REFERENCE GUIDE FOR **NEIGHBORHOOD DEVELOPMENT**

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v4

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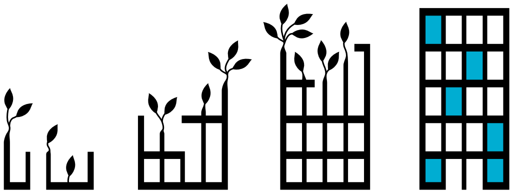

THE CASE FOR GREEN NEIGHBORHOOD DEVELOPMENTS

Green neighborhoods 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.

The challenges are especially acute in cities, which also face issues like food security, economic competitiveness, and fiscal austerity. More than half of the world's population now lives in urban rather than rural areas, and the urban share is predicted by the United Nations to rise to 70% by 2050, with the emergence of megacities of 10 million to 20 million people.[2] Rapid urbanization and natural resource stresses will significantly shape urban redevelopment and greenfield growth in the decades ahead, and the problems must be effectively addressed if communities are to become more sustainable.

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.

Since the bulk of urban growth is forecast to occur in communities of 100,000 to 250,000 people, neighborhoods will be the fundamental units of urban change and innovation. At the neighborhood level, these "drawing boards" can catalyze LEED for Neighborhood Development (ND) strategies, such as affordable housing, climate protection, and improved public health. Rapid urbanization requires community planning processes that are ideal for green intervention and transformation. Opportunities for sustainable solutions range from small green business start-ups to large-scale ecosystem services.

Growing evidence points to a strong public

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[1] *Global Footprint Network, footprintnetwork.org/en/index.php/gfn/page/world_footprint/, accessed September 11, 2012.*
[2] *UN Habitat Global Report on Human Settlements, 2009.*

preference for sustainable built environments, including LEED ND's core elements of traditional neighborhood design and multimodal travel. The National Association of Realtors recently found that two-thirds of households would prefer a smaller home within walking distance of restaurants, shops, and schools over a large-lot property farther away.[3] With tools like LEED ND, neighborhoods can become exemplars of innovative leadership in achieving sustainability goals.

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. The LEED ND rating system was launched in May 2009 after four years of development and pilot testing by a partnership of the USGBC, the Natural Resources Defense Council, and the Congress for the New Urbanism.

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 LEED ND rating system, the major prerequisites and credits are categorized as Smart Location and Linkage (SLL), Neighborhood Pattern and Design (NPD), and Green Infrastructure and Buildings (GIB).

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

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[3] *National Association of Realtors, 2011 Community Preference Survey.*

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 developments 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

In particular, LEED ND benefits are distinguished by the following:

- **Scale.** The sheer quantity of green benefits is magnified when captured at the neighborhood scale, often including dozens or hundreds of buildings and thousands of occupants.
- **Comprehensiveness and synergies.** Neighborhood planning is inherently comprehensive, and that all-inclusive scope enables unique opportunities to capture synergistic benefits. An example is rainwater management accomplished, in part, at an outdoor civic space that infiltrates runoff.
- **Longevity.** Once designed and constructed, neighborhoods may persist for hundreds of years. A sustainable neighborhood design, therefore, pays green dividends for generations, cumulatively a much larger return than on most other green investments.

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

LEED CERTIFICATION PROCESS

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

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

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

CERTIFICATION OPTIONS FOR LEED ND

The LEED for Neighborhood Development rating system comprises two adaptations, LEED ND: Plan and LEED ND: Built Project, which have certification options unique to this rating system.

Smart Location & Linkage (SLL) and Neighborhood Pattern & Design (NPD) prerequisite review. If the project team has any doubts about the project's ability to achieve the SLL or NPD prerequisites, this optional review can be a useful official determination before investing further in submission preparation. It is available to both LEED ND: Plan and LEED ND: Built Project registered projects.

Letter of Support optional review. This full review of all prerequisites and credits is available to projects registered under LEED ND: Plan that have not earned all land-use entitlements. Applicants seeking an early design-phase award from USGBC to assist with local approvals may elect to undergo this review and will receive a letter of support if successful.

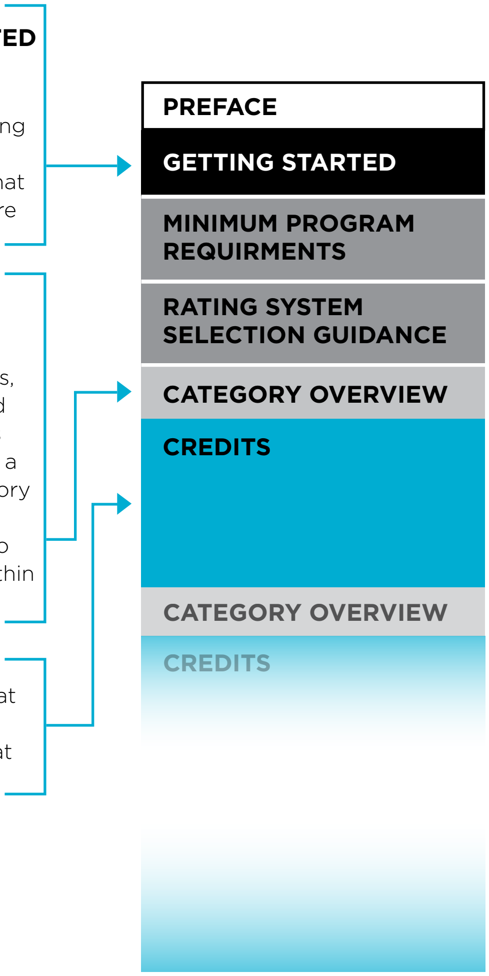
REFERENCE GUIDE OVERVIEW

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 credit 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 sometimes includes 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 wayfinding and minimize repetition.

CREDIT CATEGORIES

SMART LOCATION AND LINKAGE (SLL)

NEIGHBORHOOD PATTERN AND DESIGN (NPD)

GREEN INFRASTRUCTURE AND BUILDINGS (GIB)

INNOVATION (IN)

REGIONAL PRIORITY (RP)

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 NEIGHBORHOOD DEVELOPMENT

PROJECT GOALS

An important starting point for project certification is the formulation of overarching goals to guide the project team's work toward successful certification. To set valid goals, start by expressing objectives that are derived from or responsive to the following:

- **The developer's mission.** One of the strongest motivations for project certification should be the developer's values and organizational aims. Whether the project is undertaken by for-profit investors or nonprofit community interest organizations, LEED ND strategies can be tailored to make a strong triple-bottom-line case for certification.
- **The project's environmental setting.** The degree of environmental sensitivity on and around a project site creates both responsibilities and opportunities for leadership and innovation. LEED ND offers a full set of natural resource measures for demonstrating stewardship and helping achieve local environmental goals.
- **The project's community context.** The social and economic conditions of the surrounding community, and its overall sustainability goals, are factors that should influence project goal-setting and credit selection. LEED ND strategies can be applied to such community issues as jobs and housing balance, affordable housing, and universal visitability.

TEAM MEMBERS AND RELEVANT ORGANIZATIONS

For the purposes of LEED ND, the project team has three major components: the applicant acting as team leader, a multidisciplinary group of design professionals, and local supporting partners. The applicant is the entity that decides to certify a project under LEED ND. This can be a property owner or developer composed of individuals or companies that control a majority of the area within a project boundary, either through ownership and/or options to purchase. A property owner or developer can join with any combination of the following as joint applicants: another property owner or developer, a nonprofit organization, a homeowners association, or a public or quasi-public agency, such as a housing authority, redevelopment authority, or business improvement district.

Because the rating system integrates smart growth, new urbanism, social equity, and green building practices, a successful LEED ND submission draws on the diverse skills of a comprehensive team of professionals. The rating system can require expertise in many professions, depending on project characteristics and credits attempted.

Ensuring that a team has appropriate technical skills is crucial for successful projects and certifications, and the owner or developer should consider which of the following professions need to be represented on the project team:

- Urban planning
- Architecture
- Civil engineering
- Transportation planning
- Mechanical and electrical engineering
- Landscape architecture
- Biology and botany

At least one member of the project team should be a LEED ND Accredited Professional experienced in certifying the kind of project being proposed. Having qualified LEED ND knowledge and insight on the team will aid considerably in efficient and accurate preparation of submission documentation.

In addition to assembling a multidisciplinary and LEED ND–experienced project team, it is also important to consider local partners—the public agencies with authority or services that affect certain credits, or interested nonprofits with allied goals—when starting a submission. Project teams should identify local partners during credit selection, make them aware of the project, and seek their assistance with submission documentation where appropriate.

DEVISING A LEED WORK PLAN

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

STEP 1. IDENTIFY PROJECT SITE AND PREPARE PRELIMINARY DEVELOPMENT PROGRAM

Site selection is normally done with general development objectives in mind, along with information about available properties and market conditions in a given area. USGBC encourages the informal use of LEED ND location criteria in the site selection process. Properties chosen with LEED ND in mind and sites that already align with LEED ND principles will be easier to certify. Standard protocol is to prepare a preliminary development program once a prospective site is identified, and if a financial assessment of that program indicates project feasibility, control of the site is acquired through purchase, option to purchase, lease, or equivalent agreements.

STEP 2. SELECT RATING SYSTEM

The LEED system comprises 21 adaptations designed to accommodate the needs of a variety of market sectors (see *Rating System Selection Guidance*). The project team leader should confirm that LEED ND is the most suitable LEED rating system for the project. Some projects pursue LEED ND as well as several LEED building rating systems simultaneously. Certain multiple-building projects may want to investigate the USGBC Campus Program, which is not a rating system but a certification process.

Assuming LEED ND is the appropriate choice, the project team leader should also confirm which of two LEED ND rating systems is applicable to the project:

- **LEED ND: Plan.** A project must use the LEED ND Plan rating system if it is in a planning stage or has constructed less than 75% of its total building floor area.
- **LEED ND: Built Project.** If a project is at full build-out, it must use the LEED ND rating system.

The LEED ND: Plan and LEED ND: Built Project rating systems have identical credit requirements but differing documentation requirements and awards.

STEP 3. ASSEMBLE PROJECT TEAM AND IDENTIFY RELEVANT ORGANIZATIONS

Site acquisition and the preliminary development program will define the project type (residential, nonresidential, mixed-use), physical setting (e.g., urban infill versus suburban greenfield), and scale (amount of land, buildings, infrastructure). These characteristics influence the professional disciplines required for a LEED ND project team. If possible, the team should include a LEED ND Accredited Professional with experience certifying the kind of project envisioned for the site. This step should also identify public agencies with authority over the site and nongovernmental organizations with interests in the area or the project's goals. As credit selection and documentation proceed, having a working relationship with these entities is likely to be valuable.

STEP 4. CHECK MINIMUM PROGRAM REQUIREMENTS AND PREREQUISITES

Review the prerequisites and the minimum program requirements (see *Minimum Program Requirements*) against the project site and preliminary development program. Ensure that there are no obvious obstacles to project eligibility or prerequisite achievement.

STEP 5. FINALIZE PROJECT BOUNDARY AND DEVELOPMENT PROGRAM

Two fundamental descriptors of a LEED ND project must be finalized at this point:

- **Project boundary.** This boundary determines the land area of a project, including its buildable and nonbuildable portions. Review the minimum program requirement regarding the delineation of a project boundary.
- **Development program.** This is a summary of project land and subareas and the number of buildings by type and construction timing. The preliminary program initiated at site selection is finalized at this point for LEED ND purposes. Although development programs sometimes change over time, an operative set of land and floor area quantities needs to be used for documenting and verifying credit achievement. If a change occurs during certification review, the team should provide USGBC with amended values as soon as they are available.

