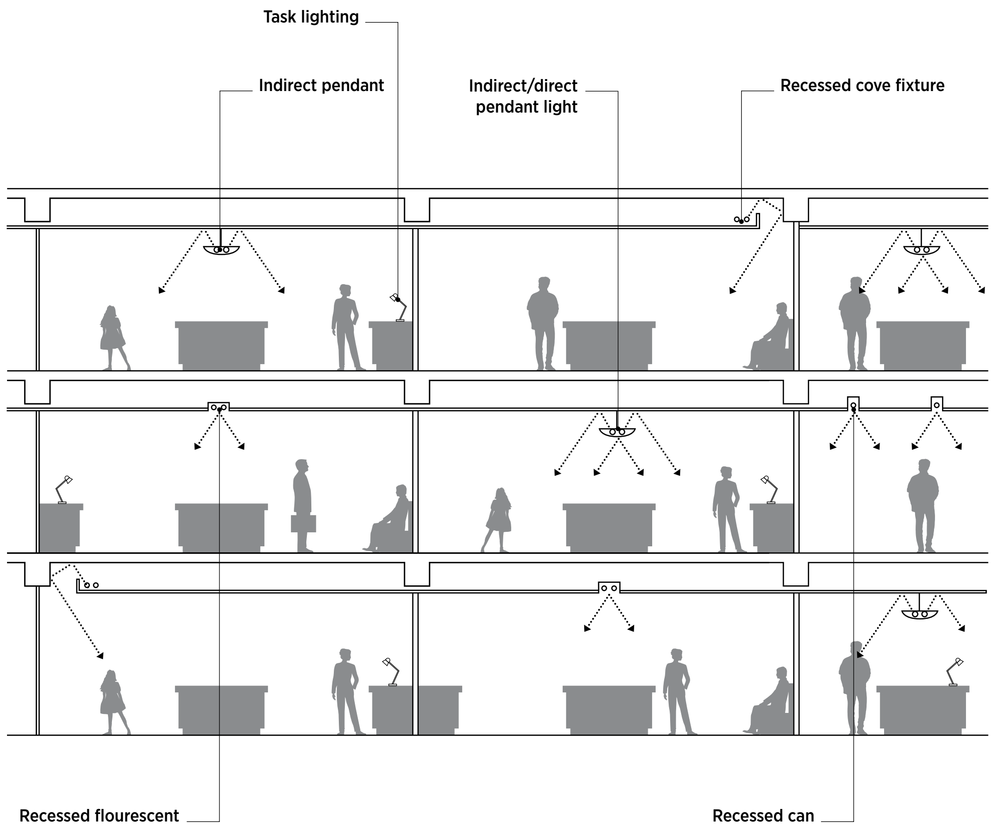
See calculations in *Step-by-Step Guidance*.

EXAMPLES

Example 1. Option 1

An office has individual occupant spaces (workstations), private offices, and a conference room. The workstations have task lighting that is part of the furniture system; the control allows for four distinct light levels. The private offices have overhead lighting with manual dimming controls. The conference room can be divided into two spaces, each with its own set of manual controls for overhead lighting. The overhead lighting is divided into two separate zones and is also fully dimmable. There are separate controls for lighting the presentation wall. Because this office has the appropriate lighting controls for at least 90% of the individual occupant spaces and all shared multioccupant spaces, the project earns 1 point under Option 1 of the credit.

Figure 1. Example 1



Example 2. Option 2, lighting quality, strategies A and D

The data for all luminaires specified in the project building's regularly occupied spaces are summarized in Table 2.

For strategy A, two luminaire types (indirect pendant and indirect-direct pendant) are excluded because there is no view of these luminaires from above. There is one luminaire type that does not meet the requirement, the surface-mounted luminaires. For this reason, the project does not achieve strategy A.

For strategy D, there are two direct-only overhead lights: recessed and surface mounted. The percentage of connected lighting load attributed to these lights is 5.7 % which is well below the 25% threshold. For this reason, the project achieves strategy D.

TABLE 2. Luminaire information for Example 2						
Description	**Connected load per luminaire (W)**	**Luminaires**	**Total connected load (W)**	**Luminance <2,500 cd/m² between 45° and 90° from nadir (Y/N)**	**Excluded from strategy A**	**Direct-only?**
Indirect pendant	112	8	896	N	Y	N
Recessed	56	4	224	Y	N	Y
Surface mounted	32	1	32	N	N	Y
Indirect-direct pendant	168	20	3,360	N	Y	N
Total connected lighting load (W): 4,512						
Percentage of connected lighting load that is direct-only: 5.7% (256 W)						

Example 3. Option 2, lighting quality, strategies B and C
Data for all light sources in the building are summarized in Table 3.

For strategy B, all three light sources have a CRI above 80. For this reason, the project achieves strategy B.

For strategy C, the lamp life for the linear fluorescent T8 and linear LED cove light both meet the lamp life requirement of 24,000 hours or more rated life or L70. The percentage of connected lighting load attributed to the light fixtures with these lamps is 96.2 % which is well above the 75% threshold. For this reason, the project achieves strategy C.

TABLE 3. Example 3 Light source information			
Light source description	**Total connected load for fixtures (W)**	**CRI**	**Lamp life (hours)**
Linear fluorescent T8	5,320	82	26,000
Halogen	250	99	5,000
Linear LED cove light	1,000	81	L70
Total connected load (W): 6,570			
Percentage of connected lighting load that meets lamp life requirement: 96.2% (6,320 W)			

Example 4. Option 2, Lighting quality, strategies E and F
The values of the reflectance for the ceilings, walls, floors, work surfaces, and partitions were determined. The results are summarized in the table below.

Figure 2. Example using form supplemental calculator

Surface Information		Surface Reflectance for Ceilings, Walls, Floors			Surface Reflectance for Furnishings	
Description of Surface	Reflectance (%)	Pctg. total regularly occupied floor area included below (%)		100%	Work Surface Area (sq ft)	Moveable Partition Area (sq ft)
		Ceiling Area (sq ft)	Wall Area (sq ft)	Floor Area (sq ft)		
high reflectance ceiling	90.00%	26786.00				
generic ceiling	80.00%	216.00				
wall type 1	65.00%		7312.00			
wall type 2	55.00%		500.00			
light wood floor	27.00%			500.00		
dark carpet	12.00%			216.00		
light carpet	25.00%			26286.00		
workstation type 1	60.00%				2000.00	
workstation type 2	50.00%				20.00	
workstation type 3	10.00%				500.00	
partition type 1	50.00%					80.00
partition type 2	55.00%					40.00
Total area incl. in calculation		**27002.00**	**7812.00**	**27002.00**	**2520.00**	**120.00**
E. Surface Reflectance for Ceilings, Walls, Floors	Average surface reflectance for ceilings					90%
	Average surface reflectance for walls					64%
	Average surface reflectance for floors					25%
F. Surface Reflectance for Furnishings	Average surface reflectance for work surfaces					50%
	Average surface reflectance for moveable partitions					52%

Example 5. Option 2, lighting quality, strategies G and H

The project's lighting designer has used lighting calculation software to determine the illuminance levels for wall, ceiling, and work surfaces and compiled Table 4. Private office 2 was excluded from the calculation because the office has low wall and ceiling illuminance values.

The project team wishes to use strategies G and H. The wall to work surface illuminance ratio exceeds 1:10 in the open office, which constitutes the majority of the floor area in the project, so the project does not attain strategy G.

However, the ceiling to work surface illuminance ratio is below 1:10 for the open office, private office 1, and the conference room. The project has also achieved strategy E, so the project complies with strategy H.

TABLE 4. Illuminance information for Example 5

Space	Floor area (ft^2)	Average illuminance (footcandles)			Illuminance ratio	
		Work surface	Wall	Ceiling	Wall to work surface	Ceiling to work surface
Open office	26,284	80 (861 lux)	7 (75 lux)	20 (214 lux)	1:11.4	1:4
Private office 1	96	75 (807 lux)	10 (107 lux)	25 (267 lux)	1:7.5	1:3
Conference room	500	60 (642 lux)	10 (107 lux)	15 (160 lux)	1:6	1:4
Private office 2	120	n/a	n/a	n/a	n/a	n/a
Total regularly occupied floor area (ft^2): 27,000						
Percentage of regularly occupied floor area that meets wall to work surface illuminance ratio of 1:10 or less (must be 75%): 2.2% (596 ft^2)						
Percentage of regularly occupied floor area that meets ceiling to work surface illuminance ratio of 1:10 or less (must be 75%): 99.6% (26,892 ft^2)						

ADDITIONAL LIGHTING RESOURCES

Studies of the effect of lighting on visual performance and comfort can be found in the following sources:

- Peter R. Boyce, *Human Factors in Lighting*, 2nd edition (Taylor and Francis, 2003).
- Lighting and Human Performance II (available at no cost from EPRI): my.epri.com/portal/server.pt?
- Lighting Guide 11: Surface Reflectance and Colour: cibseknowledgeportal.co.uk/
- Lighting Research Center at Rensselaer Polytechnic Institute: lrc.rpi.edu/
- National Research Council Canada Institute for Research in Construction: nrc-cnrc.gc.ca/eng/ibp/irc.html
- J.A. Veitch, "Psychological Processes Influencing Lighting Quality," *Journal of the Illuminating Engineering Society* 30(1) (2001): 124–40.
- *The Lighting Handbook*, 10th edition, Illuminating Engineering Society of North America (2011).

RATING SYSTEM VARIATIONS

Retail

Option 1. Lighting Control

Follow the steps for Option 1 for office and administration areas. In addition, provide at least three lighting levels—on, off, and a midlevel—in sales areas.

Hospitality

Option 1. Lighting Control

Exclude guest rooms from the lighting control calculations.

PROJECT TYPE VARIATIONS

Residential

For Option 1, residential units must have one lighting control for each individual occupant and multioccupant space. For example, for a bedroom (listed as individual occupancy), a task light in the bedroom or an overhead light with manual dimmable control would be acceptable. See *EQ Overview* for a list of individual and multioccupant space types in residential buildings.

CAMPUS

Group Approach

All project spaces in the group may be documented as one.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	Option 1	Option 2							
		A	B	C	D	E	F	G	H
Table of individual occupant and multioccupant spaces and lighting controls in each space	X								
Table of regularly occupied spaces and associated lighting details		X			X				
Calculations of total connected lighting load				X	X				
Lighting details, including manufacturer and model, results of estimations, or in situ or laboratory photometric tests		X	X	X	X				
List of ceiling surfaces, wall surfaces, floor surfaces and their associated surface reflectance values						X			
List of work surfaces and movable partitions and their associated surface reflectance values							X		
Average surface reflectance calculations						X	X		
List of work surfaces and illuminance values (lux)								X	
List of wall or ceiling surfaces with illuminance values (lux)									X
Illuminance ratio calculations								X	X

RELATED CREDIT TIPS

EQ Credit Thermal Comfort. Individual and multioccupant spaces must be applied consistently with the related credit.

EA Prerequisite Fundamental Commissioning and Verification and EA Credit Enhanced Commissioning. All lighting controls must be included in the commissioning process.

EA Credit Optimize Energy Performance. The connected lighting load calculated for hardware strategies in Option 2 of this credit should be the same for the related credit. This credit emphasizes manual user controls; the related credit rewards projects that incorporate daylighting and occupancy sensor lighting controls. Review the requirements for both credits and coordinate all automatic and manual lighting controls.

CHANGES FROM LEED 2009

- An additional point and option for lighting quality has been added to the previous lighting control requirements.
- The requirements for lighting control have been revised to require at least three lighting levels to meet the controllability criteria.

REFERENCED STANDARDS

The Lighting Handbook, 10th edition, Illuminating Engineering Society of North America: ies.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

color rendering index a measurement from 0 to 100 that indicates how accurately an artificial light source, as compared with an incandescent light, displays hues. The higher the index number, the more accurately the light is rendering colors. Incandescent lighting has a color rendering index above 95; standard high-pressure sodium lighting (such as orange-hued roadway lights) measures approximately 25; many fluorescent sources using rare earth phosphors have a color rendering index of 80 and above. (Adapted from U.S. ENERGY STAR)

illuminance the incident luminous flux density on a differential element of surface located at a point and oriented in a particular direction, expressed in lumens per unit area. Since the area involved is differential, it is customary to refer to this as illuminance at a point. The unit name depends on the unit of measurement for area: footcandles if square feet are used for area, and lux if square meters are used. (Adapted from IES) In lay terms, illuminance is a measurement of light striking a surface. It is expressed in footcandles in the U.S. (based on square feet) and in lux in most other countries (based on square meters).

individual occupant space an area where an occupant performs distinct tasks. Individual occupant spaces may be within multioccupant spaces and should be treated separately where possible.

shared multioccupant space a place of congregation, or where occupants pursue overlapping or collaborative tasks

INDOOR ENVIRONMENTAL QUALITY CREDIT

Daylight

This credit applies to:

Commercial Interiors (1-3 points)
Retail (1-3 points)
Hospitality (1-3 points)

INTENT

To connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.

REQUIREMENTS

Provide manual or automatic (with manual override) glare-control devices for all regularly occupied spaces.

Select one of the following three options.

OPTION 1. SIMULATION: SPATIAL DAYLIGHT AUTONOMY AND ANNUAL SUNLIGHT EXPOSURE (2–3 POINTS)

Demonstrate through annual computer simulations that spatial daylight autonomy$_{300/50\%}$ (sDA$_{300/50\%}$) of at least 55%, 75%, or 90% is achieved. Use regularly occupied floor area. Healthcare projects should use the perimeter area determined under EQ Credit Quality Views. Points are awarded according to Table 1.

TABLE 1. Points for daylit floor area: Spatial daylight autonomy

sDA (for regularly occupied floor area)	Points
55%	2
75%	3

AND

Demonstrate through annual computer simulations that annual sunlight exposure$_{1000,250}$ (ASE$_{1000,250}$) of no more than 10% is achieved. Use the regularly occupied floor area that is daylit per the sDA$_{300/50\%}$ simulations.

The sDA and ASE calculation grids should be no more than 2 feet (600 millimeters) square and laid out across the regularly occupied area at a work plane height of 30 inches (76 millimeters) above finished floor (unless otherwise defined). Use an hourly time-step analysis based on typical meteorological year data, or an equivalent, for the nearest available weather station.

Include any permanent interior obstructions and moveable furniture and partitions.

OR

OPTION 2. SIMULATION: ILLUMINANCE CALCULATIONS (1–2 POINTS)

Demonstrate through computer modeling that illuminance levels will be between 300 lux and 3,000 lux for 9 a.m. and 3 p.m., both on a clear-sky day at the equinox, for the floor area indicated in Table 2. Use regularly occupied floor area. Healthcare projects should use the perimeter area determined under EQ Credit Quality Views.

TABLE 2. Points for daylit floor area: Illuminance calculation

Percentage of regularly occupied floor area	Points
75%	1
90%	2

Calculate illuminance intensity for sun (direct component) and sky (diffuse component) for clear-sky conditions as follows:

- Use typical meteorological year data, or an equivalent, for the nearest available weather station.
- Select one day within 15 days of September 21 and one day within 15 days of March 21 that represent the clearest sky condition.
- Use the average of the hourly value for the two selected days.

Exclude blinds or shades from the model.

Include any permanent interior obstructions and moveable furniture and partitions.

OR

OPTION 3. MEASUREMENT (2-3 POINTS)

Achieve illuminance levels between 300 lux and 3,000 lux for the floor area indicated in Table 3.

TABLE 3. Points for daylit floor area: Measurement

Percentage of regularly occupied floor area	Points
75	2
90	3

With furniture, fixtures, and equipment in place, measure illuminance levels as follows:

- Measure at appropriate work plane height during any hour between 9 a.m. and 3 p.m.
- Take one measurement in any regularly occupied month, and take a second as indicated in Table 4.
- For spaces larger than 150 square feet (14 square meters), take measurements on a maximum 10 foot (3 meter) square grid.
- For spaces 150 square feet (14 square meters) or smaller, take measurements on a maximum 3 foot (900 millimeters) square grid.

TABLE 4. Timing of measurements for illuminance

If first measurement is taken in ...	take second measurement in ...
January	May-September
February	June-October
March	June-July, November-December
April	August-December
May	September-January
June	October-February
July	November-March
August	December-April
September	December-January, May-June
October	February-June
November	March-July
December	April-August

BEHIND THE INTENT

Increased access to daylight has positive human behavioral and health effects because it reinforces our circadian rhythms.[1] Access to sufficient daylight has been shown to increase healing times in hospitals, improve students' performance,[2] increase productivity in the workplace,[3] fight depression and lethargy, and even increase sales in retail environments.[4] A well-designed daylit building also uses less electric lighting energy, conserving natural resources and reducing air pollution.

This credit has evolved significantly and now focuses on using simulated daylight analysis and actual measurement to estimate daylight quality and daylight levels. These methods more accurately predict daylight access and support the design process for optimizing daylight. The previous prescriptive method for calculating daylight using window design less accurately accounted for such project-specific factors as building orientation, exterior conditions, the interaction with interior finishes, time of day and year, and other performance variables. The new simulation requirements use global metrics and performance values for daylight established by daylighting professionals. Other globally recognized standards-setting organizations are using the credit's language, metric conversions, and performance goals to create consistency in the daylighting and building professions.

Projects have three compliance options. The options that require more detailed design input and analysis or that demonstrate actual performance earn a correspondingly higher number of points. A good computer simulation is the best way to inform the design phase and help create a more effective daylit project. Project teams should integrate daylight concerns into the design process while taking into account such factors as heat gain and loss, glare control, visual quality, and variations in daylight availability.

STEP-BY-STEP GUIDANCE

STEP 1. ESTABLISH DAYLIGHTING GOALS

During predesign, work with the owner to understand lighting and daylighting goals. Specify daylighting performance criteria in the owner's project requirements.

STEP 2. EVALUATE BUILDING SITE AND MASSING

During schematic design, evaluate the building and project space for daylight availability.

- Review the building's orientation to see whether it allows for passive solar strategies. Consider strategies to improve daylight penetration and distribution.
- Consider the topography and landscape features that shade (or will shade) the building or minimize glare.
- Consider proximity to neighboring buildings and their effects on daylighting availability and shading.
- Evaluate the building footprint, the structural floor-to-floor height, and finished ceiling clearances to understand the ratio of window to floor area.
- Evaluate the envelope design and any exterior shading that may minimize solar heat gains and glare while admitting daylight (see *Further Explanation, Daylight Resources*).