STEP 6. RECONFIRM MINIMUM PROGRAM REQUIREMENTS AND PREREQUISITE COMPLIANCE

Return to Step 4 prerequisites and confirm the project's compliance with certainty, now using the final project boundary and development program. For project teams that have any doubts about meeting the SLL or NPD prerequisites, this is the point at which a formal prerequisite review can be useful.

STEP 7. 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 8. ASSIGN ROLES AND RESPONSIBILITIES

Itemize required documentation and calculations and assign responsibility for their preparation to team members.

STEP 9. DEVELOP CONSISTENT DOCUMENTATION

Submission work begins with two critical tasks that underpin the balance of the submission:

- **Base mapping.** A submission typically requires several credit-specific maps on one of two required base maps: (1) the project site, and (2) the vicinity within a mile of the project site. Land development projects often use standardized maps and drawings, and USGBC encourages project teams to adapt them for LEED ND base mapping purposes.
- **Cross-cutting calculations.** The rating system has multiple credits that require the same calculations. Performing them at the outset of submission preparation improves consistency and speeds up subsequent credit work. See the next section, *Maintaining Consistency in the Application*.

With base mapping and cross-cutting calculations in hand, team members will be able to complete the balance of the submission. If feasible, teams should adapt and reuse project information compiled for other purposes. However, when adapting such materials, it is best to highlight or excerpt only the portions relevant to LEED certification.

STEP 10. 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

PROJECT BOUNDARY

The project boundary defines the land and water area that is reviewed for certification (see *Minimum Program Requirements*).

Figure 1 illustrates how a project boundary may encompass a parcel, a parcel plus adjacent rights-of-way, or multiple parcels and rights-of-way. If a project team elects to include rights-of-way, the entire width of the rights-of-way must be within the boundary (Figure 1).

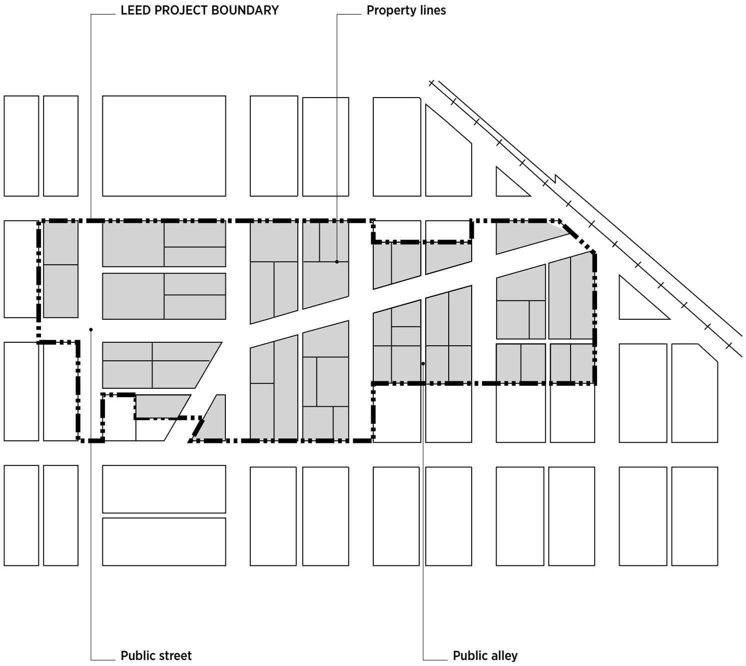


Figure 1. Example project boundary

When drawing the project boundary, teams should consider the impact of boundary location in relation to credit requirements. Inclusion or exclusion of features on the periphery of a project site may affect credit applicability and scoring. For example, the distances between through-connections on a project boundary under NPD Credit Connected and Open Community can be affected by the inclusion or exclusion of adjacent street rights-of-way. Because some credit requirements apply to existing uses as well as new construction (see Table 6), carefully consider whether the inclusion of existing areas will help or hinder the project's achievement.

SITE TYPE

A project is categorized by site type depending on where its boundary is set, the status of land inside the boundary, and the status of properties surrounding the boundary. The following site types may apply: previously developed, infill, adjacent. The subsections below define these terms and explain their use.

Previously Developed

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

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

LEED ND project teams may consider platted lots of less than 1 acre (0.4 hectares) previously developed if a building was constructed somewhere on the lot. The purpose of this allowance is to prevent teams from having to individually assess small home lots to determine the amount of land under the building footprint versus the yard space. For any lots larger than 1 acre, the team must separate the land into previously developed and undeveloped portions.

Previously developed property status can apply to a project site itself, which carries benefits under several credits, and to surrounding properties. Assessing properties with few buildings present may be confusing, however. If the land previously had buildings, it is considered previously developed even if those buildings have since been torn down. Another frequently confusing situation is parkland. Improved parks with manicured landscaping and constructed features like playgrounds (e.g., a city park) are considered previously developed. Land that has only been cleared or graded, with no additional improvements, is not considered previously developed. Land maintained in a natural state (e.g., a forest preserve) is not considered previously developed, even if minor features like walking paths are present.

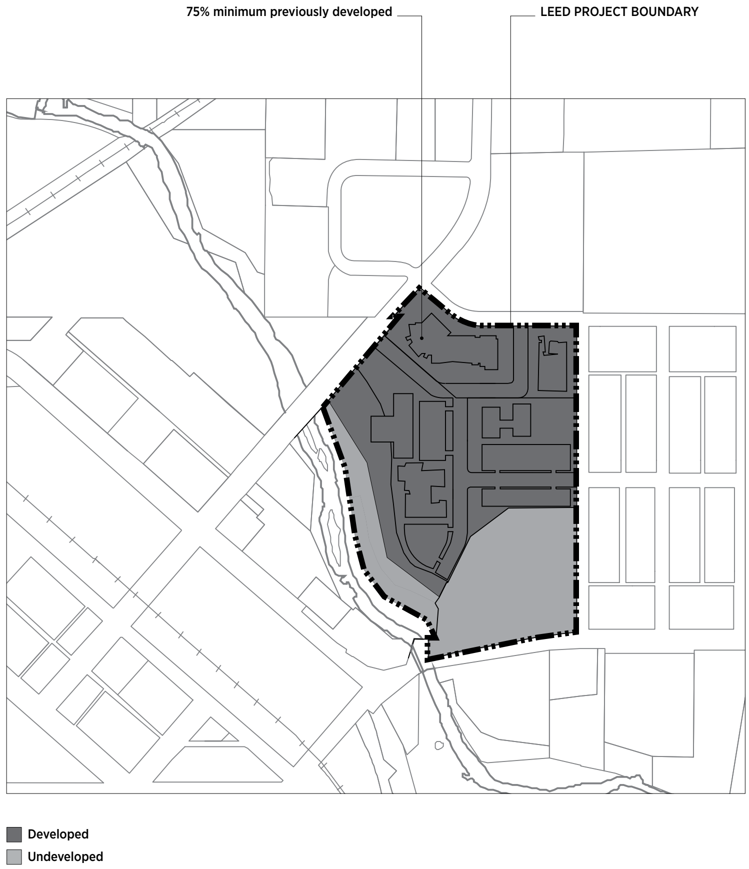


Figure 2. Example map of previously developed area within project

Infill Site

infill site a site that meets any of the following four conditions:

a. At least 75% of its boundary borders parcels that individually are at least 50% previously developed, and that in aggregate are at least 75% previously developed.

b. The site, in combination with bordering parcels, forms an aggregate parcel whose boundary is 75% bounded by parcels that individually are at least 50% previously developed, and that in aggregate are at least 75% previously developed.

c. At least 75% of the land area, exclusive of rights-of-way, within 1/2 mile (800 meters) of the project boundary is previously developed.

d. The lands within 1/2 mile (800 meters) of the project boundary have a preproject connectivity of at least 140 intersections per square mile (54 intersections per square kilometer).

The circulation network itself does not constitute previously developed land; it is the status of property on the other side of the segment of circulation network that matters. For conditions (a) and (b) above, any fraction of the perimeter that borders a water body is excluded from the calculation.

As defined above and illustrated in the accompanying diagrams, there are four circumstances in which a LEED ND project can be considered an infill site. In all instances, the characteristics of land around the project are important. Conditions (a) and (b) involve the parcels bordering or close to the LEED ND project boundary; conditions (c) and (d) involve characteristics of the area within a 1/2-mile (0.8 km) distance of the project boundary. For a parcel to qualify as "bordering," it must share a linear section of boundary; a parcel that adjoins the project at only a single point (e.g., kitty-corner) is not considered bordering.

Calculations for condition (a): Previous development on adjacent parcels

Step 1. On a vicinity map, identify parcels adjacent to the project perimeter. For each parcel, calculate the area that is previously developed. Determine the percentage of the parcel that is previously developed by dividing the previously developed area by the entire parcel area and multiplying by 100 (Equation 1). Each adjacent parcel that is at least 50% previously developed is then considered a qualifying parcel in these calculations.

EQUATION 1. Previously developed percentage of parcel

$$\text{\% of adjacent parcel previously developed} = \frac{\text{Area of parcel that is previously developed}}{\text{Total area of parcel}} \times 100$$

Step 2. Sum the previously developed land area of each qualifying parcel identified in Step 1, divide by the total land area of all qualifying parcels (Equation 2), and multiply by 100. The result must be 75% or higher.

EQUATION 2. Previously developed percentage of all qualifying parcels

$$\text{\% previously developed area of combined qualifying parcels} = \frac{\text{Total previously developed area of qualifying parcels}}{\text{Total area of qualifying parcels}} \times 100$$

Step 3. Measure the total project perimeter, any portion adjacent to waterfront, and the length of portions adjacent to qualifying parcels, from Step 1. After subtracting waterfront length from the total perimeter length, divide the perimeter length adjacent to all qualifying parcels by the total net perimeter length, and multiply by 100 to obtain the percentage of the perimeter bordering previously developed parcels (Equation 3). The result must be 75% or more.

EQUATION 3. Percentage of perimeter adjacent to qualifying parcels

$$\text{\% of perimeter adjacent to qualifying parcels} = \frac{\text{Perimeter length adjacent to qualifying parcels}}{\text{Total perimeter length — waterfront length}} \times 100$$

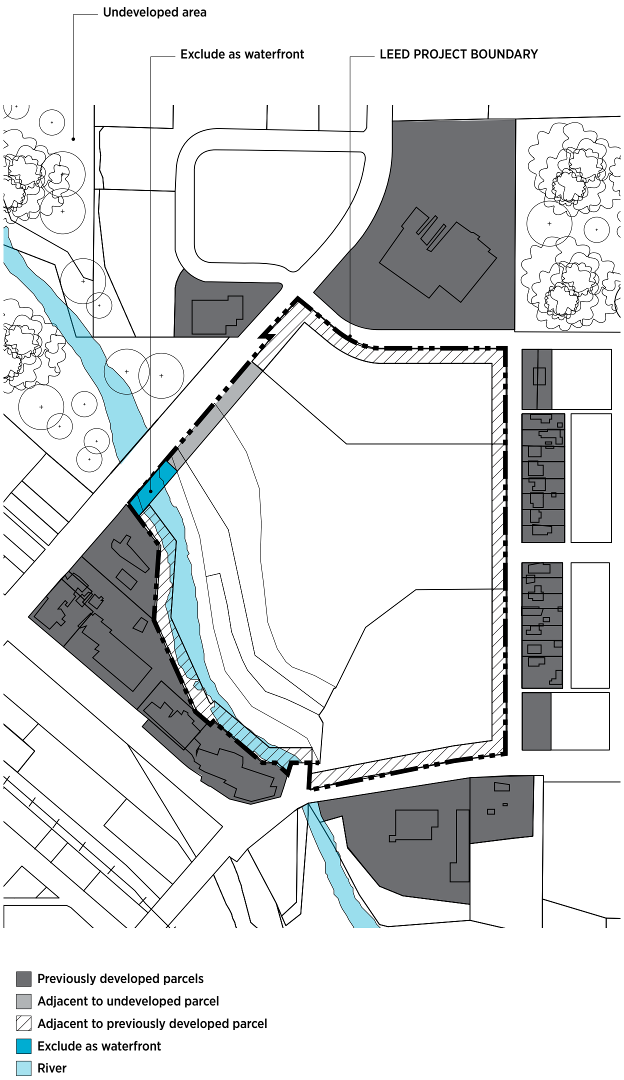


Figure 3. Infill condition (a)

Calculations for condition (b): Previous development on adjacent parcels using aggregate method

This is the same as condition (a) except that the expanded boundary is used in place of the project boundary. The boundary can encompass the project plus any parcels that directly border the project site.