STEP 3. DESIGN TO MAXIMIZE DAYLIGHT

Consider how best to allocate interior space to ensure that daylight is available in all regularly occupied spaces. Enclosure design and furniture selection will affect daylight penetration. Possible design strategies include the following:

1. *Kellert, Stephen R., Judith H. Heerwagen, and Martin L. Mador, Biophilic Design: The Theory, Science and Practice of Bringing Life into Buildings (New York: Wiley, 2008), p. 99.*
2. *Boyce, Peter, Reviews of Technical Reports on Daylight and Productivity (Rensselaer Polytechnic Institute, 2004); Heschong Mahone Group, Daylighting in Schools: An Investigation into the Relationship between Daylighting and Human Performance (1999).*
3. *Edwards, L., and P. Torcellini. A Literature Study of the Effects of Natural Light on Building Occupants (Golden, Colorado: NREL, 2002).*
4. *Peet, Ramona, Lisa Heschong, Roger Wright, and Don Aumann, Daylighting and Productivity in the Retail Sector (2004), eceee.org/conference_proceedings/ACEEE_buildings/2004/Panel_7/p7_24/paper (accessed June 12, 2013).*

- Use transparent partitions or interior glazing to provide daylight to enclosed spaces.
- In open-plan offices, select low partitions or incorporate glazed panels above 42 inches (1 070 millimeters).
- Consider using daylighting simulations early in the design process to ensure effective daylighting and to identify and minimize sources of glare.

STEP 4. IDENTIFY REGULARLY OCCUPIED SPACES

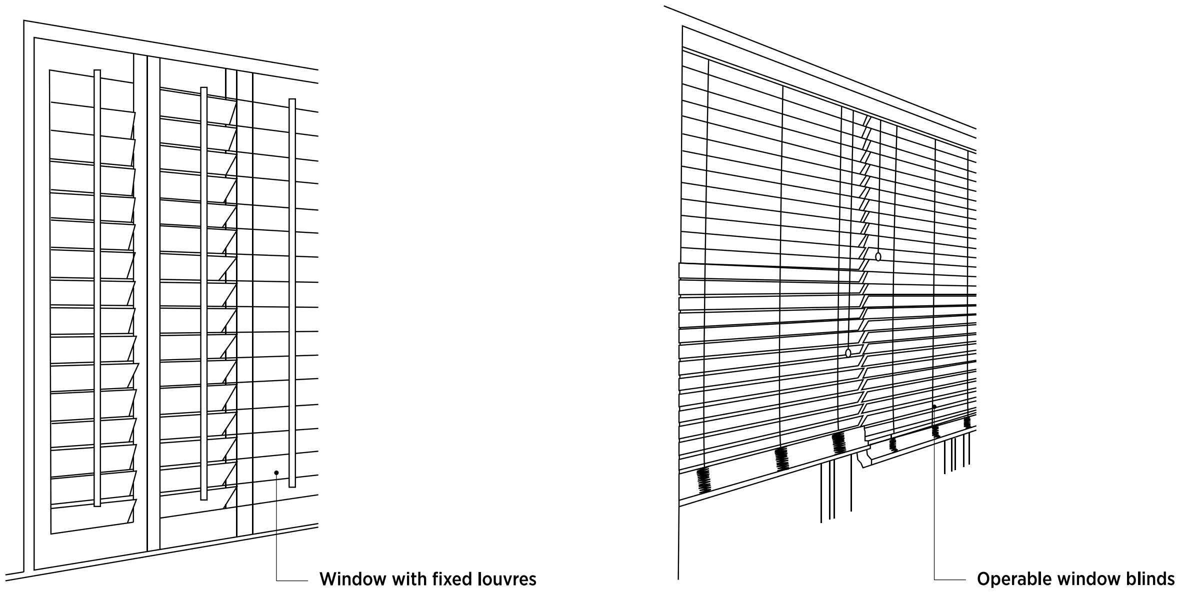
Identify all regularly occupied spaces within the project (see *EQ Overview, Regularly Occupied Spaces*). Highlight regularly occupied spaces on the floor plan or furniture plan and create a tracking table that lists all regularly occupied spaces and their respective floor area.

Determine whether any regularly occupied spaces should be excluded from the daylight requirements (see *Further Explanation, Project Type Variations*). Spaces where tasks would be hindered by the use of daylight may be excluded. Spaces may not be excluded for security or noise concerns.

STEP 5. PROVIDE GLARE CONTROLS

Provide glare-control devices (Figure 1) for all transparent glazing in regularly occupied spaces, regardless of whether the glazing receives direct sunlight or whether the space meets the illuminance requirements of this credit.

- All glare-control devices must be operable by the building's occupants to address unpredicted glare. Automatic devices with user override are acceptable.
- Acceptable glare-control devices include interior window blinds, shades, curtains, movable exterior louvers, movable screens, and movable awnings.
- Systems not acceptable as glare-control devices include fixed exterior overhangs, fixed fins and louvers, dark-colored glazing, and frit and other glazing treatments.
- Diffused and translucent glazing systems do not require glare-control devices.



Unacceptable Glare Control Devices

- Fixed exterior overhangs
- Fixed fins
- Fixed louvres
- Dark color glazing
- Frit glazing treatment
- Additional glazing treatments

Acceptable Glare Control Devices

- Interior window blinds
- Interior shades
- Curtains
- Moveable exterior louvres
- Moveable screens
- Moveable awnings

Figure 1. Glare control devices

STEP 6. SELECT ONE OPTION

Determine which option the project will pursue. Options 1 and 2 involve different modeling procedures (see *IES LM 83-12* and *Further Explanation, Illuminance Simulation Procedure*).

- Option 1 requires project teams to simulate both hourly illuminance and direct sunlight in each space over an entire year and likely necessitates engaging a daylighting consultant. The method uses a daylight simulation program that generates spatial daylight autonomy (sDA) ratios,[5] a metric that determines annual daylight performance based on annual weather data and occupancy use. This temporal analysis provides more information for design decisions than single-point-in-time calculations.[6] Only spatial daylight autonomy (and not continuous autonomy or daylight autonomy) is modeled.
- Option 2 is similar to the simulation option in previous versions of LEED and may require the help of a daylighting consultant. This compliance method has been carried over from previous LEED versions because illuminance calculation is still used by many daylighting professionals. However, project teams are now required to use site-specific daylight illuminance values instead of the program default values for weather. This provides daylight performance data that better reflect actual site conditions, leading to better design decisions.
- Option 3 is typically for renovations that involve minimal modifications to the building envelope and for substantiating a completed project's design strategies with a performance-based metric. Consider the schedule before selecting Option 3: the second required measurement must occur at least five months after the first measurement. Measurement compliance method is similar to the method used in previous versions and is now the only method for credit compliance that is not simulation based. This method has been revised to better address the differences in daylight experienced throughout the year by requiring measurements at two times—when the sun is high in the sky and when the sun is low in the sky.

5. *Illuminating Engineering Society, Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE), IES document LM-83 (2013), ies.org/store/product/approved-method-ies-spatial-daylight-autonomy-sda-and-annual-sunlight-exposure-ase-1287.cfm (accessed June 12, 2013).*

6. *Heschong Mahone Group, Daylighting Metrics (California Energy Commission, PIER Daylighting Plus Research Program, February 2012), energy.ca.gov/2012publications/CEC-500-2012-053/CEC-500-2012-053.pdf (accessed June 12, 2013).*

Option 1. Simulation—Spatial Daylight Autonomy

STEP 1. COLLECT SDA SIMULATION INPUTS

Work with the daylighting consultant to identify information needed for the daylight simulation. At a minimum, compile the following:

- Exterior building geometry and obstructions
- Site plan, location, and context
- Floor plan and furniture plan
- Interior finishes and surface reflectance (see *Further Explanation, Surface Reflectance*).
- Glazing performance specifications
- Glare control devices specifications
- Project occupancy schedule
- Local climate weather files, such as typical meteorological year (TMY2 or TMY3) data, available at nrel.gov

STEP 2. PERFORM sDA SIMULATION

Prepare the sDA model based on information collected in Step 1. Follow the modeling methodology outlined in IES LM83.

Prepare the sDA model based on information collected in Step 1. Follow the modeling methodology outlined in IES LM 83 (section numbers below refer to this standard).

- See Section 2.2, sDA—Building 3D Modeling Methodology, for guidance on the period of analysis, illuminance threshold information, temporal threshold, analysis area, analysis points, operation of blinds and shades, optical properties of blinds and shades, exterior obstructions, window and skylight details, interior surface reflectances, and furniture and partitions. For building geometries, develop a complete building model.
- Ensure that the software program selected is capable of simulating the sDA model per Section 2.3.3, Modeling Parameters.
- Determine how the regularly occupied spaces will be divided into analysis areas. The analysis areas must cover all regularly occupied floor area. For the annual sunlight exposure (ASE) calculations, at a minimum, each floor must be an analysis area.
- Include glare-control devices in the model as described in Sections 2.2.7, Blinds/Shades Operation, and 2.2.8, Blinds/Shades Optical Properties.
- Set thresholds for the simulation to 300 lux for 50% of the hours between 8 a.m. and 6 p.m. local clock time, for a full calendar year, from January 1 to December 31. See Sections 2.2.1, Period of Analysis; 2.2.2, Illuminance Threshold Information; and 2.2.3, Temporal Threshold.
- Ensure that the model includes all permanent interior obstructions. Moveable furniture and partitions may be excluded. See Section 2.2.11 for suggestions on modeling furniture and partitions.
- Refer to Section 2.3, sDA—Climatic Modeling Methodology, for guidance on climate conditions for the project's location (see *Further Explanation, Finding Meteorological Data*). Perform the sDA simulation.
- Consult with the project team on assumptions developed for early design simulations. The assumptions should be further refined as design develops. Simulation results used for credit documentation should be based on the design that is closest to the completed construction documents for the as-built scenario.

STEP 3. EVALUATE sDA COMPLIANCE

Review the simulation output results and determine the sDA value for all regularly occupied floor area.

- Record the areas that are daylit (i.e., they contribute to the sDA value by meeting the threshold for the simulation).
- Confirm that the project meets or exceeds the requirements in Table 1 in the credit requirements.

STEP 4. PERFORM ANNUAL SUNLIGHT EXPOSURE SIMULATION

Prepare the annual sunlight exposure (ASE) model based on information collected in Step 1 and the sDA model created in Step 2. The sDA model can be used for ASE analysis with a few modifications. Follow the modeling methodology outlined in IES LM83 (section numbers below refer to this standard).

- See Section 3.2, ASE—Building 3D Modeling Details, for guidance on the period of analysis, illuminance threshold information, temporal threshold, analysis area, analysis points, operation of blinds and shades, optical properties of blinds and shades, and exterior obstructions.

- The analysis areas should be the same as those used for the sDA simulations. To align with the supporting research for ASE, small analysis areas (ideally space by space, or orientation per floor) are recommended. At a minimum, the analysis area must be for all regularly occupied floor area on a single floor.
- Glare-control devices are not included in the analysis per Section 3.2.6, Blinds/Shade Operation.
- Set thresholds for the simulation to 1,000 lux of direct sunlight for more than 250 hours of the hours between 8 a.m. and 6 p.m. local clock time, for a full calendar year, from January 1 to December 31. See Sections 3.2.1, Period of Analysis; 3.2.2, Illuminance Threshold Information; and 3.2.3, Temporal Threshold).
- Refer to Section 3.3, ASE—Climatic Modeling Methodology, for guidance on climate conditions for the project's location. The ASE analysis does not require modeling of sky luminance or ground reflectance. If the software being used does not accommodate direct sunlight as described in Section 3.3, ASE may be identified based on illuminance compared with adjacent nodes.

For an alternative way to determine ASE, see *Further Explanation, Direct Sunlight Based on Lux Differences between Adjacent Grid Points*.

STEP 5. EVALUATE COMPLIANCE FOR ANNUAL SUNLIGHT EXPOSURE

Review the simulation output results and determine the ASE values for each analysis area.

- Record the ASE values for each floor area being analyzed.
- Confirm that the ASE value does not exceed 10% for each analysis area. The 10% threshold should be determined for small areas, ideally space by space or orientation per floor. At a minimum, the 10% threshold must be determined for all regularly occupied floor area.

Option 2. Simulation—Illuminance Calculations

STEP 1. COLLECT ILLUMINANCE SIMULATION INPUTS

Work with the daylighting consultant or modeler to identify information needed for the daylight simulation. At a minimum, compile the following:

- Exterior building geometry and obstructions
- Site plan, location ,and context
- Floor plan and furniture plan
- Interior finishes and surface reflectance (see *Further Explanation, Surface Reflectance*)
- Glazing performance specifications
- Local climate weather files, such as typical meteorological year (TMY2 or TMY3) data, available at nrel.gov

STEP 2. PERFORM ILLUMINANCE SIMULATION

Prepare the illuminance model based on information collected in Step 1.

- Follow the modeling methodology outlined and illustrated in *Further Explanation, Illuminance Simulation Procedure*.
- Perform the point-in-time simulations.
- Consult with the project team on assumptions developed for early design simulations. The assumptions should be further refined as design develops. Simulation results used for credit documentation should be based on the design that is closest to the completed construction documents for the as-built scenario.
- Perform one illuminance simulation at 9 a.m. on the equinox (September 21 or March 21).
- Perform a second illuminance simulation at 3 p.m. on the equinox (September 21 or March 21).

STEP 3. EVALUATE ILLUMINANCE COMPLIANCE

Review the simulation output results and determine the illuminance values for all regularly occupied floor area.

- Record the areas that are daylit (have illuminance levels between 300 lux and 3,000 lux for both 9 a.m. and 3 p.m.) and the associated floor area.
- Confirm that the project meets or exceeds the values in Table 2 in the credit requirements.

Option 3. Measurement

STEP 1. PREPARE FOR MEASUREMENTS

Determine when the first and second measurements will be taken.

- Schedule the first day of measurement after the project construction is complete, all furniture is moved in, window shades are installed, and people have occupied the space.
- Review Table 4 in the credit requirements to determine timing of the second measurement. Both measurements must occur during regularly occupied months. For example, measurements for a school may not be taken during school breaks.
- Review the regularly occupied space floor area to determine the required measurement grid. Draw the measurement grid and the measurement nodes (usually located at the center of each grid space) on a floor plan.

STEP 2. PERFORM MEASUREMENTS

Use a light meter to take a daylight illuminance measurement at workplane height (30 inches [750 millimeters] above finished floor, unless otherwise defined) between 9 a.m. and 3 p.m. (see *Further Explanation, Solar Time or Local Time*).

- Refer to the Illuminating Engineering Society (IES) Lighting Handbook, 10th edition, Section 9.7, for more information on light meters.
- Identify the location of each measurement node in the actual space.
- Record the measured illuminance at each node on the floor plan or in a tracking table.
- If measurements cannot be completed for the entire project in one day, continue the following day between 9 a.m. and 3 p.m.
- Repeat the process using the same nodes for the second measurement (see *Further Explanation, Examples, Option 3*).

STEP 3. EVALUATE ILLUMINANCE COMPLIANCE

Review the measurement results and determine the illuminance values for all regularly occupied floor area.

- Record the areas that are daylit (have illuminance levels between 300 lux and 3,000 lux for both measurements) and the associated floor area.
- Confirm that the project meets or exceeds the values in Table 3 in the credit requirements.

FURTHER EXPLANATION

CALCULATIONS

See the daylight and quality views calculator provided by USGBC.

SURFACE REFLECTANCE

IES LM 83-12, Section 2.2.10, provides general guidance for interior surface reflectances.

If surface reflectance values are not available in manufacturers' information, field measurements may be performed. Refer to IES LM 83-12, Section 9.12.2, on measuring illuminance and luminance.

Field measurements may be performed as follows:

- Use a reflectance chart, such as that found in the CIBSE's Lighting Guide 11: Surface Reflectance and colour document, to measure reflectance.
- Measure illuminance with an illuminance meter, and luminance with a spot luminance meter.
- Reflectance is defined as illuminance divided by luminance in the space.

DIRECT SUNLIGHT BASED ON LUX DIFFERENCES BETWEEN ADJACENT GRID POINTS

For ASE analysis, direct sunlight can be assumed to occur for any grid point that has an hourly illuminance level at least 1,000 lux higher than any directly adjacent grid point. This could be determined from manual post-processing of the simulation results, through a sun path and shadow program, or with software that automatically post-processes the simulation results.

FINDING METEOROLOGICAL DATA

Obtain typical meteorological year data for the nearest available weather station in a format the simulation program can accept. Example formats include TMY2 and TMY3, EPW, and WEA.

Most U.S. and international weather data can be downloaded from the U.S. Department of Energy, at apps1.eere.energy.gov/buildings/energyplus/weatherdata_about.cfm.

The National Renewable Energy Laboratory provides a weather file viewer (DView) at beopt.nrel.gov/downloadDView.

ILLUMINANCE SIMULATION PROCEDURE

The simulation methodology for illuminance simulation is similar to that described in IES LM 83-12 for sDA and ASE.

For building geometries, develop a complete building model. Some programs allow energy model geometries to be transferred to the daylight modeling interface. Include exterior walls, roofs, shading devices, glazed assemblies (including mullion thickness), sunlight and window recesses, rough opening thicknesses, and light shelves. Refer to LM 83, Section 2.2, for general guidance on the level of detail for the model.

Period of analysis. The analysis is performed at 9 A.M. and 3 P.M. on the equinox (September 21 or March 21), adjusted for daylight savings time and longitude.

Illuminance threshold. The illuminance threshold for analysis is 300 lux or greater and below 3,000 lux at the horizontal workplane, which is 30 inches (750 mm) above the finished floor, unless otherwise defined.

Analysis area and points. The analysis area should cover all regularly occupied floor area. For Healthcare projects, the analysis area must cover all perimeter floor area, which is any area within 15 feet (4.5 meters) of the building perimeter. Refer to LM 83, Section 2.2.5, for guidance on the calculation grid and location of the analysis points.

Exterior obstructions. Refer to LM 83-12, Section 2.2.8, for guidance on modeling exterior obstructions.

Window and skylight details. Refer to LM 83-12, Section 2.2.9, for guidance on modeling windows and skylights. If the modeling software requires an input of glazing transmissivity, use the visible light transmittance value provided by the manufacturer. Glare-control devices are not included in the analysis.

Surface reflectances. Prepare a list of material finishes for all model surfaces and verify material specifications with the design team. A library of materials is available with most daylight programs, such as the material.rad file structure for the RADIANCE-based[7] simulation programs. The material.rad flile may be customized, but in RADIANCE, the simulation fails if a material is incorrectly defined. Check the normal direction of model surfaces. To receive daylight, exposed surfaces should face outward from the center of each zone in which they belong. Ground surfaces should face upward. Refer to LM 83, Section 2.2.10, for further guidance on modeling interior surface reflectances.

Furniture and partitions. The model must include all permanent interior obstructions and movable furniture and partitions. See LM 83, Section 2.2.11, for suggestions on modeling furniture and partitions.

Illuminance climatic modeling methodology. Proceed as follows.

1. Obtain typical meteorological year data (see *Further Explanation, Finding Meteorological Data*). Use local weather data or TMY weather data files for the nearest city. If the simulation program is capable of automatically determining clear sky condition, select that option.

7. *radsite.lbl.gov/radiance/HOME.html (accessed June 12, 2013).*

2. To calculate the illuminance intensity for sun (direct component) and sky (diffuse component) in a TMY2 or TMY 3 file, export the data into a text file or spreadsheet format.
3. From the TMY, select the day within 15 days of September 21 that has the clearest sky condition (total sky cover at its lowest value) at 9 a.m.
4. From the TMY, select the day within 15 days of March 21 that has the clearest sky condition at 9 a.m.
5. Determine the direct horizontal irradiance (Wh/m²) values at 9 a.m. for the day selected in September and at 9 a.m. for the day selected in March. Average the two values and use the result in the 9 a.m. simulation as the direct horizontal irradiance input. If the file does not explicitly state direct horizontal irradiance, calculate it as follows:

Direct horizontal irradiance = Global horizontal irradiance − Diffuse horizontal irradiance[8]

6. Determine the diffuse horizontal irradiance (Wh/m²) values at 9 a.m. for the day selected in September and at 9 a.m. for the day selected in March. Average the two values and use the result in the 9 a.m. simulation as the diffuse horizontal irradiance input.
7. Repeat procedures 3–6 for 3 p.m. (see *Further Explanation, Examples*).
8. Prepare the model to run a simulation to input custom values for direct horizontal and diffuse horizontal irradiance.

Refer to LM83, Sections 2.3.1 and 2.3.2, for additional guidance on climate conditions for the project's location such as, the sun position and intensity, sky illuminance distribution, and modeling parameters. Refer to IES LM83, Section 2.3.3, for guidance on modeling parameters.

The daylight simulation is most successful when the light is reflected back from the interior walls into the space. The daylight modeler can specify a certain number of inter-reflections before a ray path is discarded.

SOLAR TIME OR LOCAL TIME

When performing daylight measurements, determine whether the measurements will be taken at solar or local time. Both are acceptable, but solar time may be more appropriate because it is based on the position of the sun in the sky.

Solar time varies from the local standard time because of eccentricities in Earth's orbit and because of time zones and daylight saving adjustments. Solar time is typically calculated using a third-party calculator, such as the National Oceanic and Atmospheric Administration's solar calculator.

EXAMPLES

Example 1. Option 2

An open office with core areas is being assessed for compliance with Option 2 Illuminance Simulation. The office is in New York City and includes six regularly occupied spaces (Table 5) plus several nonregularly occupied spaces, such as mechanical, elevator, and restroom space. The office has equally spaced ribbon glazing on all four sides and a window-to-wall ratio of 63%.

Illuminance simulations were performed for all the regularly occupied spaces, based on diffuse and direct horizontal radiation inputs determined in Figure 2. The calculated results for the second-floor open office are displayed in Figure 3, demonstrating that 80% of the open office area is daylighted. For the entire project, the percentage of regularly occupied area that is daylighted is 81%. The percentage of regularly occupied floor area exceeds 75%, so project has earned 1 point under Option 2.

8 *More information on determining different kinds of irradiance is available at the Natural Frequency wiki site: wiki.naturalfrequency.com/wiki/SolarRadiation/Components (accessed June 12, 2013).*

TABLE 5. Regularly occupied spaces in office

Regularly occupied space ID	Floor area (ft^2)	Floor area with daylight illuminance of 300–3,000 lux
2nd-floor open office	9,000	7,200
3rd-floor conference room	500	420
3rd-floor private office 301	96	72
3rd-floor private office 302	120	88
3rd-floor open office	8,284	6,900
4th-floor open office	9,000	7,200
Total regularly occupied area (ft^2)	**27,000**	
Daylighted regularly occupied area (ft^2)	**21,880**	
Regularly occupied area that is daylighted	**81%**	

Figure 2. Diffuse and direct horizontal radiation inputs for New York City

New York City TMY3	
Daily illuminance intensity data	**September** Lowest total sky cover for 9 a.m. on September 17 • Global horizontal irradiance = 618 Wh/m^2 • Diffuse horizontal irradiance = 98 Wh/m^2 • Direct horizontal irradiance = 618 – 98 = 520 Wh/m^2
	March Lowest total sky cover for 9 a.m. on March 21 • Global horizontal irradiance = 155 Wh/m^2 • Diffuse horizontal irradiance = 136 Wh/m^2 • Direct horizontal irradiance = 155 – 136 = 19 Wh/m^2
	Computer model will input following values: • Average diffuse horizontal irradiance = 117 Wh/m^2 • Average direct horizontal irradiance = 270 Wh/m^2

Example 2. Option 3

After construction of the New York City office building (Example 1) was completed in mid-June, the project team took daylight measurements in all regularly occupied spaces. A second set of daylight measurements was taken for the same spaces in October to determine the compliant floor areas in the building. The two measurements for each space were compared to determine the areas that were compliant at both times. Figures 3 and 4 display the measurement results for a third-floor private office, 301.

Figure 3. Measurements recorded in June

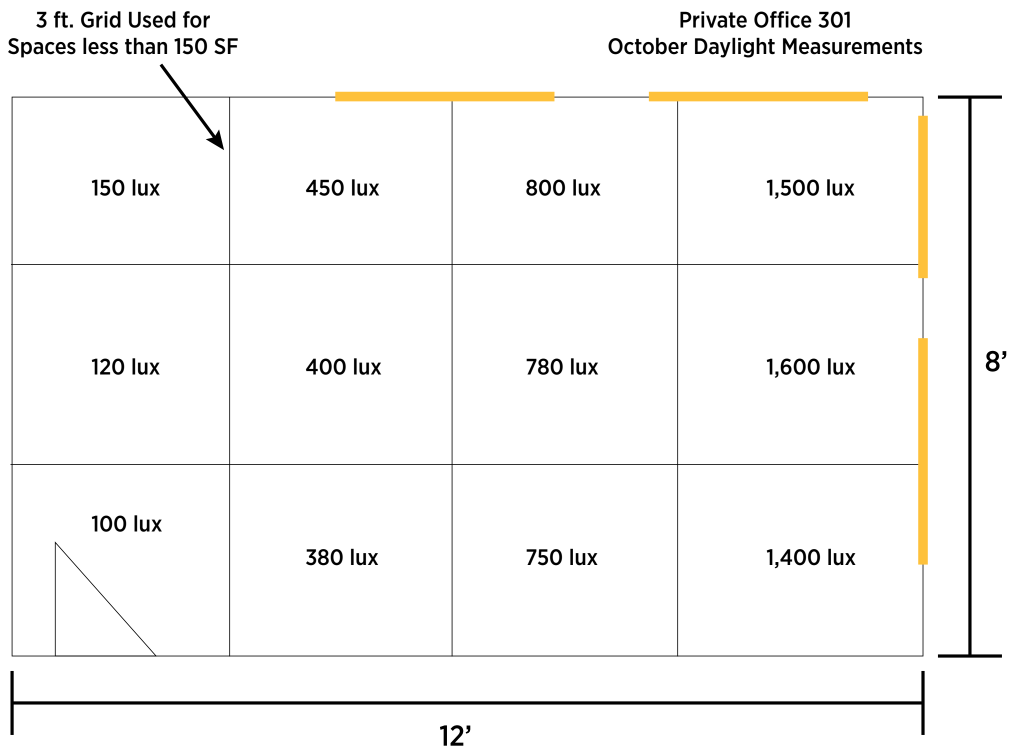
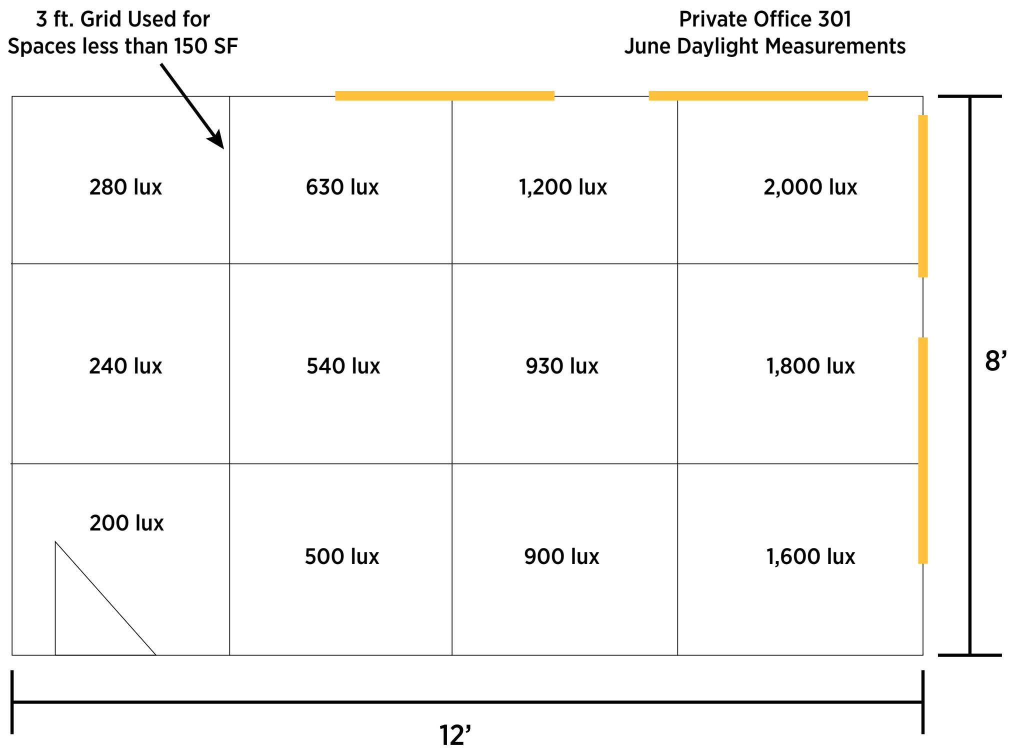


Figure 4. Measurements recorded in October



PROJECT TYPE VARIATIONS

Auditoriums

Auditoriums must be included in the daylight requirements, but a lower illuminance level is acceptable (see recommended illuminance values in The Lighting Handbook, Table 24.2[9]).

Conference rooms dedicated to video conferencing

Conference rooms that are dedicated to video conferencing may be excluded from the daylight requirements.

Gymnasiums

Gymnasiums must be included in the daylight requirements.

CAMPUS

Group Approach

Submit separate documentation for each project space.

Campus Approach

Ineligible. Each LEED project may pursue the credit individually.

REQUIRED DOCUMENTATION

Documentation	All projects	Option 1	Option 2	Option 3
Floor plans highlighting regularly occupied spaces	X	X	X	X
List of glare-control devices for all windows with their control mechanism	X	X	X	X
List of compliant spaces with their annual summary values for sDA and ASE		X		
Geometric plots from simulations		X	X	
Narrative or output file describing daylight simulation program, simulation inputs, and weather file		X	X	
List of compliant spaces with their calculated illuminance values			X	
Floor plans or list of compliant spaces with measured illuminance values for each node				X
Calculations demonstrating percentage of compliant space between 300 lux and 3,000 lux				X

RELATED CREDIT TIPS

EA Prerequisite Minimum Energy Performance and EA Credit Optimize Energy Performance. Good daylighting and glare control reduce the need for electric lighting. Consider daylight contribution when designing the lighting system. Consider incorporating daylight sensors and dimmers to reduce lighting energy consumption, and account for these efficiency measures in the related prerequisite and credit.

EQ Credit Quality Views. Design strategies that enhance daylight penetration are also likely to increase the number of occupants with exterior views. Regularly occupied spaces must be consistently reported for both this and the related credit.

EQ Credit Interior Lighting. For projects that pursue Option 1 or Option 2 of this credit, ensure that same surface reflectance values used in daylight simulation models match those used in lighting quality calculations for the related credit.

9. *Illuminating Engineering Society, The Lighting Handbook, 10th edition.*

CHANGES FROM LEED 2009

- The prescriptive compliance path has been eliminated.
- An additional simulation option is available. The new option incorporates two new metrics, spatial daylight autonomy and annual sunlight exposure, based on computer simulations run over an entire year.
- For Option 2, the illuminance simulation now relies on local weather data and uses a calculated illuminance intensity.
- For Option 3, measurements are required at two times of the year.
- The number of points available and thresholds for achievement have changed.

REFERENCED STANDARDS

IES Lighting Measurement LM 83-12, Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE): webstore.ansi.org

The Lighting Handbook, 10th edition, Illuminating Engineering Society: ies.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

annual sunlight exposure (ASE) a metric that describes the potential for visual discomfort in interior work environments. It is defined as the percentage of an analysis area that exceeds a specified direct sunlight illuminance level more than a specified number of hours per year. (Illuminating Engineering Society)

$ASE_{1000,250}$ reports the percentage of sensors in the analysis area, using a maximum 2-foot spacing between points, that are found to be exposed to more than 1000 lux of direct sunlight for more than 250 hours per year, before any operable blinds or shades are deployed to block sunlight, considering the same 10 hour/day analysis period as sDA and using comparable simulation methods

clear glazing glass that is transparent and allows a view through the fenestration. Diffused glazing allows only daylighting.

direct sunlight an interior horizontal measurement of 1,000 lux or more of direct beam sunlight that accounts for window transmittance and angular effects, and excludes the effect of any operable blinds, with no contribution from reflected light (i.e., a zero bounce analysis) and no contribution from the diffuse sky component (Adapted from IES)

movable furniture and partitions items that can be moved by the users without the need of tools or assistance from special trades and facilities management

permanent interior obstruction a structure that cannot be moved by the user without tools or assistance from special trades and facilities management. Examples include lab hoods, fixed partitions, demountable opaque full- or partial-height partitions, some displays, and equipment.

spatial daylight autonomy (sDA) a metric describing annual sufficiency of ambient daylight levels in interior environments. It is defined as the percentage of an analysis area (the area where calculations are performed, typically across an entire space) that meets a minimum daylight illuminance level for a specified fraction of the operating hours per year (i.e., the Daylight Autonomy value following Reinhart & Walkenhorst, 2001). The illluminance level and time fraction are included as subscripts, as in $sDA_{300,50\%}$. The sDA value is expressed as a percentage of area. (Illuminating Engineering Society).

sDA$_{300/50\%}$ the percentage of analysis points across the analysis area that meet or exceed this 300 lux value for at least 50% of the analysis period

INDOOR ENVIRONMENTAL QUALITY CREDIT

Quality Views

This credit applies to:

Commercial Interiors (1 point)
Retail (1 point)
Hospitality (1 point)

INTENT

To give building occupants a connection to the natural outdoor environment by providing quality views.

REQUIREMENTS

Achieve a direct line of sight to the outdoors via vision glazing for 75% of all regularly occupied floor area.

View glazing in the contributing area must provide a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance.

Additionally, 75% of all regularly occupied floor area must have at least two of the following four kinds of views:

- multiple lines of sight to vision glazing in different directions at least 90 degrees apart;
- views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing;
- unobstructed views located within the distance of three times the head height of the vision glazing; and
- views with a view factor of 3 or greater, as defined in "Windows and Offices; A Study of Office Worker Performance and the Indoor Environment."

Include in the calculations any permanent interior obstructions. Movable furniture and partitions may be excluded.

Views into interior atria may be used to meet up to 30% of the required area.

Include any permanent interior obstructions and moveable furniture and partitions.

BEHIND THE INTENT

Building occupants who can visually connect with outdoor environments while performing everyday tasks experience greater satisfaction, attentiveness, and productivity. Outside views that incorporate natural elements are more enticing and offer better visual respite. Workers seated at computers, who often develop eye strain or dry eyes from looking at their screens for extended periods without a break, find relief in attractive distance views.[1] In healthcare facilities, providing patients with views and access to nature can shorten hospital stays and reduce stress, depression, and the use of pain medication.[2]

Views to the outdoors also connect the occupants with natural environmental cues, such as diurnal changes from light to dark and the changes in light from season to season, which are important for maintaining natural circadian rhythms. Disruption of these rhythms can lead to long-term health care problems, including mental disorders.[3]

Designing for quality views involves consideration of building orientation and site design, facade, and interior layout. Integrated design enables project teams to identify potential compromises. For example, glazing with frits, fibers, patterns, colors, or tints is often used to provide privacy, enhance aesthetics, and reduce glare and solar heat gain; however, these types of glazing distort and in some cases completely block the views to the exterior.

Four former exemplary performance paths have been incorporated as credit compliance options, expanding the credit to include consideration for the quality of views provided to building occupants. Specifically, glazing color, frit, and patterns have been restricted to ensure that quality views are being maintained. Additionally, the type of objects visible in the view (e.g., vegetation, sky, brick wall, busy street)—is now an important factor. Although the bar has been raised, four credit paths give teams flexibility in how their designed spaces may comply. Also, atriums may now account for up to 30% of the required area with access to quality views—a change based on industry recognition that atriums can not only increase daylight and views for interior spaces but also reduce the need for electrical lighting in spaces that would otherwise likely require it.

STEP-BY-STEP GUIDANCE

STEP 1. EVALUATE PROJECT SITE

During schematic design, review the project's surroundings to identify the presence of elements that meet the view quality requirements of this credit, such as parks, green roofs and walls, nearby buildings, and pedestrian and vehicle movement.

STEP 2. DESIGN FOR TRANSPARENCY AND QUALITY VIEWS

During programming, consider how best to allocate interior space to maximize access to views. During design development, design enclosures and select furniture to minimize visual obstructions to perimeter glazing (see *Further Explanation, Quality View Design Considerations*).

- Consider using transparent partitions or providing interior glazing at eye level to ensure views for enclosed spaces.
- In open-plan offices, select low partitions or incorporate glazed panels to provide views in multiple directions.
- Pay particular attention to maintaining views for spaces near the core. One successful strategy is to locate open-plan areas, including classrooms, at the perimeter, while placing private offices and unoccupied areas near the core.
- Consider using glare control devices that preserve the view to the exterior. Movable glare control devices do not need to be included in the calculations.

1. *California Energy Commission, Windows and Offices: A Study of Office Worker Performance and Indoor Environment: Technical Report (2003), pp. 8–9, ff. 1–8, energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-09.PDF (accessed June 12, 2013); Oklahoma State University Healthy and Safety Office, You Can Do Something About Eyestrain (2011), ehs.okstate.edu/kopykit/eyestrain.htm (accessed June 12, 2013).*
2. *Ulrich, Roger, et al., "A Review of the Research Literature on Evidence-Based Healthcare Design," Health Environments Research and Design Journal 1(3) (2008), (http://www.herdjournal.com).*
3. *Kellert, Stephen R., Judith H. Heerwagen, and Martin L. Mador, Biophilic Design: The Theory, Science and Practice of Bringing Life into Buildings (New York: Wiley, 2008), p. 91.*

STEP 3. IDENTIFY REGULARLY OCCUPIED SPACES

Identify all regularly occupied spaces within the project (see *EQ Overview, Regularly Occupied Spaces*). Highlight regularly occupied spaces on the floor plan or furniture plan and list all regularly occupied spaces and their respective floor areas (Table 1).

TABLE 1. Quality views tracking table

Regularly occupied space ID	Space type	Floor area (ft^2 or m^2)	Quality views		
			Floor area with direct line of sight to outdoors via vision glazing	View types	
				1	2

Determine whether any regularly occupied spaces should be excluded from the views requirements (see *Further Explanation, Project Type Variations*). Spaces whose functional requirements prohibit the incorporation of glazing for direct access to views may be excluded. Spaces may not be excluded for security or noise concerns.

STEP 4. IDENTIFY SIGHT LINES TO EXTERIOR VIEWS

On floor plans or furniture plans, identify the locations of perimeter and interior glazing, and all permanent interior obstructions.