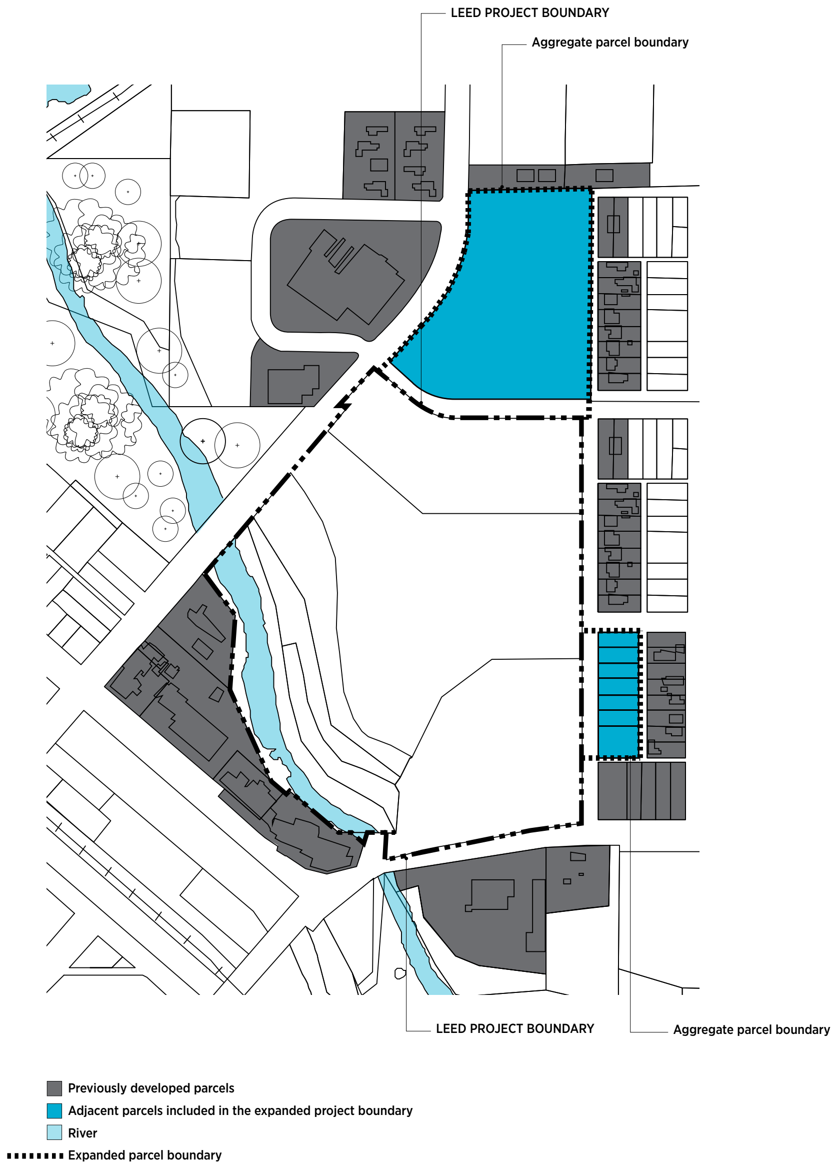


Figure 4. Infill condition (b)

Calculations for condition (c): Previous development in surrounding area

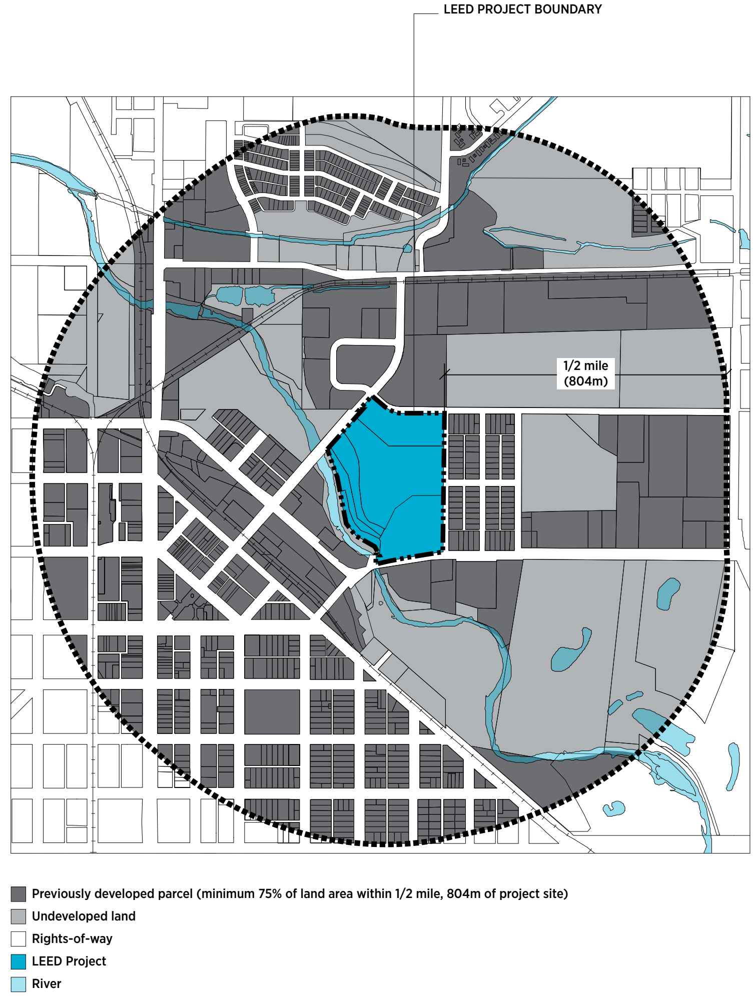


Figure 5. Infill condition (c)

EQUATION 4. Percentage of previous development within 1/2-mile (800-meter) buffer around project boundary

$$\text{\% of area within buffer} = \frac{\text{Area of all previously developed parcels within buffer}}{\text{Total land area within buffer — area of rights-of-way within buffer}}$$

Calculations for condition (d): Connectivity in surrounding area

See *Connectivity (Intersection Density)*.

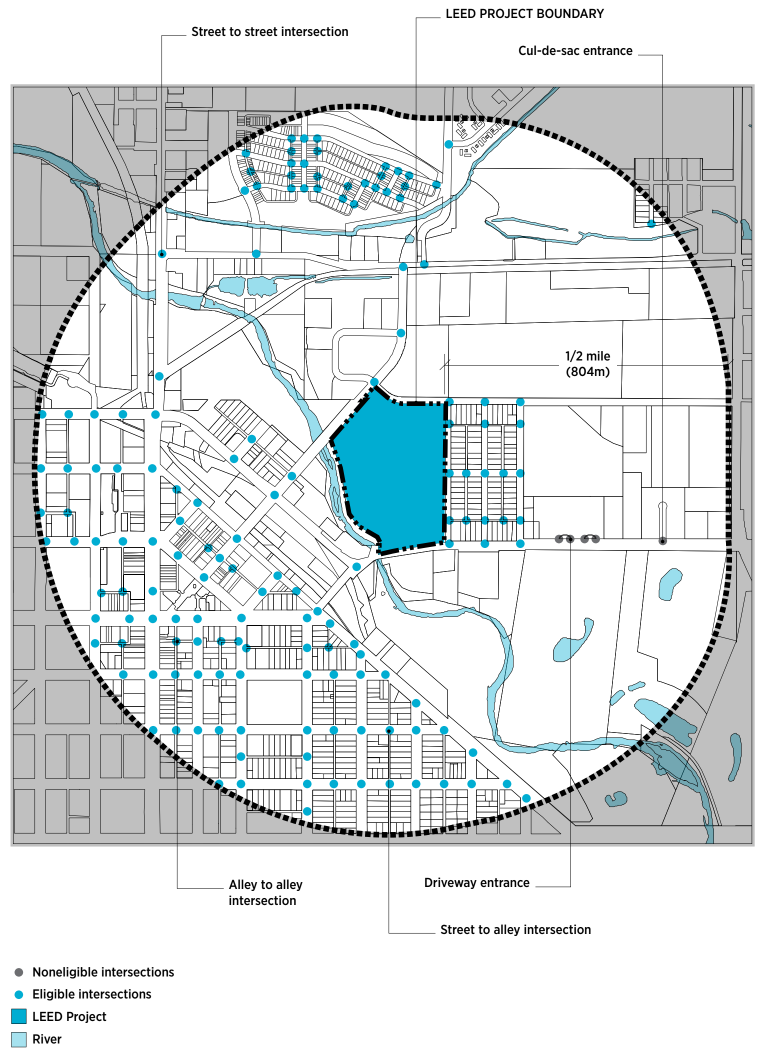


Figure 6. Infill condition (d)

Infill Example

Projects need to meet only one of the four conditions to qualify as an infill site, but for the sake of illustration, the following example project is tested against (and meets) all four criteria. The calculations are presented in IP units but are the same for project teams using SI.

A 35-acre project site is evaluated for its status as an infill parcel. The project team evaluates each parcel of land adjacent to the project boundary and collects information about the land uses within 1/2-mile of the project boundary (Table 1).

TABLE 1. Infill site determination

Total project site perimeter (excluding waterfront)	5,000 ft
Perimeter portion adjacent to parcels that are each > 50% developed	4,300 ft
Total area of adjacent parcels > 50% developed	70 acres
Total previously developed portion of all parcels > 50% developed	55 acres
Total perimeter of project site and additional bordering parcels	16,000 ft
Perimeter portion adjacent to parcels that are each > 50% developed	13,500 ft
Total area of parcels >50% developed adjacent to site and bordering parcels	125 acres
Total previously developed area of > 50% developed parcels adjacent to site and bordering parcels	105 acres
Land area within 1/2 mi of project site boundary (after exclusions)	345 acres
Previously developed land area within 1/2 mi of site boundary	270 acres
Qualifying intersections within 1/2 mi of project site boundary	100 intersections

The project meets infill condition (a) (previous development on parcels adjacent to site perimeter) because the portion of the perimeter that borders parcels that are more than 50% previously developed is 86% (Equation 3):

$$\frac{4{,}300}{5{,}000} \times 100 = 86\%$$

In addition, the adjacent parcels are in aggregate 78% previously developed (Equation 2):

$$\frac{55}{70} \times 100 = 78\%$$

The project meets infill condition (b) (previous development on parcels adjacent to the project site and any number of bordering parcels “borrowed” to create the “aggregate parcel”) because the aggregate parcel’s perimeter portion adjoining parcels that are more than 50% previously developed is 84% (Equation 3):

$$\frac{13{,}500}{16{,}000} \times 100 = 84\%$$

In addition, the parcels adjacent to the aggregate parcel are in total 84% previously developed (Equation 2):

$$\frac{105}{125} \times 100 = 84\%$$

The project meets infill condition (c) (previous development on surrounding land) because the land within 1/2 mile of the project perimeter is 78% previously developed.

$$\frac{270}{345} \times 100 = 78\%$$

The project meets infill condition (d) (connectivity of surrounding land) because the land within 1/2 mile of the project perimeter has more than 140 intersections per square mile:

$$\frac{345 \text{ acres}}{640 \text{ acres per square mile}} = 0.54 \text{ square miles}$$

$$\frac{100 \text{ intersections}}{0.54 \text{ square mile}} = \frac{185 \text{ intersections}}{\text{square mile}}$$

Adjacent Site

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

To be an adjacent site (Figure 7), the project site needs to border previously developed land along at least 25% of its boundary.