- Determine whether the perimeter and interior glazing qualifies as vision glazing (see *Further Explanation, Vision Glazing*).
- Identify permanent interior obstructions (see *Definitions*) and movable furniture and partitions. These must be included in the calculations. Movable glare control devices may be included in the calculations, but this is not required.
- Consider performing an initial rough assessment before performing the detailed assessment of view quality. Determine whether the regularly occupied floor area with proximity to vision glazing is at least 75% of the total regularly occupied floor area

STEP 5. ASSESS VIEW QUALITY

Identify which kinds of view will be used to demonstrate view quality. For each regularly occupied space or area of the floor plan, select two view types and add the selection to the tracking table. Eligible view types are as follows:

1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart
2. Views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing
3. Unobstructed views located within the distance of three times the head height of the vision glazing
4. Views with a view factor of 3 or greater, as defined in *Windows and Offices: A Study of Office Worker Performance and the Indoor Environment*[4]

Review *Further Explanation*, *Quality View Design Considerations*, for tips on which view types make the most sense for the project.

The view types may be mixed and matched, but documentation will be simpler if the same view types are used consistently across spaces.

If the entire regularly occupied space or area does not meet the requirements of the selected view type, include only the regularly occupied floor area that complies. To assess the regularly occupied space for each view type selected, perform the following steps (also see *Further Explanation, Examples*).

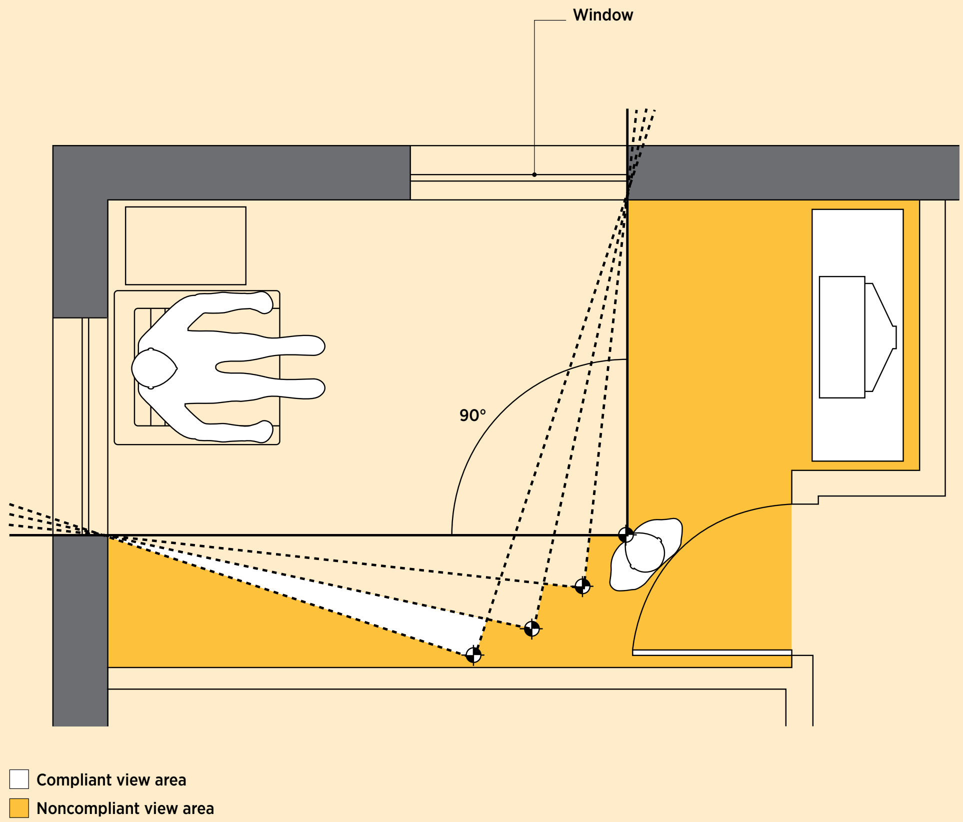
4. *California Energy Commission, Windows and Offices: A Study of Office Worker Performance and Indoor Environment: Technical Report (2003), pp. 8–9, ff. 1–8, energy.ca.gov/2003publications/CEC-500-2003-082/CEC-500-2003-082-A-09.PDF (accessed June 12, 2013).*

View type 1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart

On the floor plan or furniture plans, draw two lines of sight to the vision glazing for each location within the space.

- The space or location qualifies if the lines of sight are at least 90 degrees apart and if they are not intercepted by any permanent interior obstructions. If necessary, draw sight lines on section or elevation plans to confirm that permanent interior obstructions do not block the lines of sight.
- It may be easiest to determine the boundary of qualifying areas to non-qualifying areas (Figure 1).

Figure 1. Identifying multiple lines of sight



View type 2. Views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing

In plan, label the qualifying features located at the vision glazing.

- Two features must be indicated.
- Movement (feature 2) includes such activities as people walking, cars driving on the street, and boats moving through the water. Movement of plants and trees from wind does not qualify.
- Account for any changes in exterior views as floor elevation changes.
- In plan, draw one line of sight to the vision glazing for each location in the space. The space or location qualifies if the line of sight is not intercepted by any permanent interior obstructions. If necessary, draw sight lines on section or elevation plans to confirm permanent interior obstructions do not block the lines of sight.

View type 3. Unobstructed views located within the distance of three times the head height of the vision glazing

In section, determine the head height of the vision glazing for each regularly occupied space. In plan, identify all regularly occupied floor area that is within three times the head height of the perimeter.

- The space or location qualifies if there are no permanent interior obstructions present in the area. No permanent interior obstructions are allowed, regardless of their height.
- Any regularly occupied floor area not in the identified area does not qualify.

View type 4. Implement views with a view factor of 3 or greater, as defined in Windows and Offices; A Study of Office Worker Performance and the Indoor Environment.

On the floor plan or furniture plan, identify occupants' typical locations in each regularly occupied space (e.g., open-office workstation, enclosed office, conference room seat, counter). Indicate whether the location is the primary view location or a break view location (see *Further Explanation, View Factor*).

- Assess the view factor for each of these locations, based on either the primary view or the break view.
- In section or elevation, or through drawings or images, demonstrate how the view factor was determined.

STEP 6. CONFIRM COMPLIANCE

Complete the tracking table to confirm that at least 75% of the regularly occupied floor area meets two view types.

FURTHER EXPLANATION

CALCULATIONS

See the daylight and quality views calculator provided by USGBC.

QUALITY VIEW DESIGN CONSIDERATIONS

TABLE 2. Design considerations by view type

View type	Design considerations
1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart	Providing multiple lines of site to vision glazing in different directions could be advantageous for high-rise buildings with curtain wall exteriors, especially for open-office spaces. Interior atrium and exterior glazing provide views in several directions. Consider glazing characteristics that avoid excessive heat gain, to reduce energy use for cooling
2. Views that include at least two of following: • **(1) flora, fauna, or sky;** • **(2) movement; or** • **(3) objects at least 25 feet (7.5 meters) from exterior of glazing**	In dense urban environments, providing views of movement, flora, fauna, or sky, and objects at least 25 feet (7.5 meters) from exterior of building may prove difficult. Conversely, this criterion may be easy to achieve in low-rise buildings or buildings in suburban areas surrounded by open space and landscaping. Vertical landscaping may be effective strategy for achieving views of flora and fauna in dense urban environments.
3. Unobstructed views located within distance of three times head height of vision glazing	This option is easiest to achieve in buildings with large expanses of perimeter glazing. Layouts that include extensive open-office workstations or open areas with little interior obstructions along perimeter glazing are good candidates for this approach.
4. Views with view factor of 3 or greater	View factor must be determined by observation of available views for each workstation. This approach may allow greater flexibility in building orientation, window size, and surroundings, but without 3D modeling, team may be unable to determine view factor until substantial completion.

VIEW FACTOR

View factor is a measure of the amount and quality of views within a 90-degree cone of vision from an individual workstation. View factor is rated from 0 (poor quality) to 5 (high quality).

To achieve this credit, teams may determine the view factor for either *primary view*, what an occupant would see while working on the phone or computer, or break view, what occupants would see while taking a short break by turning their heads or moving their chairs while remaining seated.

View factor is determined for each workstation by assessing the vertical and lateral viewing angle for either the primary or the break view (Figure 2). To determine view factor, first find the smaller of the vertical or lateral view angle. Use the angle to identify the preliminary view factor (Table 3). If the view angle falls within the gray zone, assess the content of the view. View angles in the gray zone are rated up one level when the view has very high vegetation content, and down one level if the view has no vegetation content.

Alternatively, use Figure 3, which demonstrates examples of different view factors, to visually assess the view factor of a given space.

TABLE 3. View factor

Preliminary view factor	View angle	
	Min–max (degrees)	Gray-zone range (degrees)
1	1–4	
1 or 2		4–5
2	5–9	
2 or 3		9–11
3	11–15	
3 or 4		15–20
4	20–40	
4 or 5		40–30
5	50–90	

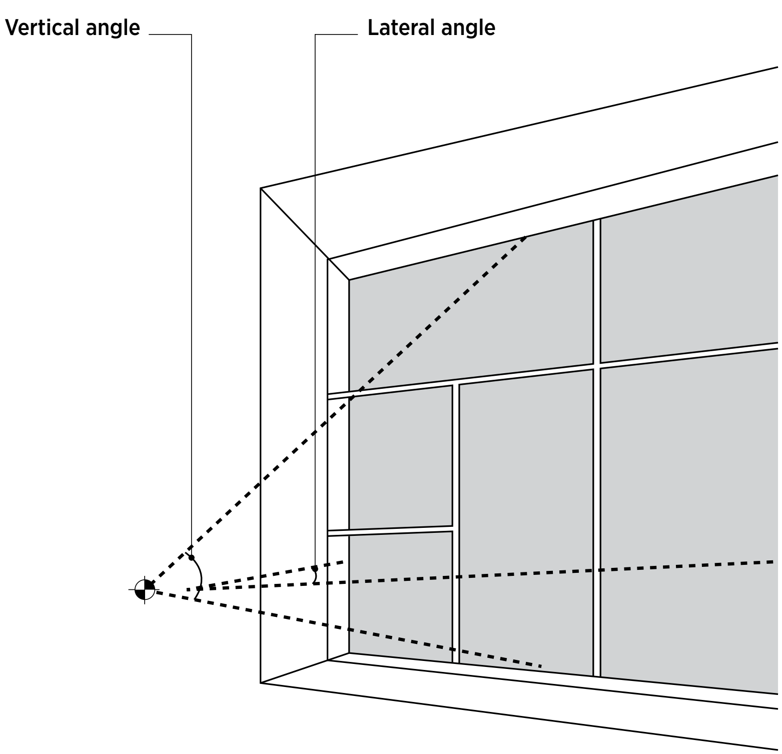
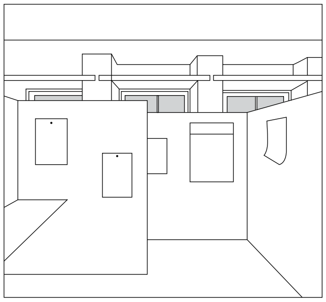
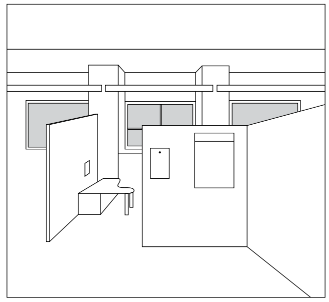


Figure 2. Assessing view angles

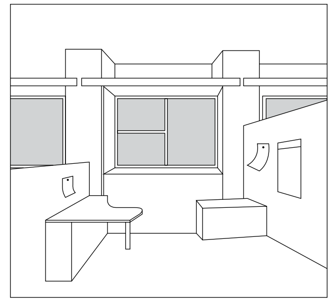
The following images illustrate the view quality associated with each view factor level.



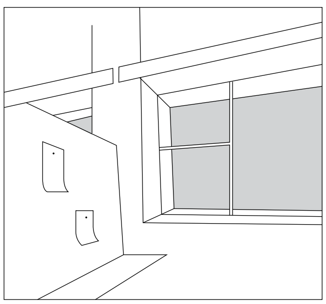
View Factor 1



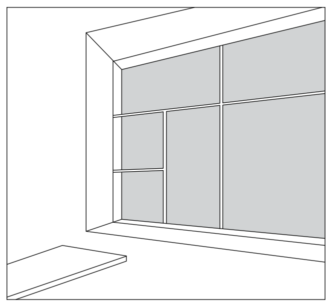
View Factor 2



View Factor 3



View Factor 4



View Factor 5

Figure 3. View factor illustrations

VISION GLAZING

Vision glazing is defined as that portion of exterior windows that permits views to the exterior (or an atrium). Vision glazing must have a clear image of the exterior, not obstructed by frits, fibers, patterned glazing, or added tints that distort color balance (Figures 4–8). Some patterns are acceptable if they preserve the view.

The glazing does not have to be located between 30 and 90 inches (750 and 2300 millimeters) above the finished floor.

Figures 4–7 illustrate examples of glazing solutions that are eligible for this credit.

Figure 4. Fritted glass with horizontal strips of clear glazing. Photo by Michael Spillers. The area between the upper and lower portions of fritted glass is acceptable vision glazing.

Figure 5. Fritted glass with vertical panels of clear glazing. Photo by Michael Spillers. The glazing between the fritted panels is acceptable vision glazing.

Figure 6. Frosted glass above, clear glazing below. Photo by Todd Reed. The area below the frosted glazing is acceptable vision glazing. This space also has multiple views more than 90 degrees apart.

Figure 7. Lightly tinted glazing. The gray tint darkens the view but does not distort color balance, so it is acceptable vision glazing.

Figure 8 is an example of glazing that is ineligible for this credit.

Figure 8. Partial-height partitions with frosted glass. Photo by Marcus Sheffer Frosted glass is not acceptable because it interferes with occupants' views to the vision glazing.

EXAMPLES

Example 1. View type 1. Multiple lines of sight to vision glazing in different directions at least 90 degrees apart

A classroom is assessed for compliance with the requirement for view type 1. The classroom has a total floor area of 750 square feet (70 square meters) and no permanent interior obstructions. To identify compliant areas within the classroom, the team has identified representative points on the classroom floor plan with two lines of sight at least 90 degrees apart (Figure 9) and determined that 500 square feet (45 square meters) of the classroom complies with the requirement.

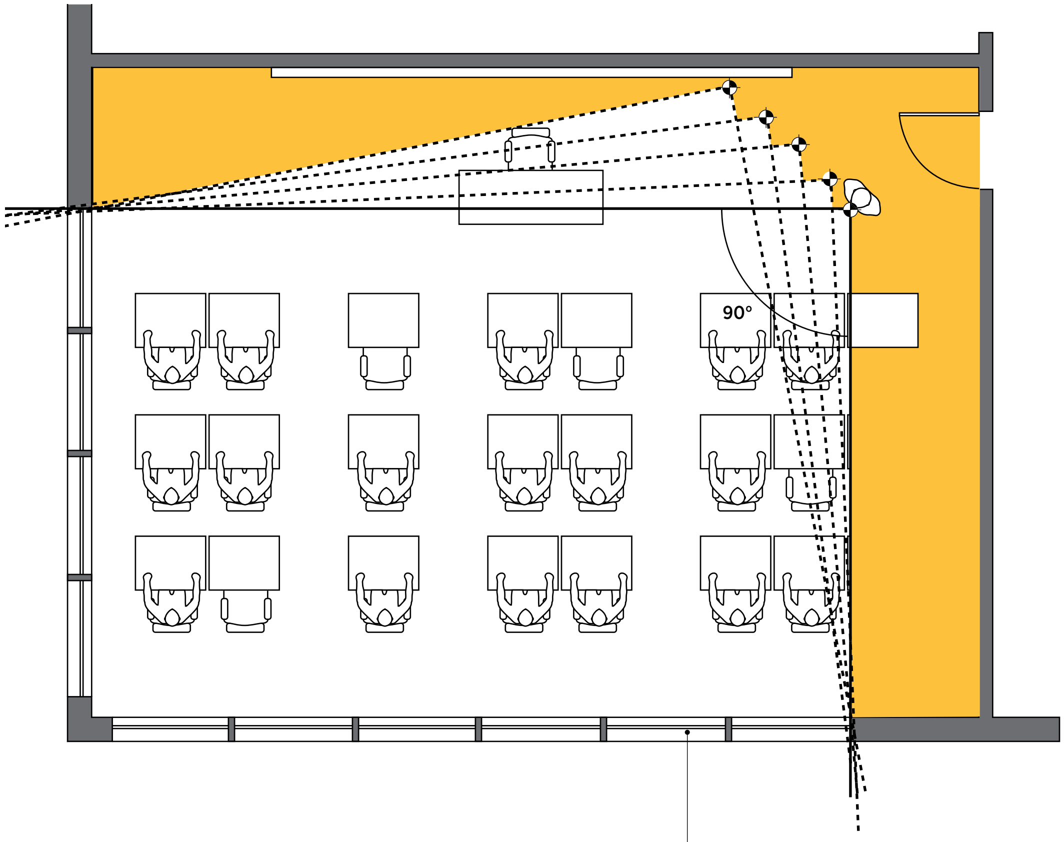


Figure 9. Lines of sight in classroom

Example 2. View type 2. Views that include at least two of the following: (1) flora, fauna, or sky; (2) movement; and (3) objects at least 25 feet (7.5 meters) from the exterior of the glazing

A regularly occupied space on the southeast side of the project building is assessed for compliance with requirements for view type 2. A section drawing of the building and adjacent properties is prepared to demonstrate that the space has views of trees close to the building and objects 25 feet (7.5 meters) from the exterior glazing (Figure 10). The section also shows that the space, which is an office, has no permanent interior obstructions, so this regularly occupied area meets the requirements.

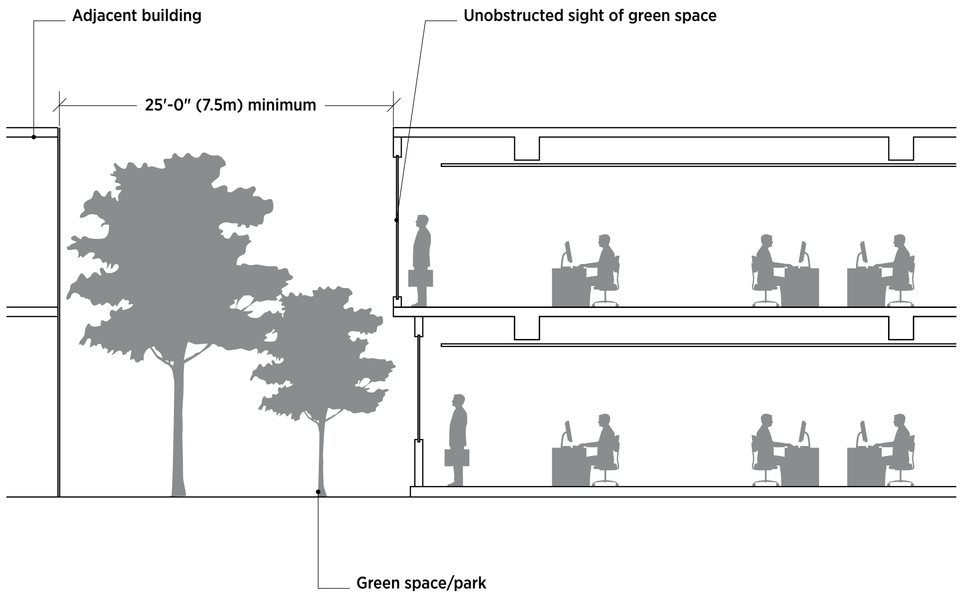


Figure 10. Flora within sight of space

Figure 11 illustrates a view with flora.

Figure 11. Planters outside a school. Photo by Marcus Sheffer.

Example 3. View type 3. Unobstructed views located within the distance of three times the head height of the vision glazing

An open-plan office space (Open Office 1) is assessed for compliance with the quality view requirement to have unobstructed views located within the distance of three times the head height of the vision glazing. A section view of the space is prepared to demonstrate that there are no permanent interior obstructions within 29 feet 3 inches (8.9 meters) of the vision glazing, which has a head height of 9 feet 9 inches (3 meters). The office space is compliant with the requirement (Figure 12).

In the same building, a similar open office space is also assessed for compliance. A section view of the space is prepared, but in this case, there are permanent interior obstructions within 29 feet 3 inches (8.9 meters) of the vision glazing, which has a head height of 9 feet 9 inches (3 meters). The fixed workstation with partitions and separate partition are both considered permanent interior obstructions. This open office space is not compliant with the requirement (Figure 12).

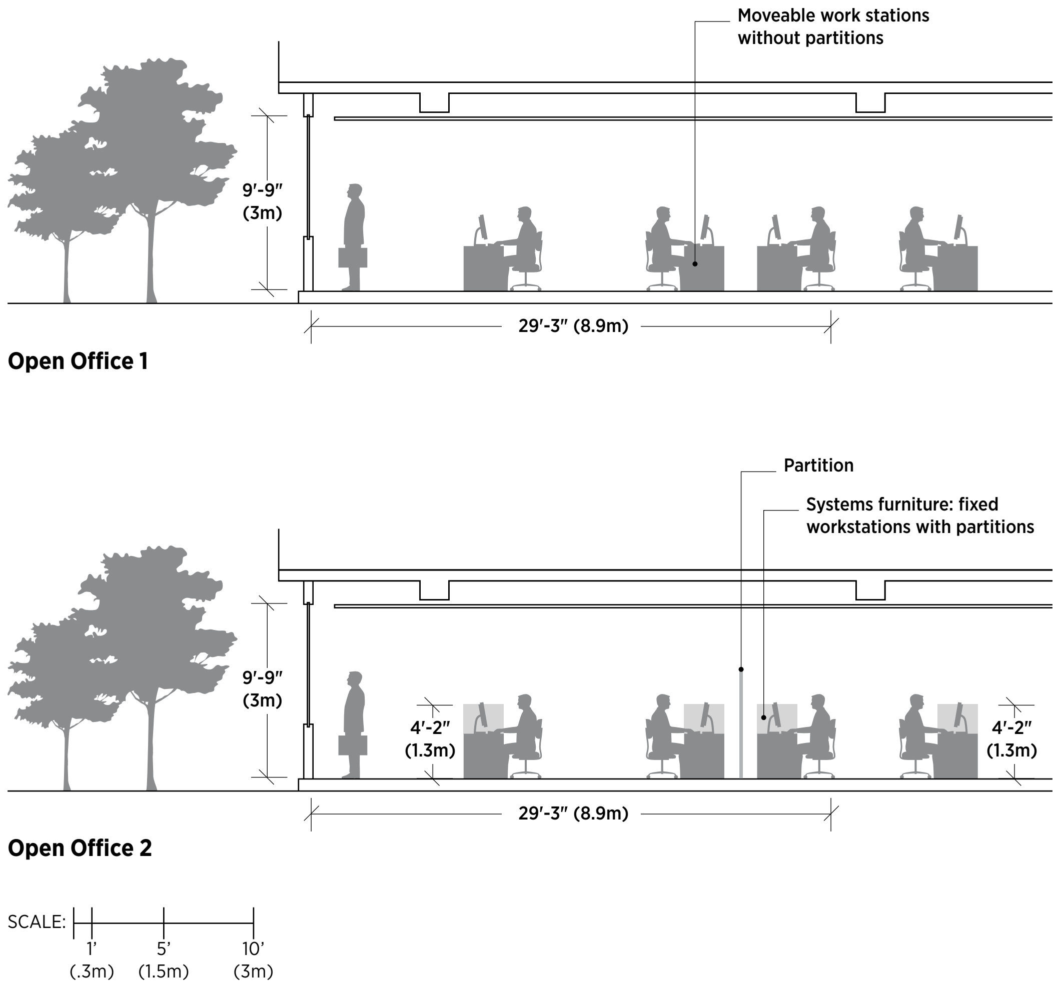


Figure 12. Compliant and noncompliant office spaces

Example 4. View type 4. Views with a view factor of 3 or greater, as defined in *Windows and Offices; A Study of Office Worker Performance and the Indoor Environment*

The primary view for a workstation in an open-office space (Figure 13) is evaluated and assigned a view factor of 5, based on the view factor illustrations provided in Figure 3. The view factor is rated 5 because the workstation is directly in front of two large windows, with no obstructions or odd angles disrupting the view to the outdoors.

Figure 13. Workstation with view factor of 5. Photo by Marcus Sheffer.

Example 5. Views into atrium

Figure 14 illustrates how regularly occupied spaces with views into a sunlit interior space can be used as an alternative to views to the outdoors. This approach can be used for up to 30% of the regularly occupied floor area. The requirements for direct line of sight and two view types still apply.

Figure 14. View into atrium. The Christman Building: Photo by Gene Meadows.

PROJECT TYPE VARIATIONS

Auditoriums
Auditoriums may be excluded from the view requirements.

Conference rooms dedicated to video conferencing
Conference rooms that are dedicated to video conferencing may be excluded from the view requirements.

Gymnasiums
Gymnasiums may be excluded from the view requirements.

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	All projects	View type			
		1: multiple lines of sight	2: exterior features	3: unobstructed views within 3H	4: view factor
List of all regularly occupied spaces, qualifying floor area in each space, and view features	X				
Sections, elevations, diagrams, renderings, or photos indicating sight lines to glazing do not encounter permanent interior obstructions.	X				
Floor plans or diagrams identifying regularly occupied spaces and the following:	X				
Multiple sight lines for each regularly occupied space		X			
Sight lines and exterior features labeled; provide multiple floor plans if view features change at varying building heights			X		
Sight lines and area indicating three times head height				X	
Area with view factor of 3 or greater					X
Primary or break view angle to perimeter glazing					X
Method for determining view factor for each typical occupant location					X

RELATED CREDIT TIPS

EQ Credit Daylight. Window tints used for solar and glare control may hinder the quality of view by distorting the color of objects and light. Increasing the area of vision glazing may provide greater access to daylight.

EA Prerequisite Minimum Energy Performance. Increased window-to-wall ratio in design can alter energy performance and has a direct correlation to lighting design strategies to conserve energy. Increased glazing may contribute to heat gain and increased HVAC energy use, but daylighting reduces the need for electric lighting.

CHANGES FROM LEED 2009

- The exemplary performance requirements from LEED 2009 are now the basis for the credit requirements.
- Glazing must provide a clear image of the outdoors. The glazing does not have to be located between 30 and 90 inches (750 and 2 300 millimeters) above the finished floor.
- Atriums now qualify for up to 30% of the total area.

REFERENCED STANDARDS

Windows and Offices: A Study of Office Worker Performance and the Indoor Environment: h-m-g.com

EXEMPLARY PERFORMANCE

Meet the requirements for 90% of all regularly occupied area.

DEFINITIONS

color rendering index a measurement from 0 to 100 that indicates how accurately an artificial light source, as compared with an incandescent light, displays hues. The higher the index number, the more accurately the light is rendering colors. Incandescent lighting has a color rendering index above 95; standard high-pressure sodium lighting (such as orange-hued roadway lights) measures approximately 25; many fluorescent sources using rare earth phosphors have a color rendering index of 80 and above. (Adapted from U.S. ENERGY STAR)

movable furniture and partitions items that can be moved by the users without the need of tools or assistance from special trades and facilities management

permanent interior obstruction a structure that cannot be moved by the user without tools or assistance from special trades and facilities management. Examples include lab hoods, fixed partitions, demountable opaque full- or partial-height partitions, some displays, and equipment.

vision glazing the glass portion of an exterior window that permits views to the exterior or interior. Vision glazing must allow a clear image of the exterior and must not be obstructed by frits, fibers, patterned glazing, or added tints that distort color balance.

INDOOR ENVIRONMENTAL QUALITY CREDIT

Acoustic Performance

This credit applies to:

Commercial Interiors (2 point)
Hospitality (2 point)

INTENT

To provide workspaces and classrooms that promote occupants' well-being, productivity, and communications through effective acoustic design.

REQUIREMENTS

For all occupied spaces, meet the following requirements, as applicable, for HVAC background noise, sound isolation, reverberation time, and sound reinforcement and masking.

HVAC Background Noise

Achieve maximum background noise levels from heating, ventilating, and air conditioning (HVAC) systems per 2011 ASHRAE Handbook, HVAC Applications, Chapter 48, Table 1; AHRI Standard 885-2008, Table 15; or a local equivalent. Calculate or measure sound levels.

For measurements, use a sound level meter that conforms to ANSI S1.4 for type 1 (precision) or type 2 (general purpose) sound measurement instrumentation, or a local equivalent.

Comply with design criteria for HVAC noise levels resulting from the sound transmission paths listed in ASHRAE 2011 Applications Handbook, Table 6; or a local equivalent.

Sound Transmission

Meet the composite sound transmission class (STC_C) ratings listed in Table 1, or local building code, whichever is more stringent.

TABLE 1. Maximum composite sound transmission class ratings for adjacent spaces		
Adjacency combinations		STC_c
Residence (within a multifamily residence), hotel or motel room	Residence, hotel or motel room	55
Residence, hotel or motel room	Common hallway, stairway	50
Residence, hotel or motel room	Retail	60
Retail	Retail	50
Standard office	Standard office	45
Executive office	Executive office	50
Conference room	Conference room	50
Office, conference room	Hallway, stairway	50
Mechanical equipment room	Occupied area	60

Reverberation Time

Meet the reverberation time requirements in Table 2 (adapted from Table 9.1 in the Performance Measurement Protocols for Commercial Buildings[1]).

TABLE 2. Reverberation time requirements

Room type	Application	T60 (sec), at 500 Hz, 1000 Hz, and 2000 Hz
Apartment and condominium	—	< 0.6
Hotel/motel	Individual room or suite	< 0.6
	Meeting or banquet room	< 0.8
Office building	Executive or private office	< 0.6
	Conference room	< 0.6
	Teleconference room	< 0.6
	Open-plan office without sound masking	< 0.8
	Open-plan office with sound masking	0.8
Courtroom	Unamplified speech	< 0.7
	Amplified speech	< 1.0
Performing arts space	Drama theaters, concert and recital halls	Varies by application
Laboratories	Testing or research with minimal speech communication	< 1.0
	Extensive phone use and speech communication	< 0.6
Church, mosque, synagogue	General assembly with critical music program	Varies by application
Library	—	< 1.0
Indoor stadium, gymnasium	Gymnasium and natatorium	< 2.0
	Large-capacity space with speech amplification	< 1.5
Classroom	—	< 0.6

1. *Adapted from ASHRAE (2007d), ASA (2008), ANSI (2002), and CEN (2007)*

Sound Reinforcement and Masking Systems

Sound Reinforcement

For all large conference rooms and auditoriums seating more than 50 persons, evaluate whether sound reinforcement and AV playback capabilities are needed.

If needed, the sound reinforcement systems must meet the following criteria:

- Achieve a speech transmission index (STI) of at least 0.60 or common intelligibility scale (CIS) rating of at least 0.77 at representative points within the area of coverage to provide acceptable intelligibility.
- Have a minimum sound level of 70 dBA.
- Maintain sound-level coverage within +/–3 dB at the 2000 Hz octave band throughout the space.

Masking Systems

For projects that use masking systems, the design levels must not exceed 48 dBA. Ensure that loudspeaker coverage provides uniformity of +/–2 dBA and that speech spectra are effectively masked.

BEHIND THE INTENT

This credit challenges project teams to address best practices in acoustic design as an indoor environmental quality imperative that complements other green building practices.

Research by the Center for the Built Environment (CBE) of 34,000 building inhabitants[2] showed that LEED buildings outperform standard design in all areas of indoor environmental quality except acoustics (Figure 1). Acoustic performance typically is considered during the design process, the study found, yet teams are just beginning to understand the trade-offs with other green building practices, such as open floor planning, highly efficient HVAC systems, and efficient lighting strategies.

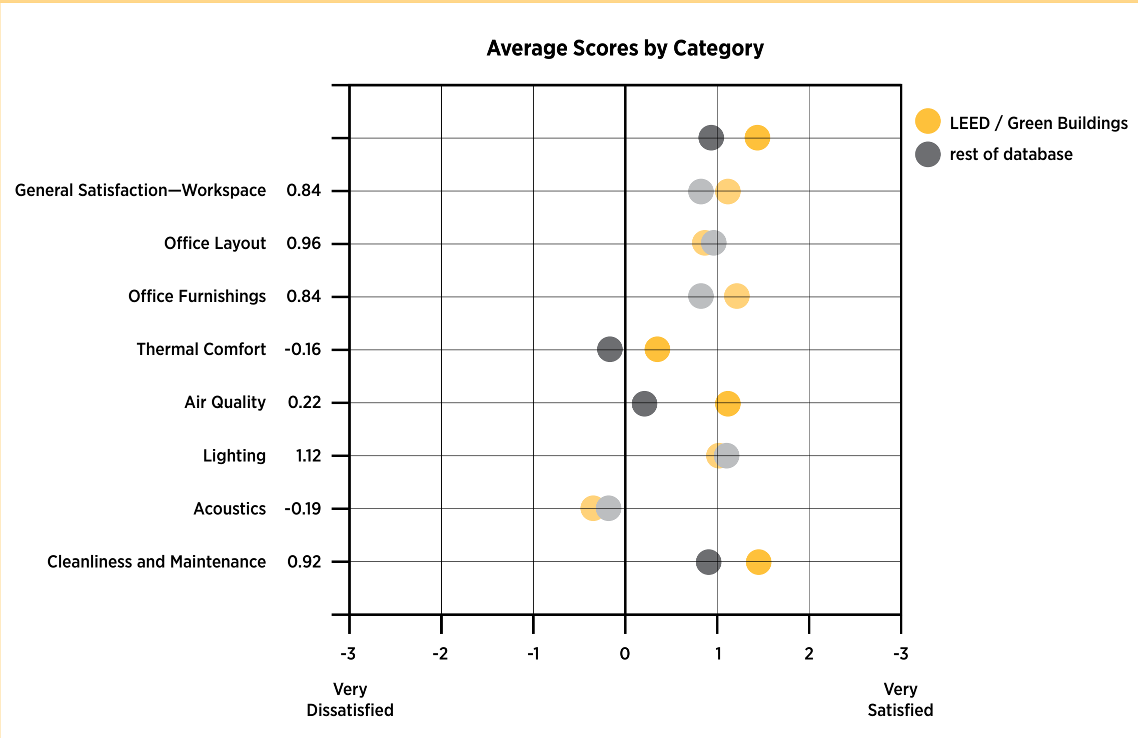


Figure 1. Occupants' satisfaction in conventional versus LEED-certified buildings. Used with permission from the Center for the Built Environment, UC Berkeley.

LEED 2009 covered acoustics in the Schools and Healthcare rating systems, partly because it critically affects learning and healing environments. Now an acoustics credit is available to all new construction projects, challenging project teams to balance acoustical design strategies with considerations for daylighting, thermal comfort, and other performance areas that must be considered when planning systems and indoor spaces. In all project types, well-designed acoustics can enhance the environmental quality of the space by facilitating communication, increasing productivity, improving the well-being of workers, or aiding in noise control and speech privacy.

2. *Huizenga, C., et al. 2005. LEED Post-occupancy Evaluation: Taking Responsibility for the Occupants. cbe.berkeley.edu/research/pdf_files/Huizenga_Greenbuild2005.pdf (accessed June 12, 2013).*

The benefits of open spaces should be balanced with acoustic design. Better acoustics do matter: research links poor acoustic performance to sleep disturbance,[3],[4] increased blood pressure and heart rates, and stress.[5]

STEP-BY-STEP GUIDANCE

STEP 1. DEFINE ACOUSTIC NEEDS FOR EACH SPACE

Identify occupied spaces and determine the following:

- Activities or user groups within each space and adjacencies
- Privacy or sound sensitivity requirements

STEP 2. REVIEW ACOUSTIC CRITERIA

Evaluate how the four performance areas addressed by this credit affect each applicable space:

- **HVAC background noise levels.** Engineers or acoustic experts will need to analyze background noise levels resulting from HVAC equipment.
- **Sound isolation.** Designers will need to specify materials to meet composite sound transmission class ratings.
- **Reverberation time.** Designers will need to specify sound-absorbing treatments and/or revisit room size to address reverberation time.
- **Sound reinforcement and masking systems.** Designers will need to analyze STI or CIS, sound level and sound-level coverage for spaces with sound reinforcement systems. Designers will also need to analyze sound level, loudspeaker coverage, and speech spectra for spaces with masking systems.

Prepare a log or spreadsheet to record pertinent acoustic information for each space.

Determine how the acoustic requirements fit into the design process so that each can be addressed by the responsible party at the appropriate time.

STEP 3. ADDRESS HVAC BACKGROUND NOISE

Identify equipment and air distribution elements that could contribute to HVAC background noise in occupied spaces. The following steps refer to the referenced standard, 2011 HVAC 2011 HVAC Applications ASHRAE Handbook, Chapter 48, Noise and Vibration Control ("Chapter 48").

- When selecting and designing HVAC systems, consider basic acoustic design techniques (e.g., Chapter 48, page 48.8).
- Consider specific source design considerations (e.g., Chapter 48, pages 48.1–48.41 and 48.8–48.30).
- Compile acoustic performance data at specific operating points from the HVAC equipment manufacturer's data. This information may inform the HVAC background noise criteria used for compliance.
- Consider source-receiver paths when locating occupied spaces, and HVAC equipment. For example, noise-generating HVAC equipment could be placed above a corridor rather than above a conference room. Review Chapter 48, Table 6, and address each applicable transmission path.

STEP 4. VERIFY HVAC BACKGROUND NOISE

Determine noise criteria (NC), room criteria (RC), A-weighted sound pressure levels, or C-weighted sound pressure levels for each occupied space through one or more of the following methods (see *Further Explanation, Selecting a Sound Rating Method*). Consider sound pressure levels from HVAC equipment only; plumbing, lighting, and electrical may be excluded.