A LEED ND project site can be considered adjacent even if a narrow greenway or undeveloped, permanently protected land separates it from previously developed parcels. The greenway or undeveloped land may average no more than 400 feet (125 meters) in width and be no more than 500 feet (155 meters) wide in any one place. The undeveloped land must be protected from residential and nonresidential construction by easement, deed restriction, or other enforceable legal instrument.

For a project site to qualify as an adjacent site for SLL Prerequisite Smart Location, Option 2, the greenway or other protected open space must allow through-connections to the previously developed land.

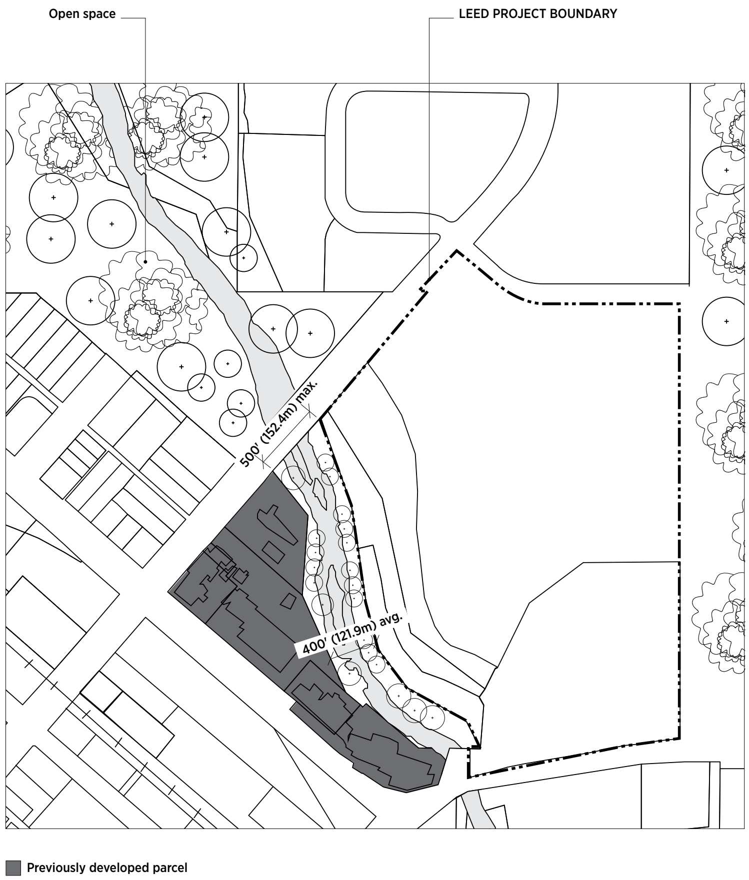


Figure 7. Adjacent site

When determining infill and adjacent status, if the project site is next to a street right-of-way, the team must consider the previous development status of property on the other side. Parks with physical improvements are considered previously developed; legally dedicated land in its natural state is considered undeveloped. When waterfront occurs on the other side of a street right-of-way, the length of that waterfront may be excluded from the calculation.

Once a project boundary has been established, the project team should assemble information on the type and location of previous development within the boundary to determine whether the site itself qualifies as a previously developed site.

BUILDABLE LAND

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 or LEED for Neighborhood Development prerequisites.

Buildable land (Figure 8) is an important element of a project because it is the denominator in the calculation of land-use densities. First, determine the base amount of buildable land in the project. Then, if additional land is voluntarily set aside and protected from development, it may be moved into the nonbuildable category, not to exceed 15% of the base amount of buildable land. To be considered nonbuildable under this provision, the land must be protected from construction by easement, deed restriction, or other enforceable legal instrument. Any additional land that is voluntarily set aside and not built on, such as open space, must be considered buildable (after the first 15%) because it was available for construction but set aside voluntarily.

For example, in a 20-acre project with a 4-acre park required by local government code, the base buildable land would be 16 acres. Should the developer wish to set aside additional land for permanent protection, up to 15% of the base 16 acres (i.e., up to 2.4 acres) could be set aside and also considered nonbuildable.

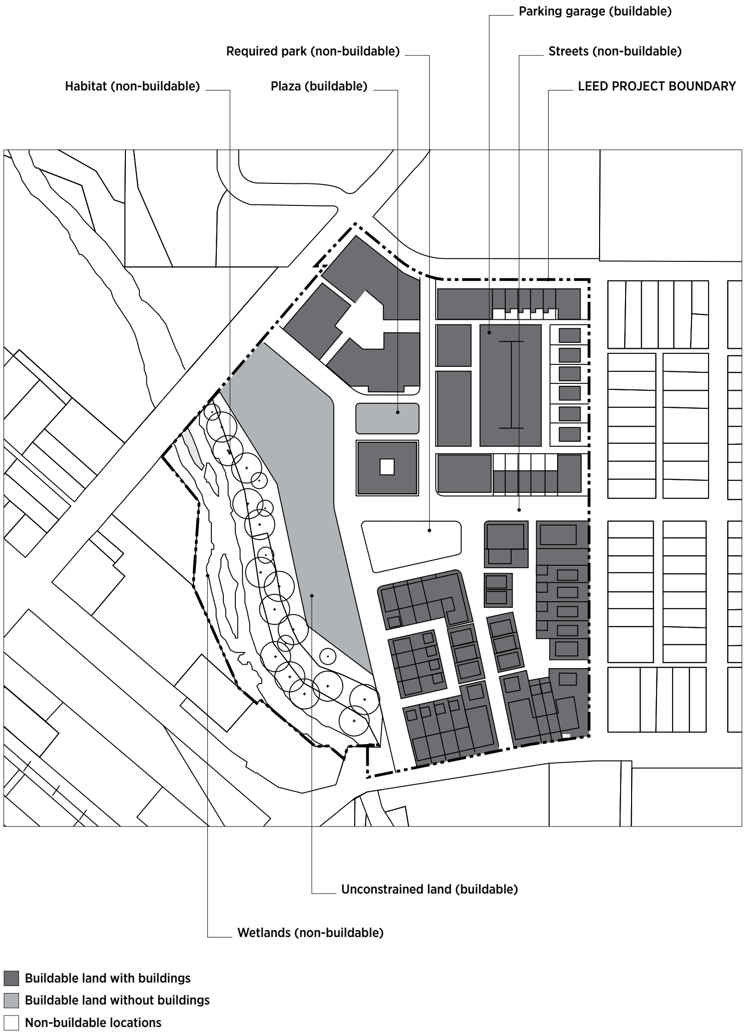


Figure 8. Buildable and nonbuildable land

DEVELOPMENT PROGRAM

The development program is a tabular presentation typically prepared by a developer detailing land uses and the demolition, construction, renovation, or retention of buildings within the project boundary. The development program should account for all land and water within the boundary according to the buildable and nonbuildable categories, discussed above. In preparing the development program, teams should consider the following:

> **New construction.** A majority of a project's square footage should be new construction or major renovation. When an existing building undergoes major renovations as part of a project, it is typically considered new construction, but the determination varies by credit. For example, GIB Prerequisite Indoor Water Use Reduction lumps major renovations in with new construction because replacing water fixtures is common practice in a major renovation. Please refer to individual credit sections of this guide for more information. Major renovation is defined as follows:
>
> > **Major renovation.** Extensive alteration work in addition to work on the exterior shell of the building and/or primary structural components and/or the core and peripheral MEP and service systems and/or site work. Typically, the extent and nature of the work is such that the primary function space cannot be used for its intended purpose while the work is in progress and where a new certificate of occupancy is required before the work area can be reoccupied.
>
> **Existing buildings.** As used in LEED ND, *existing* refers to buildings undergoing no alterations and those undergoing minor renovations. If existing buildings are included in a project, the project team should carefully review each prerequisite and credit for its applicability: some credit calculations include existing buildings and some do not. Table 6 summarizes treatment of existing and planned project features by credit.

DEVELOPMENT TIMELINE

Several provisions of the rating system are tied to milestone dates on a project's development timeline, beginning with property acquisition and extending through build-out and occupancy. Some rating system provisions must be applied in perpetuity. It is critical that the project team understand the timeline concepts within LEED ND. The following milestone dates should be carefully considered in the LEED ND context:

- **Property acquisition** is the date that the project developer purchased or took equivalent control of a majority of the land area inside the project boundary.
- **Preproject conditions** are those present on the date the developer acquired rights to a majority of its buildable land through purchase or option to purchase.
- **Existing conditions** are those present on the date of certification submission. However, a built feature is not considered existing if it was constructed by the project developer as part of the LEED ND project (this will come into play only for projects under construction).
- **Build-out** is the time at which all habitable buildings on the project are complete and ready for occupancy.

Tables 2–4 show major milestones for credits on a timeline that assumes concurrent build-out and occupancy.

TABLE 2. Credit requirements with deadlines

Prerequisite, Credit	Title	Commitment	Meet credit requirement by....
GIB Credit	Solar Orientation	Buildings not more than 25% shaded	1st building occupancy
NPD Credit	Transportation Demand Management	Provide private transit or vehicle sharing	20% occupancy
NPD Credit	Mixed-Use Neighborhoods	Businesses open	50% occupancy
SLL Prerequisite	Smart Location	Future transit operational	50% occupancy
NPD Credit	Local Food Production	Future farmers market open	50% occupancy
NPD Credit	Neighborhood Schools	New school open	50% residential occupancy
NPD Prerequisite	Compact Development	Meet minimum density	5 years after 1st building occupied
GIB Credit	Heat Island Reduction	Provide shade from trees	10 years after plant installation
NPD Credit	Tree-Lined and Shaded Streetscapes	Provide shade from trees	10 years after plant installation

TABLE 3. Credit requirements with defined time commitments

Credit	Title	Commitment	Maintain requirement for....
NPD Credit	Local Food Production	CSA shares provided	2 years after occupancy
SLL Credit	Site Design for Habitat or Wetland and Water Body Conservation	Maintenance of natural areas	3 years after buildout
SLL Credit	Restoration of Habitat or Wetlands and Water Bodies	Maintenance of natural areas	3 years after buildout
NPD Credit	Transportation Demand Management	Provide private transit	3 years after buildout
SLL Credit	Long-Term Conservation Management of Habitat or Wetlands and Water Bodies	Maintenance of natural areas	10 years after buildout
NPD Credit	Housing Types and Affordability	Affordability of rental housing	15 years after units are built

TABLE 4. Credits with perpetual commitments

Prerequisite, Credit	Title	Commitment
SLL Prerequisite	Imperiled Species and Ecological Communities Conservation	Protect habitat
SLL Prerequisite	Agricultural Land Conservation	Protect agricultural land
SLL Credit	Steep Slope Protection	Protect steep slopes
SLL Credit	Site Design for Habitat or Wetland and Water Body Conservation	Protect sensitive areas
SLL Credit	Restoration of Habitat or Wetlands and Water Bodies	Protect sensitive areas
NPD Credit	Walkable Streets	Prohibit shutters on retail windows
NPD Credit	Local Food Production	Allow growing spaces in yards
GIB Credit	Minimized Site Disturbance	Protect undisturbed areas
GIB Credit	Light Pollution Reduction	Adhere to light pollution measures

MAPPING

Because of the numerous geographic provisions and calculations in the rating system, mapping is an important part of documenting project characteristics and verifying credit achievement. Project teams should use the following types of maps (Figure 9):

> **Project site.** A standardized project site base map should be used throughout the submission to illustrate site-level features relevant to individual credits.
>
> **Vicinity.** A standardized vicinity base map should be used throughout the submission to illustrate relevant surrounding features for up to 1 mile (1.6 km) around the project boundary.
>
> **Special maps.** Certain credits require information that is more feasibly shown on special maps instead of the standard base maps. For example, maps of the high-priority redevelopment areas under Option 3 of SLL Credit Preferred Locations may cover large parts of communities.