- Calculate sound pressure levels per Chapter 48 and follow the steps outlined in the HVAC Noise-Reduction Design Procedures section of the handbook. Calculations may be done in the design phase.
- Calculate sound pressure levels per AHRI Standard 885–2008, Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets. Follow the steps outlined in

3. *Aaron, J.N., et al., "Environmental Noise as a Cause of Sleep Disruption in an Intermediate Respiratory Care Unit," SLEEP 19(9) (1996): 707–710.*
4. *Novaes, M.A., et al., "Stressors in ICU: Patients' Evaluation," Intensive Care Medicine 23(12) (1997): 1282–1285.*
5. *Baker, C.F., "Discomfort to Environmental Noise: Heart Rate Responses of SICU Patients," Critical Care Nursing Quarterly 15(2) (1992): 75–90.*

Section 6, Calculation Procedures for Estimating Sound Levels in Occupied Spaces. Calculations may be done in the design phase.

- Measure sound pressure levels per Chapter 48. Follow field measurement guidelines from Determining Compliance section. Follow guidelines from the Room Noise Measurements sections. The measurements must be performed postconstruction and should be done in furnished spaces with HVAC systems operating in typical conditions and while no occupants are present. Noises from sources other than HVAC systems should be minimized or turned off during testing.

A local standard, procedure, or handbook that is equivalent to one of the above methods may also be used.

Prepare a narrative that describes the methods followed and a summary report with measurements or calculations.

Demonstrate compliance with the overall sound pressure limits listed in Chapter 48, page 48.3, Table 1, or AHRI Standard 885-2008, Table 15, for applicable spaces.

STEP 5. VERIFY NOISE REDUCTION METHODS FOR SOUND TRANSMISSION PATHS

In a narrative and associated drawings or details, highlight each transmission path from Chapter 48, Table 6, that is applicable to the project and the specific noise reduction measures selected.

STEP 6. IDENTIFY ADJACENCIES FOR SOUND ISOLATION REQUIREMENTS

Identify occupied spaces and their adjacency combinations. Review Table 1 of the credit requirements and the local building code to determine the applicable composite sound transmission class (STC_c) rating.

Identify all assemblies (e.g., wall, floor-ceiling, roof-ceiling, door, window) that serve to acoustically isolate each occupied space.

STEP 7. VERIFY SOUND ISOLATION

Verify that the assemblies for each occupied space meet the sound isolation requirements. Demonstrate compliance through published data, calculation, or measurement, as follows:

- **Published data.** Select walls, doors, and windows with published manufacturer's data
- **Calculation.** Perform averaging calculations that allow a trade-off between higher STC of walls and lower STC ratings of doors, windows, and penetrations (see *Further Explanation, Determining Composite Sound Transmission Class*). Calculations may be done in the design phase.
- **Measurement.** Measure noise isolation class (NIC) for all assemblies per Annex A.3 of ANSI S12.60–2010 and compare the results with the sound isolation requirements. A NIC rating within 3 points of the specified STC rating may be considered compliant. Measurements cannot be performed until after the substantial completion of construction.

Assemblies with similar construction details may be grouped together. Any significant variance in opening areas, such as window or door ratios, should be evaluated separately.

Compile a list of each occupied space. For each space, list the maximum STC rating, the design STC rating or measured results, and data or calculations to support the values.

STEP 8. IDENTIFY SPACE REVERBERATION TIME REQUIREMENTS

Use Table 2 in the credit requirements to determine reverberation time requirements for each occupied space in the project. For spaces that vary by application or are not listed in the table, use criteria from referenced standards, or use values for the space type with the closest functional use.

STEP 9. IMPLEMENT REVERBERATION TIME MITIGATION STRATEGIES

Use sound-absorptive materials or other strategies to limit the reverberation times for each occupied space as appropriate for the room type.

Consider the following surfaces when specifying materials:

- Sound-absorptive materials can be applied to any planar surface in the space. Although applying treatment to the walls is typically effective, a sound-absorptive ceiling is generally more cost-effective.
- Absorptive wall surfaces or vertical acoustic panels in spaces that require hard surfaces, such as laboratories
- Soft or upholstered backs and seats for spaces with seating
- Window curtains, ceiling baffles, or other acoustic finishes

Determine sound-absorption coefficients for absorptive materials. Use manufacturers' documentation or Table 3 for common materials.

TABLE 3. Sound absorption coefficients for common materials

	Coefficient (α)				Coefficient (α)		
Material	**500HZ**	**1000HZ**	**2000HZ**	**Material**	**500Hz**	**1000Hz**	**2000HZ**
Walls				**Floor**			
Brick, unglazed	.03	.04	.05	Concrete or Terrazzo	.015	.02	.02
Brick, unglazed, painted	.02	.02	.02	Linoleum, asphalt, rubber, or cork tile on concrete	.03	.03	.03
Plaster, gypsum, or lime, smooth finish on tile or brick	.02	.03	.04	Wood	.10	.07	.06
Plaster, gypsum, or lime, rough or smooth finish on lath	.06	.05	.04	Wood parquet in asphalt on concrete	.07	.06	.06
Concrete block, light, porous	.31	.29	.39	Carpet, heavy, on concrete	.14	.37	.60
Concrete block, dense, painted	.06	.07	.09	Same, on 40 oz hairfelt or foam rubber	.57	.69	.71
Gypsum boards. 1/2-inch nailed to 2x4s, 16 inches o.c.	.05	.04	.07	Same, with impermeable latex backing on 40 oz hairfelt or foam rubber	.39	.34	.48
Plywood paneling, 3/8-inch thick	.17	.09	.10	Marble or glaze tile	.01	.01	.02
Large panes of heavy plate glass	.04	.03	.02	**Fabrics**			
Ordinary window glass	.18	.12	.07	Light velour, 10 oz per sq yd, hung straight, in contact with walll	.11	.17	.24
Misc				Medium velour, 14 oz per sq yd, draped to half area	.49	.75	.70
Chairs, metal or wood seats, each, unoccupied	.22	.39	.38	Heavy velour, 18 oz per sq yd, draped to half area	.55	.72	.70

STEP 10. VERIFY THAT REVERBERATION TIME REQUIREMENTS ARE MET

Calculate or measure the reverberation time for each occupied space (see *Further Explanation, Reverberation Time*).

- Reverberation time must be verified at 500, 1,000, and 2,000 Hz.
- Retain calculations and measurements for credit documentation.
- Spaces with identical size and material treatments may be documented together. To reduce documentation burden, calculations and measurements can also be based on acoustically critical spaces or room types or on worst-case combinations of room assemblies.

STEP 11. SELECT SOUND REINFORCEMENT AND MASKING SYSTEMS, IF NEEDED

Determine whether the project will have any sound reinforcement or masking systems (see *Further Explanation, Sound Reinforcement*, and *Further Explanation, Masking Systems*). This credit does not require that sound reinforcement or masking systems be implemented, but it does require that any installed system meet specific criteria.

- For each space using sound reinforcement, select sound reinforcement strategies that meet the speech intelligibility, sound level, and sound-level coverage credit requirements (see *Further Explanation, Meeting Sound Reinforcement Credit Requirements*).
- For each space using masking systems, select a system that meets the credit requirements for sound level and system uniformity (see *Further Explanation, Selecting a Sound Rating Method*).
- Document the needs that are addressed through a sound reinforcement or masking system, or the rationale for not including these systems.

FURTHER EXPLANATION

CALCULATIONS

Reverberation Time

Equation 1 must be calculated separately for each frequency: 500, 1,000, and 2,000 Hz. The calculation should include all finish materials in the room.

EQUATION 1. Total sound absorption for room

$$A = (\alpha_1 S_1 + \alpha_2 S_2 + \alpha_3 S_3 + \ldots\ldots \alpha_n S_n)$$

where

α is the sound absorption coefficient for a material at a specific frequency
S is the total surface area for that material in square feet (or square meters).

Reverberation time must be calculated for all rooms at each of the three frequencies; all must meet the specified T60 requirement in Table 2 in the credit requirements.

EQUATION 2. Reverberation time (IP)

$$RT = 0.049 \times \frac{V}{A}$$

where

V is the room volume in cubic feet
A is the total sound absorption in the room (from Equation 1)

EQUATION 3. Reverberation time (SI)

$$RT = 0.161 \times \frac{V}{A}$$

where

V is the room volume in cubic meters
A is the total sound absorption in the room (from Equation 1).

DETERMINING COMPOSITE SOUND TRANSMISSION CLASS (STC) RATINGS

Composite sound transmission class (STC) rating is a weighted value for the capacity of a partition to attenuate airborne sound. STC rating is calculated by averaging the transmission loss through an entire assembly.

In design, consider both the acoustic performance and ratio of partition materials. Because sound has a tendency to travel through the weakest element (that with the lowest STC rating), carefully evaluate the use of penetrations, openings, or fenestration in assemblies with a high STC rating requirement.

Ensure compliance with the standard through an evaluation of wall and floor sections and specification of tested window and door assemblies. STC ratings are typically reported by manufacturers on product data sheets and other documentation that show tested results based on standard wall materials.

SOUND REINFORCEMENT

Sound reinforcement may be needed for meeting, open office, public, or presentation spaces in the project that seat more than 50 people, depending on their function. For smaller spaces and for spaces with simple geometry, simple amplification systems may meet the credit criteria.

For spaces with unique architecture or 'live' acoustic environments, systems with advanced balancing and signal processing may be required to meet the credit criteria. Balancing the sound reinforcement system assists in providing appropriate coverage throughout the audience. The balancing requirements and methodology depend on the type of sound system strategy implemented and the sound reinforcement system equipment available. Signal-processing equipment can aid in improving the sound system fidelity and uniformity of coverage.

MEETING SOUND REINFORCEMENT REQUIREMENTS

For each space with a sound reinforcement system, verify compliance with the speech intelligibility (the extent to which a listener can hear and comprehend spoken words over other noise), sound level, and uniformity of coverage requirements, which involve evaluating the relationship of the room acoustic environment, sound reinforcement system design or location, background noise level, and the listeners' location(s). For more information on the performance criteria, see the following:

- For speech intelligibility, CIS criterion, see the Speech Intelligibility White Paper by 3M.[6] The speech transmission index (STI) varies from 0 (totally unintelligible) to 1.0 (perfectly intelligible). The common intelligibility scale (CIS) relates to STI with the following equation: CIS = 1 + log (STI).
- For sound-level and uniformity of coverage, refer to ANSI/INFOCOMM 1M–2009, Audio Coverage Uniformity in Enclosed Listener Areas.

Compliance with the criteria can be determined with basic calculations, acoustic modeling software, or with measurements.

If the space is not compliant, consider one or a combination of the following options:

- Revising the room's acoustic treatment strategy (typically by increasing the distribution and amount of treatment)
- Revising the sound reinforcement strategy (adjusting the type of sound reinforcement system or location and the type and aiming of loudspeakers)
- Lowering the background noise level in the room
- Adjusting the sound output as needed to increase the output level while maintaining uniform coverage

MASKING SYSTEMS

Sound masking is a technology that uses artificially produced sound to cover or mask unwanted environmental noise. These systems may be appropriate in open-floor layouts where full height partitions do not exist between workspaces. Sound-masking systems can mitigate the perception that open offices are noisy and distracting places to work.

Our hearing system tends to notice specific sounds when they are above ambient noise levels. Therefore, very quiet spaces with isolated areas of activity may be balanced by targeted sound-masking systems.

Project teams using sound masking should consider their use as a supplement to architectural finishes or other passive strategies for sound isolation. Masking systems need to be carefully designed and calibrated so that their coverage is uniform and even and the sound spectrum (not just overall loudness) is appropriate for masking the intended environmental noise. A system should not sound "hissy" or "rumbly," and the level should be low enough that it does not cause listening fatigue. A system's use time period also needs to be evaluated. Consider incorporating "ramping" in the masking system design, whereby the equipment gradually increases noise levels throughout the day or when a space is occupied.

A commonly applied rule is to control no more than 1,000 square feet (93 square meters) per zone, though project teams may consult with sound-masking system experts to identify appropriate control strategies.

For more information on sound masking and how it can improve workplaces, see "Sound Matters," available at gsasoundmatters.com/.

MEETING MASKING SYSTEM REQUIREMENTS

Typically, a sound masking system's specification includes the required frequency spectrum (or spectra), which could be assessed to make sure that the maximum masking noise levels are at or below 48 dBA. See ASTM E1130 for an example of a speech spectrum.

6. *http://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSufSevTsZxtUoY_vN82eevUqevTSevTSevTSeSSSSSS--&fn=Speech*

Make sure the system will be measured or evaluated after installation to confirm the masking system operates as designed. Consider specifying the procedures and reporting methods from ASTM Standard E1573.

SELECTING A SOUND RATING METHOD

The referenced standards for this credit present HVAC background noise level guidelines based on space type. The guidelines use the following sound rating methods:

- Noise criteria (NC)
- Room criteria (RC) or room criteria neutral (RCN)
- A-weighted decibel (dBA)
- C-weighted decibel (dBC)
- RC Mark II rating method

The methods are described in the 2011 ASHRAE Handbook, HVAC Applications, Chapter 48, Noise and Vibration Control. Teams must demonstrate compliance with one of the background noise rating methods for each space. The selection of rating method depends on the project requirements for acoustic quality but may be affected by the availability of data for HVAC components' sound levels.

In each method, sound levels must be calculated or measured across a range of audible frequencies. NC and RC methods are more sensitive to the balance of sound frequencies, whereas dBA reports the maximum sound level within a frequency range.

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation		All projects
Background noise	Occupied spaces' sound level values	X
	Calculation, measurement narrative, or manufacturers' data	X
	Noise reduction narrative	X
Sound isolation	STC_c ratings for space adjacencies	X
	Calculation, measurement narrative, or manufacturers' data	X
Reverberation time	Reverberation criteria for each room	X
	Calculation, measurement narrative, or manufacturers' data	X
Sound reinforcement and masking systems	List of all large conference rooms and auditoriums	X
	Explanation of sound reinforcement methodology (if installed)	X
	Explanation of sound reinforcement system components and specifications (if installed)	X
	Explanation of masking system components and specifications narrative (if installed)	X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

This is a new credit.

REFERENCED STANDARDS

ASHRAE 2011 HVAC Applications Handbook, Chapter 48, Sound and Vibration Control: ashrae.org

AHRI Standard 885–2008: ahrinet.org

ANSI S1.4 Performance Measurement Protocols for Commercial Buildings: ashrae.org

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

occupied space an enclosed space intended for human activities, excluding those spaces that are intended primarily for other purposes, such as storage rooms and equipment rooms, and that are only occupied occasionally and for short periods of time. Occupied spaces are further classified as regularly occupied or nonregularly occupied spaces based on the duration of the occupancy, individual or multioccupant based on the quantity of occupants, and densely or nondensely occupied spaces based on the concentration of occupants in the space.

sound-level coverage a set of uniformity criteria that ensure consistent intelligibility and directionality of audible frequencies for all occupants within a space

speech spectra the distribution of acoustic energy as a function of frequency for human speech

Innovation (IN)

OVERVIEW

Sustainable design strategies and measures are constantly evolving and improving. New technologies are continually introduced to the marketplace, and up-to-date scientific research influences building design strategies. The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies.

Occasionally, a strategy results in building performance that greatly exceeds what is required in an existing LEED credit. Other strategies may not be addressed by any LEED prerequisite or credit but warrant consideration for their sustainability benefits. In addition, LEED is most effectively implemented as part of a cohesive team, and this category addresses the role of a LEED Accredited Professional in facilitating that process.

INNOVATION CREDIT

Innovation

This credit applies to:

Commercial Interiors (1-5 points)
Retail (1-5 points)
Hospitality (1-5 points)

INTENT

To encourage projects to achieve exceptional or innovative performance.

REQUIREMENTS

Project teams can use any combination of innovation, pilot, and exemplary performance strategies.

OPTION 1. INNOVATION (1 POINT)

Achieve significant, measurable environmental performance using a strategy not addressed in the LEED green building rating system.

Identify the following:

- the intent of the proposed innovation credit;
- proposed requirements for compliance;
- proposed submittals to demonstrate compliance; and
- the design approach or strategies used to meet the requirements.

AND/OR

OPTION 2. PILOT (1 POINT)

Achieve one pilot credit from USGBC's LEED Pilot Credit Library.

AND/OR

OPTION 3. ADDITIONAL STRATEGIES

Innovation (**1-3 points**)

- Defined in Option 1 above.

Pilot (1-3 points)

- Meet the requirements of Option 2.

Exemplary Performance (1–2 points)

- Achieve exemplary performance in an existing LEED v4 prerequisite or credit that allows exemplary performance, as specified in the LEED Reference Guide, v4 edition. An exemplary performance point is typically earned for achieving double the credit requirements or the next incremental percentage threshold.

BEHIND THE INTENT

Sustainable design comes from innovative strategies and thinking. Institutional measures that reward such thinking—such as the achievement of this credit—benefit our environment. Recognition of exceptional efforts will spur further innovation.

When project teams innovate and go beyond LEED requirements, they not only achieve measurable environmental benefits beyond those specified by the LEED rating system, they also have the opportunity to explore cutting-edge pilot credits and contribute to the development of future LEED credits. When they can demonstrate that the project exceeds the standard level of performance associated with one or more LEED credits, their innovations can be adopted by other teams in the future.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY INNOVATIVE STRATEGIES

Innovation may begin at a project's conception, but it can enter at any step of the process and come from any member of the project team.

- During initial meetings or design charrettes, explore opportunities to incorporate innovative strategies, achieve exemplary performance for existing LEED credits, and develop pilot credits, based on the project scope.
- Review the project goals and targeted credits to determine whether the project is likely to meet any exemplary performance criteria.
- Identify any environmental strategies included in the project that are not addressed by existing LEED credits.
- Discuss pilot credits, green housekeeping, public education, and other opportunities for innovation.

STEP 2. DEVELOP INNOVATION POINT STRATEGY

Projects may earn up to 5 points for Innovation through any combination of the following:

- Innovation (up to 4 points). This option is appropriate for strategies that are not addressed by any existing credits in the LEED rating system under which the project will be certified.
- Pilot credits (up to 4 points). This option requires project teams to achieve, document, and provide feedback on pilot credit strategies developed by USGBC members and committees.
- Exemplary performance (up to 2 points). This option is achieved by demonstrating performance that greatly exceeds the level or scope required by existing LEED prerequisites or credits.

Innovation (up to 4 points)

STEP 1. CONFIRM CREDIT ELIGIBILITY

For innovations that are not addressed by existing LEED credits, confirm that the proposed strategy meets the following three basic criteria:

- The project must demonstrate a quantitative improvement in environmental performance by identifying or establishing a baseline of standard performance and comparing that benchmark with the final design performance.
- The strategy must be comprehensive. Measures that address a limited portion of a project or are not comprehensive in other ways are not eligible. The project team must demonstrate that the proposed innovation credit applies to the entire project being certified under LEED and has at least two components (i.e., it is not limited to use of a single product).
- The strategy must be significantly better than standard sustainable design practices.

Points can also be earned by achieving selected credits from other LEED rating systems.

Strategies must demonstrate a comprehensive approach, have significant, measurable environmental benefits, and be better than standard practice (see *Further Explanation, Suggested Topics for Innovation Credits* and *Ineligible Strategies*).

STEP 2. DEVELOP DOCUMENTATION

Document credit eligibility as outlined above, and note any project-specific strategies.

STEP 3. IMPLEMENT CREDIT

Develop and execute the innovative strategy or program in a manner that yields a meaningful environmental benefit. Retain documentation and calculations to validate the project team's approach and implementation.

Pilot credits (up to 4 points)

STEP 1. SELECT CREDIT

Select a credit from the LEED Pilot Credit Library on the USGBC website. The Pilot Credit Library includes credit intent and requirements, submittals, and specific feedback questions for each pilot credit.

- Pilot credits open and close at varying intervals. Check the website for a current list of available pilot credit strategies.
- Pilot credits are applicable to specific rating systems. Review the list on the USGBC website to identify pilot credits for the applicable rating system.

STEP 2. REGISTER PILOT CREDIT

Register for the selected pilot credit through the Pilot Credit Library.

- Since pilot credit availability changes over time, register for a credit as soon as the project team decides to pursue it, rather than waiting until documentation review.
- When a project is registered for a pilot credit, the project team may continue to pursue it even if it is closed to new registrants.

STEP 3. IMPLEMENT CREDIT

Follow the required steps to implement the credit as outlined in the pilot credit. Visit the LEEDuser forums for the selected pilot credit to ask questions or get advice on strategy.

STEP 4. PROVIDE FEEDBACK

Complete the credit's feedback survey, found on the USGBC website. Include any information that might be helpful in future revisions of the credit.

STEP 5. DOCUMENT CREDIT

Complete all credit specific documentation as outlined in the pilot credit.

- Some pilot credits will have documentation forms or calculators.
- Pilot credits may be attempted in any review stage and can be replaced before the next review if the initial credit is not accepted.

Exemplary Performance (up to 2 points)

STEP 1. IDENTIFY TARGET EXEMPLARY PERFORMANCE CREDITS

During design, review exemplary performance criteria and select credits for which exemplary performance will be pursued. Credits that allow exemplary performance through a predetermined approach are noted throughout this reference guide.

STEP 2. CONFIRM IMPLEMENTATION

Incorporate design elements and specifications requirements to ensure that the selected exemplary performance criteria are met. Provide the required documentation as noted in the base credit.

FURTHER EXPLANATION

SUGGESTED TOPICS FOR INNOVATION CREDITS

Project teams are encouraged to explore the full range of innovative opportunities in their buildings. Refer to the online Innovation database for examples of successful innovation credits. The examples do not constitute preapproval of any Innovation strategy, however, and Innovation credit awarded for a project today does not imply automatic approval for similar strategies in the future. A team seeking formal preapproval should submit a project credit interpretation request (CIR).

The following example was submitted for an Innovation credit:
Public education. Provide an educational program on the environmental and human health benefits of green building practices and how building occupants or the public can help improve green performance within the LEED space (such as recycling and appropriate use of efficient fixtures and equipment). The program must be actively instructional and include at least two instructional initiatives that have ongoing components such as a signage program, case study, guided tours, educational outreach program through periodic events covering green building topics, and/or a website or electronic newsletter.

INELIGIBLE STRATEGIES

Innovation credits are not awarded for the use of a particular product or design strategy if the technology aids in the achievement of an existing LEED credit, even if the project is not attempting to earn that credit.

Innovation strategies that are closed pilot credits are not available unless they are listed in the online Innovation database.

No strategy can achieve more than 1 point under Innovation. That is, a single strategy cannot be double-counted for both exemplary performance and innovation (or both exemplary performance and a pilot credit, or both a pilot credit and innovation).

Corporate strategies are not considered innovative. The innovation strategy must be specific to the LEED project under review.

CAMPUS

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

Campus Approach
Eligible.

REQUIRED DOCUMENTATION

Documentation	Innovation	Pilot credit	Exemplary performance
Innovation narrative	X		
Supporting documentation	X	X	X
Pilot credit registration		X	
Pilot credit survey		X	
Pilot credit specific submittals		X	
Exemplary performance credit and level			X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

The maximum number of exemplary performance strategies eligible for IN credits has changed from three to two.

REFERENCED STANDARDS

None.

DEFINITIONS

None.

INNOVATION CREDIT

LEED Accredited Professional

This credit applies to:

Commercial Interiors (1 point)
Retail (1 point)
Hospitality (1 point)

INTENT

To encourage the team integration required by a LEED project and to streamline the application and certification process.

REQUIREMENTS

At least one principal participant of the project team must be a LEED Accredited Professional (AP) with a specialty appropriate for the project.

BEHIND THE INTENT

A LEED Accredited Professional (LEED AP) with specialty can be a valuable resource in the LEED certification process. The presence of a LEED AP with specialty helps project team members understand the elements of the rating system, the importance of interactions among the prerequisites and credits, and the LEED application process.

STEP-BY-STEP GUIDANCE

STEP 1. ENGAGE LEED AP WITH SPECIALTY

Identify a project team member who is a LEED AP with specialty, or engage a LEED AP with specialty to support the project and participate in the certification process.

- Select a project team member with a LEED AP Interior Design + Construction (LEED AP ID+C) credential.
- The LEED AP with specialty identified for this credit must have an active credential at the time of certification review (see *Further Explanation, Maintaining a LEED Credential*).
- LEED APs without specialty (legacy LEED APs) do not qualify for this credit.

FURTHER EXPLANATION

MAINTAINING A LEED CREDENTIAL

The LEED AP with specialty credential can be maintained through either of the following methods:

- Retaking and passing the LEED accreditation exam
- Earning 30 continuing education hours per credentialing period

A credential is considered active (and eligible for this credit) only if the credential holder has completed his or her credential maintenance through the GBCI Credential Maintenance Program. For more information, visit USGBC's website.

CAMPUS

Group Approach
Submit separate documentation for each project space.

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

REQUIRED DOCUMENTATION

Documentation	Required
Full name and specialty credential of LEED AP	X

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

LEED APs without specialty (legacy LEED APs) are no longer eligible for this credit.

REFERENCED STANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

Regional Priority (RP)

OVERVIEW

Because some environmental issues are particular to a locale, volunteers from USGBC chapters and the LEED International Roundtable have identified distinct environmental priorities within their areas and the credits that address those issues. These Regional Priority credits encourage project teams to focus on their local environmental priorities.

USGBC established a process that identified six RP credits for every location and every rating system within chapter or country boundaries. Participants were asked to determine which environmental issues were most salient in their chapter area or country. The issues could be naturally occurring (e.g., water shortages) or man-made (e.g., polluted watersheds) and could reflect environmental concerns (e.g., water shortages) or environmental assets (e.g., abundant sunlight). The areas, or zones, were defined by a combination of priority issues—for example, an urban area with an impaired watershed versus an urban area with an intact watershed.

The participants then prioritized credits to address the important issues of given locations. Because each LEED project type (e.g., a data center) may be associated with different environmental impacts, each rating system has its own RP credits.

The ultimate goal of RP credits is to enhance the ability of LEED project teams to address critical environmental issues across the country and around the world.

REGIONAL PRIORITY CREDIT

Regional Priority

This credit applies to:

Commercial Interiors (1-4 points)
Retail (1-4 points)
Hospitality (1-4 points)

INTENT

To provide an incentive for the achievement of credits that address geographically specific environmental, social equity, and public health priorities.

REQUIREMENTS

Earn up to four of the six Regional Priority credits. These credits have been identified by the USGBC regional councils and chapters as having additional regional importance for the project's region. A database of Regional Priority credits and their geographic applicability is available on the USGBC website, http://www.usgbc.org.

One point is awarded for each Regional Priority credit achieved, up to a maximum of four.

BEHIND THE INTENT

LEED projects are designed, built, and operated in many different contexts. Climate, population density, and local regulations can differ significantly from one location to another, making certain environmental issues more critical than others. Examples include water conservation in arid climates versus rainwater management in wet climates.

LEED projects can be more transformative if teams recognize their location's priority environmental issues and address them through design, construction, and operation choices. LEED encourages a focus on regional issues through RP credits—existing LEED credits that USGBC volunteers have determined to be especially important in a given area. For every location in the U.S., six credits are prioritized. The ultimate intent is to motivate project teams to earn the credits that address an area's priority issues.

STEP-BY-STEP GUIDANCE

STEP 1. IDENTIFY APPLICABLE RP CREDITS

Review the credits flagged for regional priority in the project's area (see USGBC's website). Consider how achievement of these credits will affect the project.

STEP 2. DETERMINE PERFORMANCE REQUIRED TO EARN RP POINTS

- For credits with multiple thresholds (e.g., percentage improvement in energy efficiency), points are awarded at particular levels of achievement.
- If such a credit is flagged as RP for the project's location, confirm the threshold the project must meet to earn the bonus point.

FURTHER EXPLANATION

None.

REQUIRED DOCUMENTATION

Documentation
No additional documentation is required to earn Regional Priority credits. Document compliance for the selected credits, and the related RP bonus points for their achievement will be awarded automatically.

RELATED CREDIT TIPS

None.

CHANGES FROM LEED 2009

The RP credits for a given region may be different than they were for LEED 2009.

REFERENCED STRANDARDS

None.

EXEMPLARY PERFORMANCE

Not available.

DEFINITIONS

None.

APPENDICES

APPENDIX 1. USE TYPES AND CATEGORIES

TABLE 1. Use Types and Categories

Category	Use type
Food retail	Supermarket
	Grocery with produce section
Community-serving retail	Convenience store
	Farmers market
	Hardware store
	Pharmacy
	Other retail
Services	Bank
	Family entertainment venue (e.g., theater, sports)
	Gym, health club, exercise studio
	Hair care
	Laundry, dry cleaner
	Restaurant, café, diner (excluding those with only drive-thru service)
Civic and community facilities	Adult or senior care (licensed)
	Child care (licensed)
	Community or recreation center
	Cultural arts facility (museum, performing arts)
	Education facility (e.g., K—12 school, university, adult education center, vocational school, community college)
	Government office that serves public on-site
	Medical clinic or office that treats patients
	Place of worship
	Police or fire station
	Post office
	Public library
	Public park
	Social services center
Community anchor uses (BD+C and ID+C only)	Commercial office (100 or more full-time equivalent jobs)

Adapted from Criterion Planners, INDEX neighborhood completeness indicator, 2005.

APPENDIX 2. DEFAULT OCCUPANCY COUNTS

Use Table 1 to calculate default occupancy counts. Only use the occupancy estimates if occupancy is unknown.

For the calculation, use gross floor area, not net or leasable floor area. Gross floor area is defined as the sum of all areas on all floors of a building included within the outside faces of the exterior wall, including common areas, mechanical spaces, circulation areas, and all floor penetrations that connect one floor to another. To determine gross floor area, multiply the building footprint (in square feet or square meters) by the number of floors in the building. Exclude underground or structured parking from the calculation.

TABLE 1. Default Occupancy Numbers

	Gross square feet per occupant		Gross square meters per occupant	
	Employees	**Transients**	**Employees**	**Transients**
General office	250	0	23	0
Retail, general	550	130	51	12
Retail or service (e.g., financial, auto)	600	130	56	12
Restaurant	435	95	40	9
Grocery store	550	115	51	11
Medical office	225	330	21	31
R&D or laboratory	400	0	37	0
Warehouse, distribution	2,500	0	232	0
Warehouse, storage	20,000	0	1860	0
Hotel	1,500	700	139	65
Educational, daycare	630	105	59	10
Educational, K–12	1,300	140	121	13
Educational, postsecondary	2,100	150	195	14

Sources:

- ANSI/ASHRAE/IESNA Standard 90.1–2004 (Atlanta, GA, 2004).
- 2001 Uniform Plumbing Code (Los Angeles, CA)
- California Public Utilities Commission, 2004–2005 Database for Energy Efficiency Resources (DEER) Update Study (2008).
- California State University, Capital Planning, Design and Construction Section VI, Standards for Campus Development Programs (Long Beach, CA, 2002).
- City of Boulder Planning Department, Projecting Future Employment—How Much Space per Person (Boulder, 2002).
- Metro, 1999 Employment Density Study (Portland, OR 1999).
- American Hotel and Lodging Association, Lodging Industry Profile Washington, DC, 2008.
- LEED for Core & Shell Core Committee, personal communication (2003 - 2006).
- LEED for Retail Core Committee, personal communication (2007)
- OWP/P, Medical Office Building Project Averages (Chicago, 2008).
- OWP/P, University Master Plan Projects (Chicago, 2008).
- U.S. General Services Administration, Childcare Center Design Guide (Washington, DC, 2003).

APPENDIX 3. RETAIL PROCESS LOAD BASELINES

TABLE 1A. Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Broiler, underfired	Gas	Cooking	30%	16,000 Btu/h/ ft^2 peak input	35%	12,000 Btu/h/ ft^2 peak input
Combination ovens, steam mode (P = pan capacity)	Elec	Cooking	40% steam mode	0.37P+4.5 kW	50% steam mode	0.133P+0.6400 kW
Combination ovens, steam mode	Gas	Cooking	20% steam mode	1,210P+35,810 Btu/h	38% steam mode	200P+6,511 Btu/h
Combination ovens, convection mode	Elec	Cooking	65% convection mode	0.1P+1.5 kW	70% convection mode	0.080P+0.4989 kW
Combination ovens, convection mode	Gas	Cooking	35% convection mode	322P+13,563 Btu/h	44% convection mode	150P+5,425 Btu/h
Convection oven, full-size	Elec	Cooking	65%	2.0 kW	71%	1.6 kW
Convection oven, full-size	Gas	Cooking	30%	18,000 Btu/h	46%	12,000 Btu/h
Convection oven, half-size	Elec	Cooking	65%	1.5 kW	71%	1.0 kW
Conveyor oven, > 25-inch belt	Gas	Cooking	20%	70,000 Btu/h	42%	57,000 Btu/h
Conveyor oven, ≤ 25-inch belt	Gas	Cooking	20%	45,000 Btu/h	42%	29,000 Btu/h
Fryer	Elec	Cooking	75%	1.05 kW	80%	1.0 kW
Fryer	Gas	Cooking	35%	14,000 Btu/h	50%	9,000 Btu/h
Griddle (based on 3 ft model)	Elec	Cooking	60%	400 W/ ft^2	70%	320 W/ ft^2
Griddle (based on 3 ft model)	Gas	Cooking	30%	3,500 Btu/h/ ft^2	38%	2,650 Btu/h/ ft^2
Hot food holding cabinets (excluding drawer warmers and heated display) 0 < V < 13 ft^3 (V = volume)	Elec	Cooking	na	40 W/ ft^3	na	21.5V Watts
Hot food holding cabinets (excluding drawer warmers and heated display) 13 ≤ V < 28 ft^3	Elec	Cooking	na	40 W/ ft^3	na	2.0V + 254 Watts
Hot food holding cabinets (excluding drawer warmers and heated display) 28 ft^3 ≤ V	Elec	Cooking	na	40 W/ ft^3	na	3.8V + 203.5 Watts
Large vat fryer	Elec	Cooking	75%	1.35 kW	80%	1.1 kW

TABLE 1A (CONTINUED). Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)						
	Baseline energy usage for energy modeling path				**Levels for prescriptive path**	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Large vat fryer	Gas	Cooking	35%	20,000 Btu/h	50%	12,000 Btu/h
Rack oven, double	Gas	Cooking	30%	65,000 Btu/h	50%	35,000 Btu/h
Rack oven, single	Gas	Cooking	30%	43,000 Btu/h	50%	29,000 Btu/h
Range	Elec	Cooking	70%		80%	
Range	Gas	Cooking	35%	na	40% and no standing pilots	na
Steam cooker, batch cooking	Elec	Cooking	26%	200 W/pan	50%	135 W/pan
Steam cooker, batch cooking	Gas	Cooking	15%	2,500 Btu/h/pan	38%	2,100 Btu/h/pan
Steam cooker, high production or cook to order	Elec	Cooking	26%	330 W/pan	50%	275 W/pan
Steam cooker, high production or cook to order	Gas	Cooking	15%	5,000 Btu/h/pan	38%	4,300 Btu/h/pan
Toaster	Elec	Cooking	na	1.8 kW average operating energy rate	na	1.2 kW average operating energy rate
Ice machine, IMH (ice-making head, H = harvest ice), H ≥ 450 lb/day	Elec	Ice	6.89 – 0.0011H kWh/100 lb ice	na	$37.72*H^{-0.298}$ kWh/100 lb ice	na
Ice machine, IMH (ice-making head), H < 450 lb/day	Elec	Ice	10.26 – 0.0086H kWh/100 lb ice	na	$37.72*H^{-0.298}$ kWh/100 lb ice	na
Ice machine RCU (remote condensing unit, w/o remote compressor), H < 1,000 lb/day	Elec	Ice	8.85 – 0.0038H kWh/100lb ice	na	$22.95*H^{-0.258}$ + 1.00 kWh/100 lb ice	na
Ice machine RCU (remote condensing unit), 1600 > H ≥ 1000 lb/day	Elec	Ice	5.10 kWh/100 lb ice	na	$22.95*H^{-0.258}$ + 1.00 kWh/100 lb ice	na
Ice machine RCU (remote condensing unit), H ≥ 1600 lb/day	Elec	Ice	5.10 kWh/100 lb ice	na	-0.00011*H + 4.60 kWh/100 lb ice	na
Ice machine SCU (self-contained unit), H < 175 lb/day	Elec	Ice	18.0 – 0.0469H kWh/100 lb ice	na	$48.66*H^{-0.326}$ + 0.08 kWh/100 lb ice	na
Ice machine self-contained unit, H ≥ 175 lb/day	Elec	Ice	9.80 kWh/100 lb ice	na	$48.66*H^{-0.326}$ + 0.08 kWh/100 lb ice	na

TABLE 1A (CONTINUED). Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)						
	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Ice machine, water-cooled ice-making head, H ≥ 1436 lb/day (must be on chilled loop)	Elec	Ice	4.0 kWh/100 lb ice	na	3.68 kWh/100 lb ice	na
Ice machine, water-cooled ice-making head, 500 lb/day < H < 1436 (must be on chilled loop)	Elec	Ice	5.58 – 0.0011H kWh/100 lb ice	na	5.13 – 0.001H kWh/100 lb ice	na
Ice machine, water-cooled ice-making head, H < 500 lb/day (must be on chilled loop)	Elec	Ice	7.80 – 0.0055H kWh/100 lb ice	na	7.02 – 0.0049H kWh/100 lb ice	na
Ice machine water-cooled once-through (open loop)	Elec	Ice	Banned	Banned	Banned	Banned
Ice machine, water-cooled SCU (self-contained unit), H < 200 lb/day (must be on chilled loop)	Elec	Ice	11.4 – 0.0190H kWh/100 lb ice	na	10.6 – 0.177H kWh/100 lb ice	na
Ice machine, water-cooled self-contained unit, H ≥ 200 lb/day (must be on chilled loop)	Elec	Ice	7.6 kWh/100 lb ice	na	7.07 kWh/100 lb ice	na
Chest freezer, solid or glass door	Elec	Refrig	0.45V + 0.943 kWh/day	na	≤ 0.270V + 0.130 kWh/day	na
Chest refrigerator, solid or glass door	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.125V + 0.475 kWh/day	na
Glass-door reach-in freezer 0 < V < 15 ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.607V + 0.893 kWh/day	na
Glass-door reach-in freezer 15 ≤ V < 30 ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.733V – 1.00 kWh/day	na
Glass-door reach-in freezer, 30 ≤ V < 50 ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.250V + 13.50 kWh/day	na
Glass-door reach-in freezer, 50 ≤ V ft^3	Elec	Refrig	0.75V + 4.10 kWh/day	na	≤ 0.450V + 3.50 kWh/day	na
Glass-door reach-in refrigerator, 0 < V < 15 ft^3	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.118V + 1.382 kWh/day	na
Glass-door reach-in refrigerator, 15 ≤ V < 30 ft^3	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.140V + 1.050 kWh/day	na
Glass-door reach-in refrigerator, 30 ≤ V < 50 ft^3	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.088V + 2.625 kWh/day	na