Visual verification of credit documentation is an important element of LEED ND certification. Each map should have a title with the applicable credit name, northpoint, scale, and the relevant features clearly labeled and dimensioned in sufficient detail to enable verification of credit compliance. Maps and other drawings should be concise, clear, and of sufficiently high resolution to allow detailed review of project features. Overly large documents, however, are difficult to manage; create concise maps that document only the relevant credit requirements.

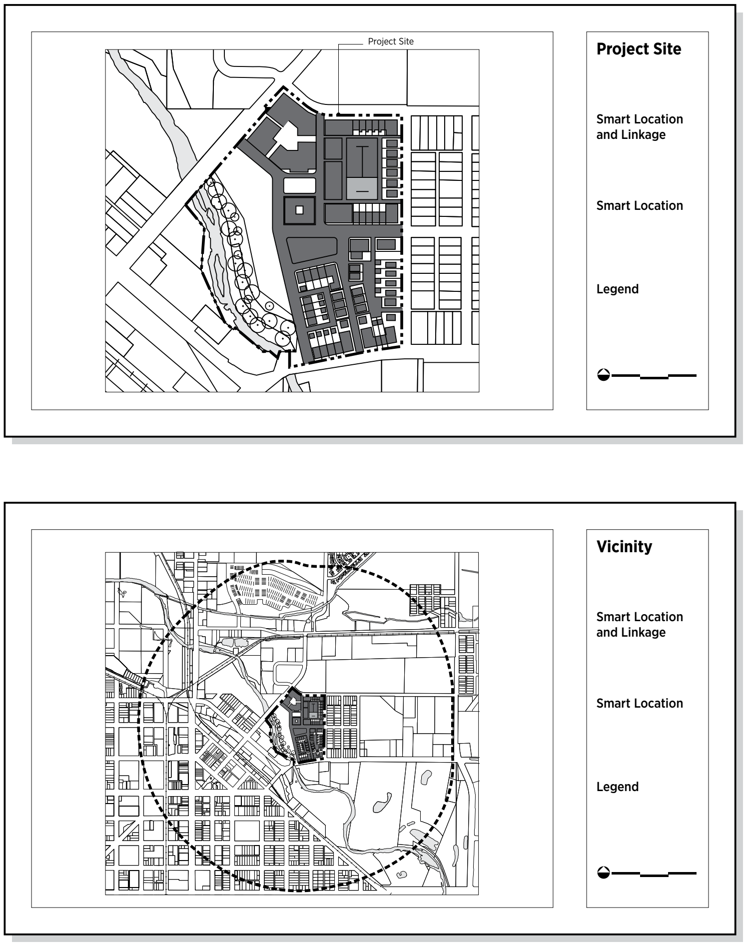


Figure 9. Example maps

WALKING AND BICYCLING DISTANCES

The second most common set of metrics in the rating system is the distances traveled by pedestrians and bicyclists from origins, such as dwellings, to destinations, such as schools. Walking and biking distances must be measured along pedestrian and bicycle networks that comply with the following LEED definitions:

> **walk 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.
>
> **bicycle network** a continuous network consisting of any combination of the following: (1) 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, (2) physically designated on-street bicycle lanes at least 5 feet (1.5 meters) wide, and (3) streets designed for a target speed of 25 mph (40 kmh)

Sometimes known as shortest path analysis, the measurement is the distance a pedestrian or bicyclist would travel from an origin point to the closest destination of a given type, such as the closest bus stop (Figure 10). The term *walkshed* denotes an area created from a compilation of walk distances from an origin, such as a polygon encompassing all possible pathways within 1/4-mile walking distance. Walksheds can sometimes be used as a way to assess compliance with credits.

Dwellings or businesses accessed through common building entries are counted according to the number of dwelling units or business establishments reached through such entrances. For example, a multifamily building entrance used to access 20 dwelling units counts as 20 origin points. A nonresidential building entrance leading to 10 office tenants and two retail tenants counts as 12 origin points.

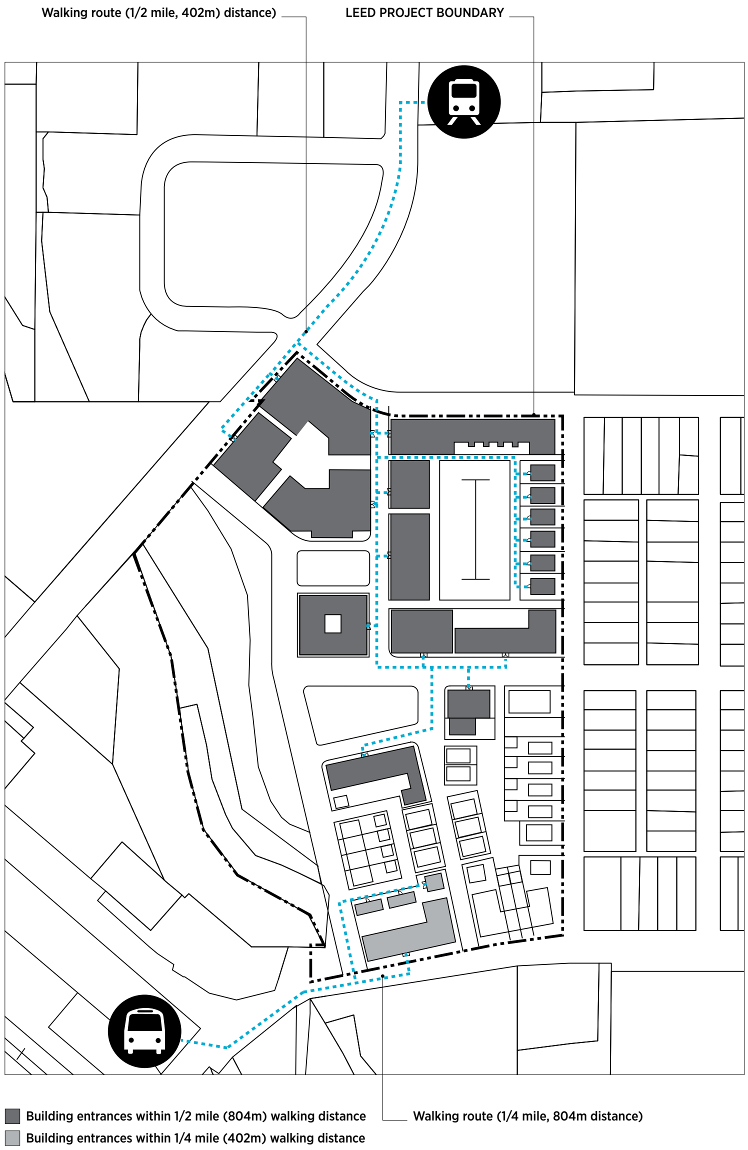


Figure 10. Walking distance

LAND-USE DENSITIES

The rating system measures land-use density in two categories, residential and nonresidential. Density is calculated according to the following definitions:

> **density** the amount of building structures constructed on the project site, measured for residential buildings as dwelling units per acre of buildable land available for residential uses, and for nonresidential buildings as the floor-area ratio of buildable land area available for nonresidential uses. In both cases, structured parking is excluded.
>
> **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.

To be considered a dwelling unit (for the purpose of inclusion in a residential density calculation), the space should be intended for long-term occupancy and provide facilities for cooking, sleeping, and sanitation. Hotel rooms, for example, are not dwelling units.

Determine densities as follows:

Step 1. Sum the amounts of buildable land area by these categories:

- Residential
- Nonresidential
- Mixed-use (a combination of residential and nonresidential)
- Other (e.g., voluntary set-asides of open space)

The total must equal 100% of the project's buildable land.

Step 2. For mixed-use buildings, assign proportional shares of the associated land area to residential and nonresidential categories using the following equations:

EQUATION 5. Residential percentage of floor area

$$\text{Residential percentage of floor area} = \frac{\text{Residential floor area}}{\text{Total floor area}}$$

EQUATION 6. Nonresidential percentage of floor area

$$\text{Nonresidential percentage of floor area} = \frac{\text{Nonresidential floor area}}{\text{Total floor area}}$$

EQUATION 7. Mixed-use land area assigned to residential category

$$\text{Mixed-use land area assigned to residential category} = \left(\text{Mixed-use land area}\right) \times \left(\text{Residential percentage of floor area}\right)$$

EQUATION 8. Mixed-use land area assigned to nonresidential category

$$\text{Mixed-use land area assigned to nonresidential category} = \left(\text{Mixed-use land area}\right) \times \left(\text{Nonresidential percentage of floor area}\right)$$

Step 3. Add the land area of the "other" buildable land category to the nonresidential land category.

Step 4. Sum the residential and nonresidential land areas from above to obtain their respective total land areas for the entire project.

Step 5. Divide the project's total dwelling units or total nonresidential floor area by the total residential or nonresidential land area, respectively. This gives residential density as dwelling units per acre (hectare) of residential buildable land, and nonresidential density as a floor area ratio for nonresidential buildable land.

The project's base land-use densities may be adjusted in two instances: (1) the buildable land adjustment when extra protected areas are set aside (see *Buildable Land*, above), and (2) under SLL Prerequisite Agricultural Land Conservation, where provision of a community garden enables a density increase. The latter adjustment applies only to that prerequisite.

DEVELOPMENT FOOTPRINT

A project's development footprint is essentially all of its impervious surfaces. The footprint calculation is used in seven credits where imperviousness is a consideration, such as GIB Credit Rainwater Management. Development footprint is defined as follows:

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

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

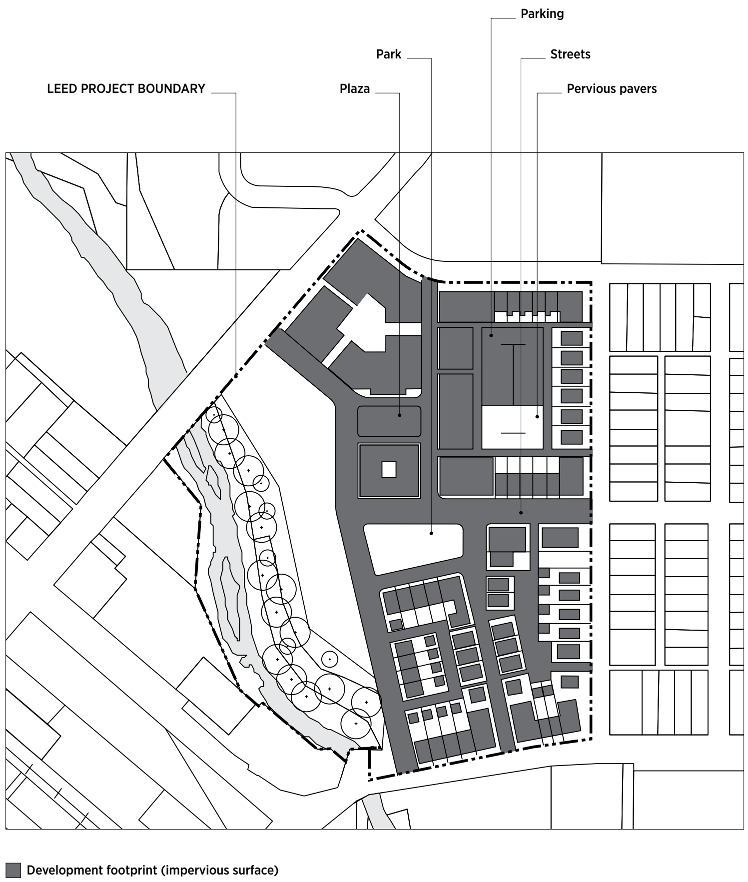


Figure 11. Development footprint

TRANSIT SERVICE

Another common cross-cutting metric is transit service, expressed in daily trips at stops. An important partner in projects with a transit component is the transit agency serving the site. Transit-related credits should be reviewed with the agency during goal setting and credit selection, and if possible, submission documentation should be reviewed with the agency before submission.