TABLE 1A (CONTINUED). Commercial kitchen appliance prescriptive measures and baseline for energy cost budget (IP units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance Type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline Idle Rate**	**Prescriptive Efficiency**	**Prescriptive Idle Rate**
Glass-door reach-in refrigerator, 50 ≤ V ft^3	Elec	Refrig	0.12V + 3.34 kWh/day	na	≤ 0.110V + 1.500 kWh/day	na
Solid-door reach-in freezer, 0 < V < 15 ft^3	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.250V + 1.25 kWh/day	na
Solid-door reach-in freezer, 15 ≤ V < 30 ft^3	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.400V – 1.000 kWh/day	na
Solid-door reach-in freezer, 30 ≤ V < 50 ft^3	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.163V + 6.125 kWh/day	na
Solid-door reach-in freezer, 50 ≤ V ft^3	Elec	Refrig	0.4V + 1.38 kWh/day	na	≤ 0.158V + 6.333 kWh/day	na
Solid-door reach-in refrigerator, 0 < V < 15 ft^3	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.089V + 1.411 kWh/day	na
Solid-door reach-in refrigerator, 15 ≤ V < 30 ft^3	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.037V + 2.200 kWh/day	na
Solid-door reach-in refrigerator, 30 ≤ V < 50 ft^3	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.056V + 1.635 kWh/day	na
Solid-door reach-in refrigerator, 50 ≤ V ft^3	Elec	Refrig	0.1V + 2.04 kWh/day	na	≤ 0.060V + 1.416 kWh/day	na
Clothes washer	Gas	Sanitation	1.72 MEF	na	2.00 MEF	na
Door-type dish machine, high temp	Elec	Sanitation	na	1.0 kW	na	0.70 kW
Door-type dish machine, low temp	Elec	Sanitation	na	0.6 kW	na	0.6 kW
Multitank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.6 kW	na	2.25 kW
Multitank rack conveyor dish machine, low temp	Elec	Sanitation	na	2.0 kW	na	2.0 kW
Single-tank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.0 kW	na	1.5 kW
Single-tank rack conveyor dish machine, low temp	Elec	Sanitation	na	1.6 kW	na	1.5 kW
Undercounter dish machine, high temp	Elec	Sanitation	na	0.9 kW	na	0.5 kW
Undercounter dish machine, low temp	Elec	Sanitation	na	0.5 kW	na	0.5 kW

The energy efficiency, idle energy rates, and water use requirements, where applicable, are based on the following test methods:

ASTM F1275 Standard Test Method for Performance of Griddles

ASTM F1361 Standard Test Method for Performance of Open Deep Fat Fryers

ASTM F1484 Standard Test Methods for Performance of Steam Cookers

ASTM F1496 Standard Test Method for Performance of Convection Ovens

ASTM F1521 Standard Test Methods for Performance of Range Tops

ASTM F1605 Standard Test Method for Performance of Double-Sided Griddles

ASTM F1639 Standard Test Method for Performance of Combination Ovens

ASTM F1695 Standard Test Method for Performance of Underfired Broilers

ASTM F1696 Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, ASTM Door-Type Commercial Dishwashing Machines

ASTM F1704 Standard Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems

ASTM F1817 Standard Test Method for Performance of Conveyor Ovens

ASTM F1920 Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines

ASTM F2093 Standard Test Method for Performance of Rack Ovens

ASTM F2140 Standard Test Method for Performance of Hot Food Holding Cabinets

ASTM F2144 Standard Test Method for Performance of Large Open Vat Fryers

ASTM F2324 Standard Test Method for Prerinse Spray Valves

ASTM F2380 Standard Test Method for Performance of Conveyor Toasters

ARI 810-2007: Performance Rating of Automatic Commercial Ice Makers

ANSI/ASHRAE Standard 72–2005: Method of Testing Commercial Refrigerators and Freezers with temperature setpoints at 38°F for medium-temp refrigerators, 0°F for low-temp freezers, and -15°F for ice cream freezers

TABLE 1B. Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Broiler, underfired	Gas	Cooking	30%	50.5 kW/m^2	35%	37.9 kW/m^2
Combination oven, steam mode (P = pan capacity)	Elec	Cooking	40% steam mode	0.37P + 4.5 kW	50% steam mode	0.133P + 0.6400 kW
Combination oven, steam mode	Gas	Cooking	20% steam mode	(1 210P + 35 810)/3 412 kW	38% steam mode	(200P + 6 511)/ 3 412 kW
Combination oven, convection mode	Elec	Cooking	65% convection mode	0.1P + 1.5 kW	70% convection mode	0.080P + 0.4989 kW
Combination oven, convection mode	Gas	Cooking	35% convection mode	(322P + 13 563)/3 412 kW	44% convection mode	(150P + 5 425)/ 3 412 kW
Convection oven, full-size	Elec	Cooking	65%	2.0 kW	71%	1.6 kW
Convection oven, full-size	Gas	Cooking	30%	5.3 kW	46%	3.5 kW
Convection oven, half-size	Elec	Cooking	65%	1.5 kW	71%	1.0 kW
Conveyor oven, > 63.5-cm belt	Gas	Cooking	20%	20.5 kW	42%	16.7 kW
Conveyor oven, < 63.5-cm belt	Gas	Cooking	20%	13.2 kW	42%	8.5 kW
Fryer	Elec	Cooking	75%	1.05 kW	80%	1.0 kW
Fryer	Gas	Cooking	35%	4.1 kW	50%	2.64 kW
Griddle (based on 90-cm model)	Elec	Cooking	60%	4.3 kW/m^2	70%	3.45 kW/m^2

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)						
	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Griddle (based on 90-cm model)	Gas	Cooking	30%	11 kW/m²	33%	8.35 kW/m²
Hot food holding cabinets (excluding drawer warmers and heated display) 0 < V < 0.368 m³ (V = volume)	Elec	Cooking	na	1.4 kW/m³	na	(21.5*V)/0.0283 kW/m³
Hot food holding cabinets (excluding drawer warmers and heated display) 0.368 ≤ V < 0.793 m³	Elec	Cooking	na	1.4 kW/m³	na	(2.0*V + 254)/0.0283 kW/m³
Hot food holding cabinets (excluding drawer warmers and heated display) 0.793 m³ ≤ V	Elec	Cooking	na	1.4 kW/m³	na	(3.8*V + 203.5)/0.0283 kW/m³
Large vat fryer	Elec	Cooking	75%	1.35 kW	80%	1.1 kW
Large vat fryer	Gas	Cooking	35%	5.86 kW	50%	3.5 kW
Rack oven, double	Gas	Cooking	30%	19 kW	50%	10.25 kW
Rack oven, single	Gas	Cooking	30%	12.6 kW	50%	8.5 kW
Range	Elec	Cooking	70%	na	80%	na
Range	Gas	Cooking	35%	na	40% and no standing pilots	na
Steam cooker, batch cooking	Elec	Cooking	26%	200 W/pan	50%	135 W/pan
Steam cooker, batch cooking	Gas	Cooking	15%	733 W/pan	38%	615 W/pan
Steam cooker, high production or cook to order	Elec	Cooking	26%	330 W/pan	50%	275 W/pan
Steam cooker, high production or cook to order	Gas	Cooking	15%	1.47 kW/pan	38%	1.26 kW/pan
Toaster	Elec	Cooking	na	1.8 kW average operating energy rate	na	1.2 kW average operating energy rate
Ice machine IMH (ice-making head, H = ice harvest) H ≥ 204 kg/day	Elec	Ice	0.0015 – 5.3464E^{-07} kWh/kg ice	na—	≤ 13.52*H$^{-0.298}$ kWh/100 kg ice	na
Ice machine IMH (ice making head) ice-making head, H < 204 kg/day	Elec	Ice	0.2262 – 4.18E^{-04} kWh/kg ice	na	≤ 13.52*H$^{-0.298}$ kWh/100 kg ice	na
Ice machine, RCU (remote condensing unit, w/o remote compressor) H < 454 kg/day	Elec	Ice	0.1951 – 1.85E^{-04} kWh/kg ice	na	≤ 111.5835*H$^{-0.258}$ + 2.205 kWh/100 kg ice	na

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)						
	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	Fuel	Function	Baseline Efficiency	Baseline idle Rate	Prescriptive Efficiency	Prescriptive idle Rate
Ice machine RCU (remote condensing unit) 726 > H ≥ 454 kg/day	Elec	Ice	0.1124 kWh/kg ice	na	≤ $111.5835*H^{-0.258}$ + 2.205 kWh/100 kg ice	na
Ice machine RCU (remote condensing unit) H ≥ 726 kg/day	Elec	Ice	0.1124 kWh/kg ice	na	≤ -0.00024H + 4.60 kWh/100 kg ice	na
Ice machine SCU (self contained unit), H < 79 kg/day	Elec	Ice	0.3968 – $2.28E^{-03}$ kWh/kg ice	na	$236.59*H^{-0.326}$ + 0.176 kWh/100 kg ice	na
Ice machine SCU (self-contained unit), H ≥ 79 kg/day	Elec	Ice	0.2161 kWh/kg ice	na	$236.59*H^{-0.326}$ + 0.176 kWh/100 kg ice	na
Ice machine, water-cooled ice-making head, H ≥ 651 kg/day (must be on a chilled loop)	Elec	Ice	0.0882 kWh/kg ice	na	≤ 8.11 kWh/100 kg ice	na
Ice machine, water-cooled ice-making head, 227 ≤ H < 651 kg/day (must be on a chilled loop)	Elec	Ice	0.1230 – $5.35E^{-05}$ kWh/kg ice	na	≤ 11.31 – 0.065H kWh/100 kg ice	na
Ice machine, water-cooled ice-making head, H < 227 kg/day (must be on a chilled loop)	Elec	Ice	0.1720 – $2.67E^{-04}$ kWh/kg ice	na	≤ 15.48 – 0.0238H kWh/100 kg ice	na
Ice machine, water-cooled once-through (open loop)	Elec	Ice	Banned	Banned	Banned	Banned
Ice machine water-cooled SCU (self-contained unit) H < 91 kg/day (must be on a chilled loop)	Elec	Ice	0.2513 – $29.23E^{-04}$ kWh/kg ice	na	≤ 23.37 – 0.086H kWh/100 kg ice	na
Ice machine, water-cooled SCU (self-contained unit) H ≥ 91 kg/day (must be on a chilled loop)	Elec	Ice	0.1676 kWh/kg ice	na	15.57 kWh/100 kg ice	na
Chest freezer, solid or glass door	Elec	Refrig	15.90V + 0.943 kWh/day	na	9.541V + 0.130 kWh/day	na
Chest refrigerator, solid or glass door	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 4.417V + 0.475 kWh/day	na
Glass-door reach-in freezer, 0 < V < 0.42 m^3	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 21.449V + 0.893 kWh/day	na
Glass-door reach-in freezer, 0.42 ≤ V < 0.85 m^3	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 25.901V – 1.00 kWh/day	na
Glass-door reach-in freezer, 0.85 ≤ V < 1.42 m^3	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 8.834V + 13.50 kWh/day	na

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)						
	Baseline energy usage for energy modeling path				**Levels for prescriptive path**	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Glass-door reach-in freezer, 1.42 ≤ V m³	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 15.90V + 3.50 kWh/day	na
Glass-door reach-in refrigerator, 0 < V < 0.42 m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 4.169V + 1.382 kWh/day	na
Glass-door reach-in refrigerator, 0.42 ≤ V < 0.85 m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 4.947V + 1.050 kWh/day	na
Glass-door reach-in refrigerator, 0.85 ≤ V < 1.42 m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 3.109V + 2.625 kWh/day	na
Glass-door reach-in refrigerator, 1.42 ≤ V m³	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 3.887V + 1.500 kWh/day	na
Solid-door reach-in freezer, 0 < V < 0.42 m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 8.834V + 1.25 kWh/day	na
Solid-door reach-in freezer, 0.42 < V < 0.85 m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 4.819V – 1.000 kWh/day	na
Solid-door reach-in freezer, 0.85 ≤ V < 1.42 m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 5.760V + 6.125 kWh/day	na
Solid-door reach-in freezer, 1.42 ≤ V m³	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 5.583V + 6.333 kWh/day	na
Solid-door reach-in refrigerator, 0 < V < 0.42 m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 3.145V + 1.411 kWh/day	na
Solid-door reach-in refrigerator, 0.42 ≤ V < 0.85 m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 1.307V + 2.200 kWh/day	na
Solid-door reach-in refrigerator, 0.85 ≤ V < 1.42 m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 1.979V + 1.635 kWh/day	na
Solid-door reach-in refrigerator, 1.42 ≤ V m³	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 2.120V + 1.416 kWh/day	na
Clothes washer	Gas	Sanitation	1.72 MEF		2.00 MEF	
Door-type dish machine, high temp	Elec	Sanitation	na	1.0 kW	na	0.70 kW
Door-type dish machine, low temp	Elec	Sanitation	na	0.6 kW	na	0.6 kW
Multitank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.6 kW	na	2.25 kW
Multitank rack conveyor dish machine, low temp	Elec	Sanitation	na	2.0 kW	na	2.0 kW
Single-tank rack conveyor dish machine, high temp	Elec	Sanitation	na	2.0 kW	na	1.5 kW

TABLE 1B (CONTINUED). Commercial Kitchen Appliance Prescriptive Measures and Baseline for Energy Cost Budget (SI units)

	Baseline energy usage for energy modeling path				Levels for prescriptive path	
Appliance type	**Fuel**	**Function**	**Baseline Efficiency**	**Baseline idle Rate**	**Prescriptive Efficiency**	**Prescriptive idle Rate**
Single-tank rack conveyor dish machine, low temp	Elec	Sanitation	na	1.6 kW	na	1.5 kW
Undercounter dish machine, high temp	Elec	Sanitation	na	0.9 kW	na	0.5 kW
Undercounter dish machine, low temp	Elec	Sanitation	na	0.5 kW	na	0.5 kW

The energy efficiency, idle energy rates, and water use requirements, where applicable, are based on the following test methods:

ASTM F1275 Standard Test Method for Performance of Griddles

ASTM F1361 Standard Test Method for Performance of Open Deep Fat Fryers

ASTM F1484 Standard Test Methods for Performance of Steam Cookers

ASTM F1496 Standard Test Method for Performance of Convection Ovens

ASTM F1521 Standard Test Methods for Performance of Range Tops

ASTM F1605 Standard Test Method for Performance of Double-Sided Griddles

ASTM F1639 Standard Test Method for Performance of Combination Ovens

ASTM F1695 Standard Test Method for Performance of Underfired Broilers

ASTM F1696 Standard Test Method for Energy Performance of Single-Rack Hot Water Sanitizing, ASTM Door-Type Commercial Dishwashing Machines

ASTM F1704 Standard Test Method for Capture and Containment Performance of Commercial Kitchen Exhaust Ventilation Systems

ASTM F1817 Standard Test Method for Performance of Conveyor Ovens

ASTM F1920 Standard Test Method for Energy Performance of Rack Conveyor, Hot Water Sanitizing, Commercial Dishwashing Machines

ASTM F2093 Standard Test Method for Performance of Rack Ovens

ASTM F2140 Standard Test Method for Performance of Hot Food Holding Cabinets

ASTM F2144 Standard Test Method for Performance of Large Open Vat Fryers

ASTM F2324 Standard Test Method for Prerinse Spray Valves

ASTM F2380 Standard Test Method for Performance of Conveyor Toasters

ARI 810-2007: Performance Rating of Automatic Commercial Ice Makers

ANSI/ASHRAE Standard 72–2005: Method of Testing Commercial Refrigerators and Freezers with temperature setpoints at 3°C for mediumtemp refrigerators, -18°C for low-temp freezers, and -26°C for ice cream freezers.

TABLE 2. Supermarket refrigeration prescriptive measures and baseline for energy cost budget

Item	Attribute	Prescriptive Measure	Baseline for Energy Modeling Path
Commercial Refrigerator and Freezers	Energy Use Limits	ASHRAE 90.1-2010 Addendum g. Table 6.8.1L	ASHRAE 90.1-2010 Addendum g. Table 6.8.1L
Commercial Refrigeration Equipment	Energy Use Limits	ASHRAE 90.1-2010 Addendum g. Table 6.8.1M	ASHRAE 90.1-2010 Addendum g. Table 6.8.1M

TABLE 3. Walk-in coolers and freezers prescriptive measures and baseline for energy cost budget

Item	Attribute	Prescriptive Measure	Baseline for Energy Modeling Path
Envelope	Freezer insulation	R-46	R-36
	Cooler insulation	R-36	R-20
	Automatic closer doors	Yes	No
	High-efficiency low- or no-heat reach-in doors	40W/ft (130W/m) of door frame (low temperature), 17W/ft (55W/m) of door frame (medium temperature)	40W/ft (130W/m) of door frame (low temperature), 17W/ft (55W/m) of door frame (medium temperature)

Evaporator	Evaporator fan motor and control	Shaded pole and split phase motors prohibited; use PSC or EMC motors	Constant-speed fan
	Hot gas defrost	No electric defrosting	Electric defrosting
Condenser	Air-cooled condenser fan motor and control	Shaded pole and split phase motors prohibited; use PSC or EMC motors; add condenser fan controllers	Cycling one-speed fan
	Air-cooled condenser design approach	Floating head pressure controls or ambient subcooling	10°F (-12°C) to 15°F (-9°C) dependent on suction temperature
Lighting	Lighting power density (W/sq.ft.)	0.6 W/sq.ft. (6.5 W/sq. meter)	0.6 W/sq.ft. (6.5 W/sq. meter)
Commercial Refrigerator and Freezers	Energy Use Limits	na	Use an Exceptional Calculation Method if attempting to take savings
Commercial Refrigerator and Freezers	Energy Use Limits	na	Use an Exceptional Calculation Method if attempting to take savings

TABLE 4. Commercial kitchen ventilation prescriptive measures and baseline for energy cost budget

Strategies	Prescriptive Measure	Baseline
Kitchen hood control	ASHRAE 90.1-2010 Section 6.5.7.1, except that Section 6.5.7.1.3 and Section 6.5.7.1.4 shall apply if the total kitchen exhaust airflow rate exceeds 2,000 cfm (960 L/s) (as opposed to 5,000 cfm (2,400 L/s) noted in the ASHRAE 90.1-2010 requirements)	ASHRAE 90.1-2010 Section 6.5.7.1 and Section G3.1.1 Exception (d) where applicable