Steps for calculating and documenting transit service are as follows (including some special procedures depending on the prerequisite or credit):

Step 1. Identify dwelling units and nonresidential use entrances within project boundary

On a site map, indicate the location of all building entrances and dwelling units.

- See *Walking and Bicycling Distances.*

Step 2. Determine whether any new transit is planned

Research transit plans for the area to determine whether any new transit is planned near or within the project. Stops along the planned routes qualify only if they meet one of the three criteria outlined in the rating system:

- A funding agreement with the Federal Transit Administration (or equivalent national-level agency for projects outside the U.S.)
- Approval in an agency budget
- Preliminary engineering for a rail line and allocated funding

Step 3. Identify transit stops within 1/4 mile (400 meters) or 1/2 mile (800 meters)

On a map, identify the locations of existing and planned transit stops (planned stops must meet the requirements in Step 2) that are within a 1/4-mile (400-meter) or 1/2-mile (800-meter) walking distance of the project's dwelling units or nonresidential use entrances, based on vehicle type. Bus, streetcar, or rideshare stops qualify if they are within 1/4 mile of at least one project building entrance. Bus rapid transit, light or heavy rail, commuter rail, or ferry stops qualify if they are within 1/2 mile of at least one project building entrance.

Each point at which a transit vehicle stops to receive or discharge passengers is considered a separate transit stop; this includes stops facing each other on opposite sides of a street. This method of counting is specific to LEED for Neighborhood Development; the LEED Building Design and Construction rating system uses another method.

Step 4. Identify transit vehicle types

Identify the type of transit vehicles that serve each qualifying transit stop: bus, streetcar, bus rapid transit, rail, or ferry.

Step 5. Create walk route and distance map

Calculate walk routes and distances from the project's dwelling units and nonresidential use entrances to transit stops. The routes must comply with the rating system's requirements for pedestrian facilities. See *Walking and Bicycling Distances*.

- Count the number of dwelling units and nonresidential use entrances within a 1/4-mile (400-meter) walk of a bus or streetcar stop or within a 1/4-mile (800-meter) walk of a rail, bus rapid transit or ferry stop.
- Confirm that at least 50% of the project's dwelling units and nonresidential use entrances are within the required walking distance of one or more transit stops.

Step 6. Count trips at each qualifying transit stop

A trip is defined as the moment a transit vehicle stops at a stop. If a single vehicle stops at multiple stops along a route, each stop is considered a trip.

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

- The number of transit vehicle rides on a weekday. If service varies by weekday, count the weekday with the lowest number of trips.
- The number of transit vehicle trips on each weekend day. If counts per weekend day are different, use an average; however, no day may have zero trips.
- An individual transit stop can be counted only once, regardless of the number of dwelling units or nonresidential use entrances within walking distance of it.
- Total the trips provided at all qualifying transit stops and determine whether the number meets the daily transit service threshold for both weekday and weekend trips, as noted in the credit requirements.

Step 7. Assess achievement of relevant prerequisites and credits

Transit service thresholds vary by prerequisite and credit. The following credits contain transit calculations:

- SLL Prerequisite Smart Location
- SLL Prerequisite Agricultural Land Conservation
- SLL Credit Access to Quality Transit
- NPD Prerequisite Compact Development
- NPD Credit Mixed-Use Neighborhoods
- NPD Credit Transportation Demand Management

Transit service example for SLL Prerequisite Smart Location

A 5-acre project involves new construction of 75 dwellings and 10 businesses plus two existing nonresidential buildings. Twenty-five of the dwellings are in a multifamily building, and the remainder are detached single-family units. Of the businesses, five share a building, and the others are in their own buildings. This gives a total of

51 residential buildings and eight nonresidential buildings, for a project total of 59 buildings. For the sake of brevity, it is assumed that each of the 59 buildings has a single entrance and that the project and vicinity pedestrian networks comply with rating system requirements.

The project team does a preliminary assessment of transit service in the area and finds one rail station with two platforms (essentially two stops) and six bus lines near the project. The six bus lines have a total of 20 stops near the project.

Closer assessment reveals that four of the bus stops cannot be reached by any existing or planned project building within a 1/4-mile walking distance, so these are eliminated from consideration. For the remaining two rail stops and 16 bus stops, all qualify because at least one existing or planned project building entrance is within the allowed walking distances.

Additionally, a new bus line is planned that has the required funding commitments. Six new bus stops will be within walking distance of the project, bringing the total to 22 qualifying bus stops.

The team calculates the number of dwelling and nonresidential entrances within walking distance of at least one of the 22 bus stops. Using shortest path analysis, the team finds that 40 of the 59 building entrances are within the required distance of at least one bus stop, then calculates the percentage: 40 / 59 = 0.68%. Because 68% of the entrances have access to transit, the project exceeds the required threshold (50% of total origin points).

Next, the team counts the number of daily transit trips at the 22 stops for each day of the week. Based on timetables, the team finds that the stops, in aggregate, have 400 trips per weekday, 250 Saturday trips, and 100 trips on Sunday. Because Saturday and Sunday trip numbers are different, the team must use their average: 250 + 100 = 350, and 350 / 2 = 175. (Although the Saturday and Sunday trips can be different, neither can be zero.)

With 400 daily weekday trips and an average 175 daily weekend trips, the project exceeds the prerequisite's thresholds of 60 and 40, respectively.

CONNECTIVITY (INTERSECTION DENSITY)

Another rating system metric is connectivity, expressed as intersections per square mile (square kilometer). Connectivity is an important objective of LEED ND because it enables multimodal travel that, in turn, reduces energy use and emissions of pollutants, including greenhouse gases, while improving public health and equitable access.

Connectivity can be calculated internally (within the project boundary) or in the area surrounding the project (within a specified distance of the project boundary).

For both internal and surrounding connectivity, eligible and ineligible intersections are as follows (Figure 12):

- Count publicly accessible intersections of the circulation network, including intersections of streets with dedicated alleys and transit rights-of-way, and intersections of streets with nonmotorized rights-of-way.
- If one must both enter and exit an area through the same intersection, exclude that intersection and any intersections beyond that point; intersections leading only to culs-de-sac are also not counted.

Assemble maps of existing and planned streets and rights-of-way inside the project boundary (internal connectivity) or existing streets and rights-of-way in the vicinity (surrounding connectivity). Use mapped street data from GIS or CAD files of right-of-way centerlines, normally available from the local government.

Exclude ineligible intersections (as listed above) and count the remaining qualifying intersections. Sum the number of qualifying intersections for the project site area (internal connectivity) or the area within a 1/4-mile (400-meter) distance of the project boundary (surrounding connectivity).

When determining area, include street rights-of-way. Exclude the area of water bodies, parks larger than 1/2 acre (0.2 hectare), public facility campuses, airports, rail yards, slopes over 15%, and areas nonbuildable under codified law or the rating system.

Finally, prorate the eligible intersections in the area to the equivalent of a square mile or square kilometer. For example, 50 intersections in a 0.75-square-mile (1.9-square-kilometer) project site equates to 67 intersections per square mile (174 intersections per square kilometer).

The results of Equation 9 determine compliance with the connectivity prerequisite and credit.

EQUATION 9. Intersections per square mile (square kilometer)

$$\frac{\text{Intersections}}{\text{mi}^2 \text{ or km}^2} = \frac{\text{Qualifying intersections}}{\text{Land area minus any exclusions}}$$

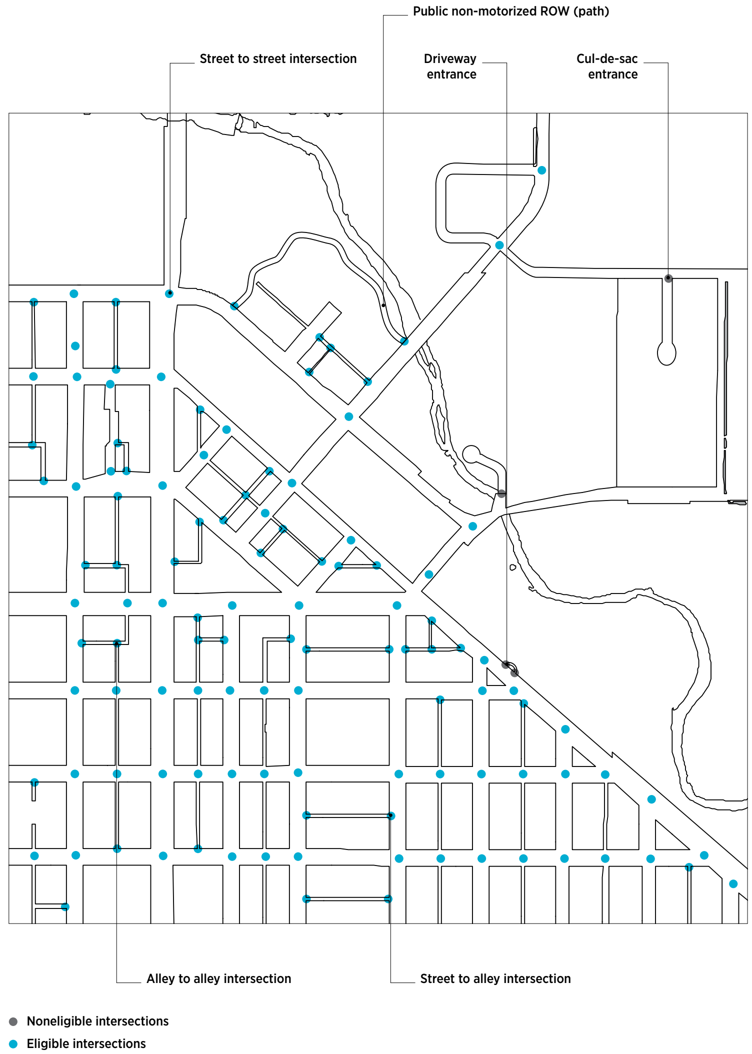


Figure 12. Eligible and ineligible intersections for determining connectivity

PROJECT GEOGRAPHIC CENTER

Several credits require measuring the distance from a project's geographic center to certain features, such as farmers markets. In CAD or GIS terms, the project's geographic center is the "centroid" of the polygon created by the project boundary.

THROUGH CONNECTIONS AND RIGHT-OF-WAY INTERSECTS

SLL Prerequisite Smart Location and two NPD credits require the measurement of distances between the points where internal right-of-way centerlines pass through or terminate at the project boundary. Figure 13 shows how rights-of-way may intersect a project boundary. NPD Prerequisite Connected and Open Community and NPD Credit Connected and Open Community allow rights-of-way to terminate at the project boundary, as well as pass through it. As shown in Figures 15–18, the points where the centerlines of rights-of-way intersect the project boundary are the points used to measure interval distances between those points along the boundary. Maximum allowable distances between intersect points are stipulated in each credit.

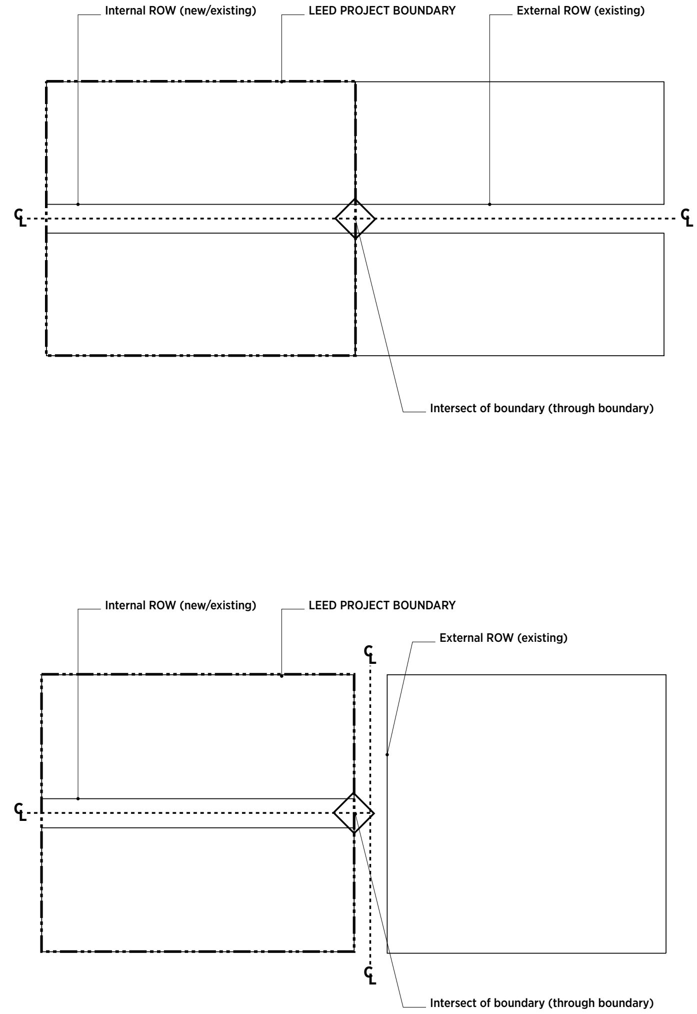


Figure 13. Through connections

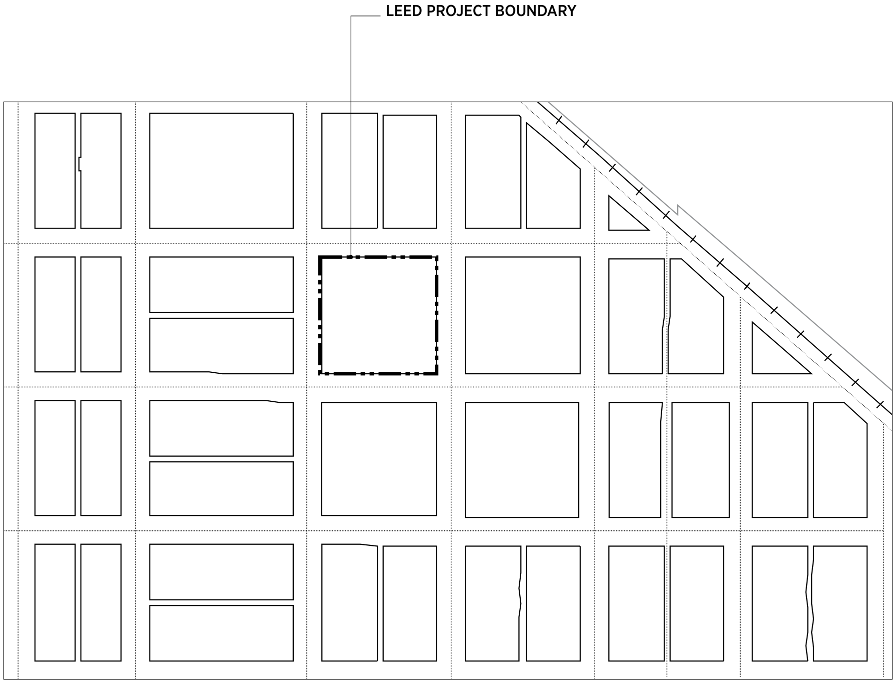


Figure 14. No through connections

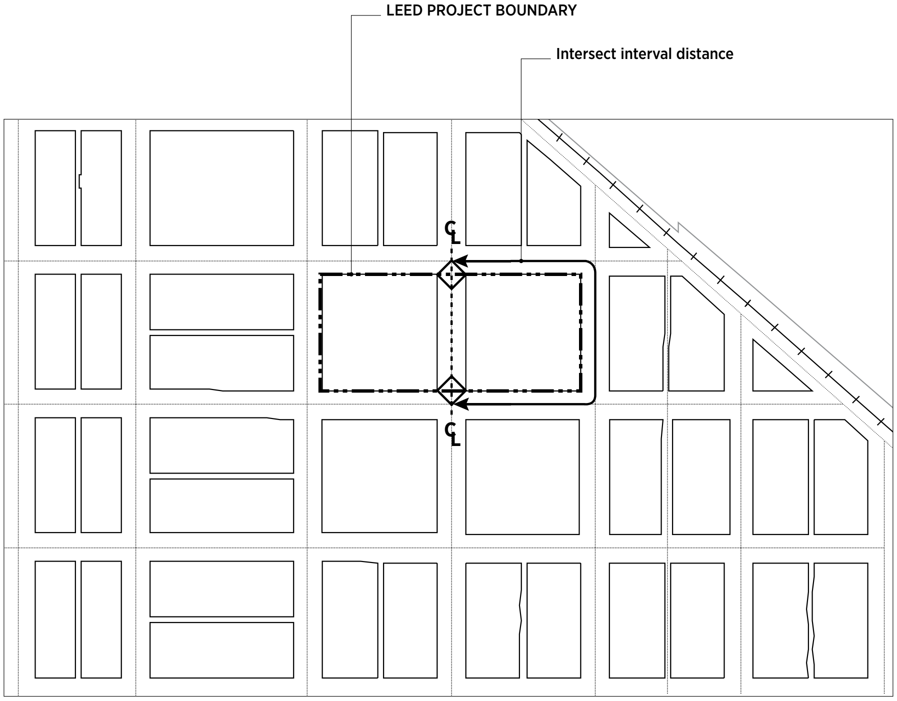


Figure 15. Through connections, two-block project

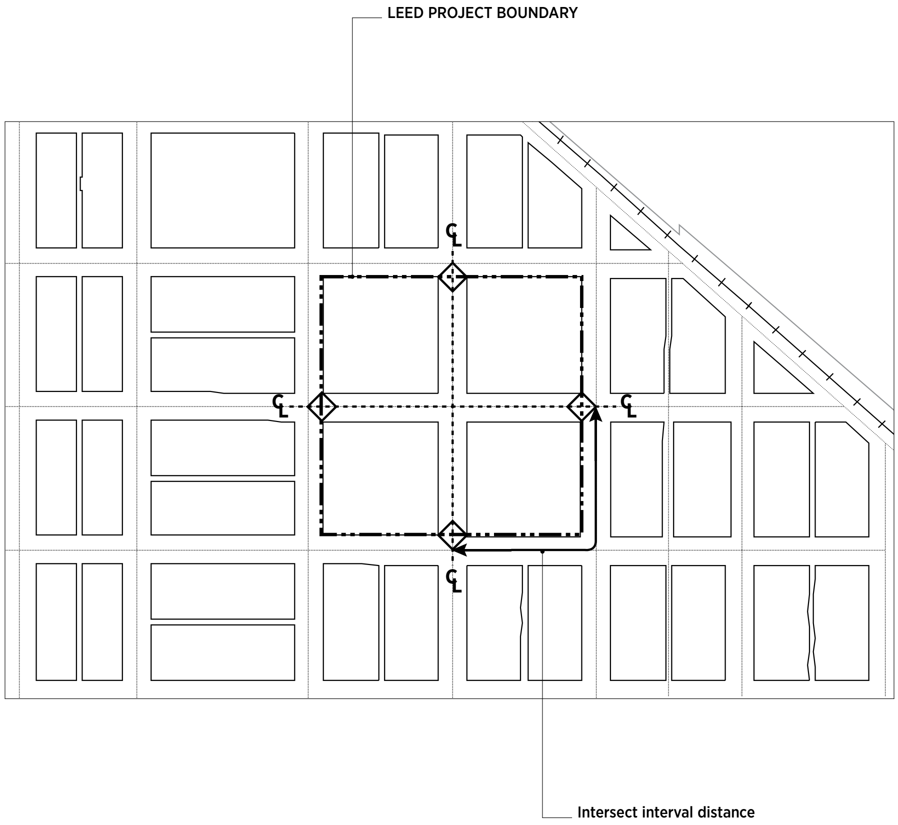


Figure 16. Through connections, four-block project

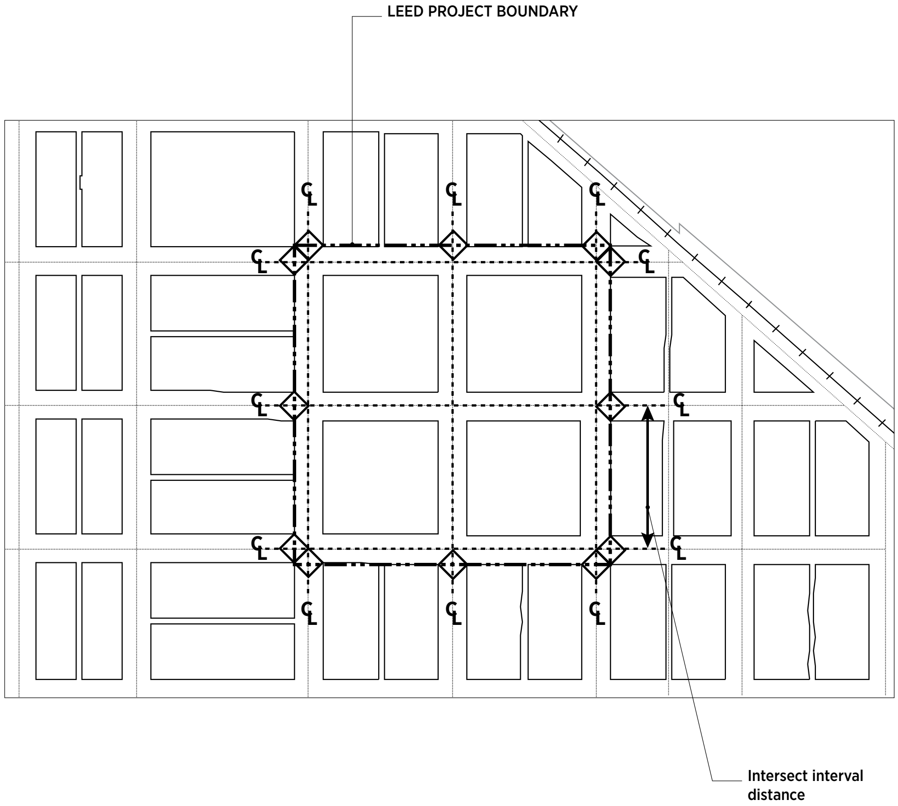


Figure 17. Through connection, four-block project including bordering streets

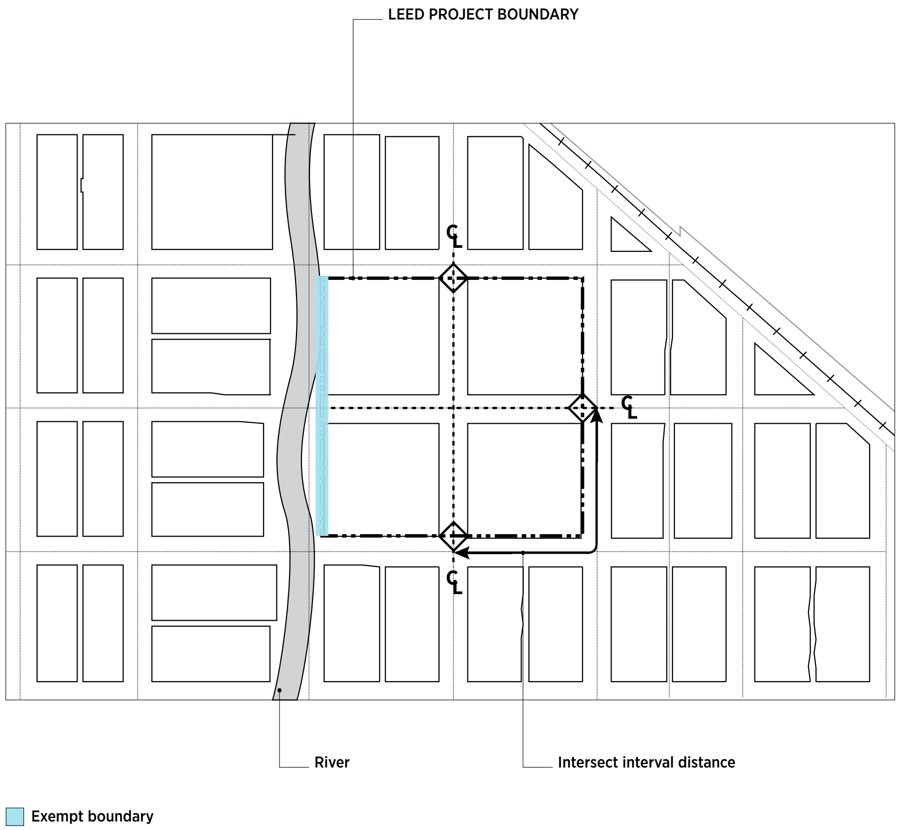


Figure 18. Through connection with exempt boundary portion

CIRCULATION NETWORK AND BLOCK FRONTAGES

Three NPD credits stipulate requirements for circulation networks, block length, and building frontages. Circulation network and block length are defined as follows:

> **circulation network** all motorized, nonmotorized, and mixed-mode travel ways permanently accessible to the public, not including driveways, parking lots, highway access ramps, and rights-of-way exclusively dedicated to rail. It is measured in linear feet.
>
> **block length** the distance along a block face; specifically, the distance from an intersecting right-of-way edge along a block face, when that face is adjacent to a qualifying circulation network segment, to the next ROW edge intersecting that block face, except for intersecting alley ROWs.

The applicability of these terms to a typical streetscape is shown in Figure 19.

Sidewalks are usually (but not always) located within the circulation network right-of-way. When measuring the length of the circulation network using the above definition, count a right-of-way only once, regardless of how many travel modes or lanes use it. For example, a street segment containing four vehicular lanes, a bicycle lane, and a bordering sidewalk is considered a single length of circulation network. If, however, a pedestrian-only right-of-way does not occur along a street but stands alone, its length is counted separately for the circulation network.

The dividing line between the right-of-way and block frontage is the property line, regardless of sidewalk location.

Some elements of a project, such as a plaza or square, may occasionally allow vehicular passage but are not part of the circulation network. For example, a plaza serving primarily as a public meeting space is not considered part of the dedicated circulation network, even if emergency vehicles are allowed to drive through it.

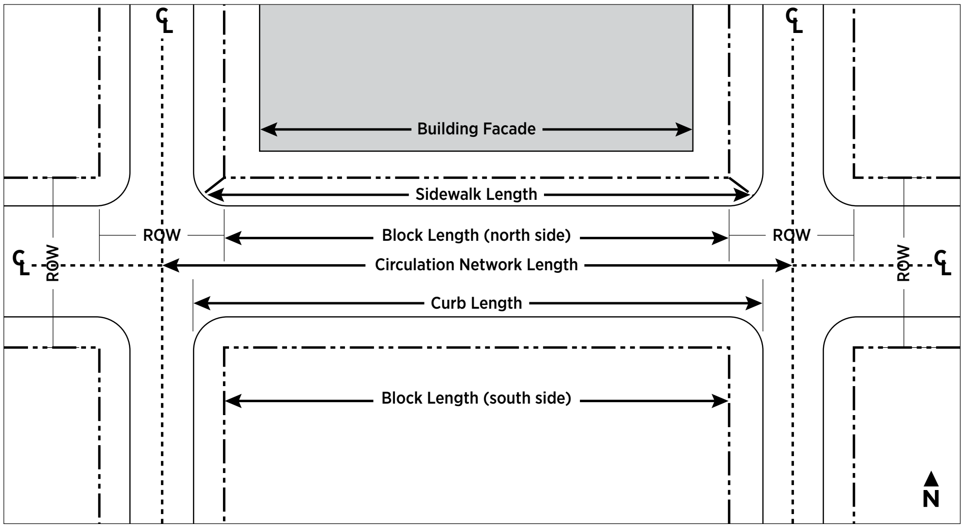


Figure 19. Measuring the circulation network and frontages

OCCUPANCY

Many kinds of people use a typical LEED building, and the mix varies by project type. Occupants are sometimes referred to in a general sense; for example, "Publicize the availability of subsidized transit passes to project occupants." 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 LEED project. 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 10).

EQUATION 10.

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

For buildings with more unusual occupancy patterns, calculate the FTE building occupants based on a standard eight-hour occupancy period (Equation 11).

EQUATION 11.

$$\text{FTE employees} = \frac{\Sigma \text{ all employee hours}}{8}$$

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 SLL 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 project. All of the following are considered visitors.

Retail customers are considered visitors. In water-related 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, use 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.

The following LEED ND credits reference occupancy:

- SLL Credit Bicycle Facilities
- NPD Credit Transportation Demand Management
- NPD Credit Local Food Production
- GIB Prerequisite and Credit Indoor Water Use Reduction
- GIB Credit Solid Waste Management

QUICK REFERENCE

TABLE 5. Scorecard and policy areas

Prerequisite/ Credit	Credit name	Points	Exemplary performance		
				Climate protection	**Infrastructure efficiency**
SLL	**Smart Location and Linkage**				
P	Smart Location	Required		X	X
P	Imperiled Species and Ecological Communities Conservation	Required			
P	Wetland and Water Body Conservation	Required			
P	Agricultural Land Conservation	Required			
P	Floodplain Avoidance	Required			
C	Preferred Locations	10	Y	X	X
C	Brownfield Remediation	2			
C	Access to Quality Transit	7	Y	X	X
C	Bicycle Facilities	1		X	X
C	Housing and Jobs Proximity	3		X	X
C	Steep Slope Protection	1			
C	Site Design for Habitat or Wetland and Water Body Conservation	1			
C	Restoration of Habitat or Wetlands and Water Bodies	1	Y		
C	Long-Term Conservation Management of Habitat or Wetlands and Water Bodies	1			
NPD	**Neighborhood Pattern and Design**				
P	Walkable Streets	Required		X	X
P	Compact Development	Required		X	X
P	Connected and Open Community	Required		X	X
C	Walkable Streets	12	Y	X	X
C	Compact Development	6		X	X
C	Mixed-Use Neighborhoods	4	Y	X	X
C	Housing Types and Affordability	7	Y		
C	Reduced Parking Footprint	1		X	
C	Connected and Open Community	2		X	X
C	Transit Facilities	1		X	X
C	Transportation Demand Management	2		X	X
C	Access to Civic and Public Space	1		X	X
C	Access to Recreation Facilities	1		X	X
C	Visitability and Universal Design	1	Y		
C	Community Outreach and Involvement	2			
C	Local Food Production	1	Y	X	
C	Tree-Lined and Shaded Streetscapes	2	Y	X	
C	Neighborhood Schools	1		X	X

Policy-oriented credit sets						
Public health	Walkable amenties	Water protection	Smart growth	Social equity	Natural resource protection	Cross-credit policy synergies
X	X	X	X	X	X	8
		X	X		X	3
		X	X		X	3
			X		X	2
		X	X		X	3
X			X	X		5
X			X	X	X	5
X	X		X	X		6
X	X		X	X		7
X	X		X	X		6
		X	X		X	3
		X			X	2
		X			X	2
		X			X	2
X	X					4
	X		X			4
X	X		X	X		6
X	X					4
	X		X			4
X	X		X			5
	X			X		2
	X					2
X	X		X	X		6
X	X					4
X	X					5
X	X			X	X	6
X	X	X		X		6
X				X		2
				X		
X	X			X		5
	X					2
X	X			X		5

TABLE 5 (CONTINUED). Scorecard and policy areas

Prerequisite/ Credit	Credit name	Points	Exemplary performance		
				Climate protection	Infrastructure efficiency
GIB Green Infrastructure and Buildings					
P	Certified Green Building	Required		X	X
P	Minimum Building Energy Performance	Required		X	X
P	Indoor Water Use Reduction	Required		X	X
P	Construction Activity Pollution Prevention	Required			
C	Certified Green Buildings	5	Y	X	X
C	Optimize Building Energy Performance	2	Y	X	X
C	Indoor Water Use Reduction	1	Y	X	X
C	Outdoor Water Use Reduction	1	Y	X	X
C	Building Reuse	1	Y	X	X
C	Historic Resource Preservation and Adaptive Reuse	1	Y		X
C	Minimized Site Disturbance	1			
C	Rainwater Management	4	Y	X	X
C	Heat Island Reduction	1	Y	X	X
C	Solar Orientation	1	Y	X	X
C	Renewable Energy Production	3	Y	X	X
C	District Heating and Cooling	2	Y	X	X
C	Infrastructure Energy Efficiency	1	Y	X	X
C	Wastewater Management	2	Y	X	X
C	Recycled and Reused Infrastructure	1	Y	X	X
C	Solid Waste Management	1		X	X
C	Light Pollution Reduction	1		X	

Policy-oriented credit sets						Cross-credit policy synergies
Public health	Walkable amenties	Water protection	Smart growth	Social equity	Natural resource protection	
X		X				5
						3
		X				4
X		X			X	4
X		X				4
						3
		X				4
		X				4
			X			3
					X	2
		X			X	2
		X			X	5
X						4
						2
						3
						3
						3
		X				4
						3
X		X				5
X						2

TABLE 6. Applicability of requirements to planned versus existing features

Prerequisite/ Credit	Credit name	Case or option	Planned features	Existing features
SLL Smart Location and Linkage				
P	Smart Location	2. Adjacent Sites with Connectivity	—	Intersections, circulation network
		3. Transit Corridor	Buildings, transit	Buildings, transit
		4. Sites with Nearby Neighborhood Assets	Buildings	Buildings, uses
P	Wetland and Water Body Conservation	2. Sites with Wetlands, Water Bodies	Land-use densities	Land-use densities
P	Agricultural Land Conservation	5. Sites with Affected Soils	Land-use densities	Land-use densities
C	Access to Quality Transit	1. Transit-Served Location	Buildings, transit	Buildings, transit
C	Bicycle Facilities	All Projects: Bicycle Storage	Dwellings, uses	—
		1. Bikable Location	—	Bicycle network, uses
		2. Bicycle Network	Dwellings, uses, bicycle network	Dwellings, uses, bicycle network
C	Housing and Jobs Proximity	1. Project with Affordable Residential Component	Buildings	Buildings, jobs
		2. Project with Residential Component	Buildings	Buildings, jobs
		3. Infill Project with Nonresidential Component	Buildings, jobs	Buildings, transit, dwellings
C	Steep Slope Protection	All Projects	—	Slopes
NPD Neighborhood Pattern and Design				
P	Walkable Streets	a. Functional Entry	Buildings	—
		b. Building-Height-to-Street-Centerline Ratio	Buildings, circulation network	Buildings, circulation network
		c. Sidewalks	Sidewalks	—
		d. Garage Frontages	Circulation network	Circulation network
P	Compact Development	1. Projects with Access to Quality Transit	Land uses, transit	Land uses, transit
		2. All Other Projects	Land uses, transit	Land uses, transit
P	Connected and Open Community	1. Surrounding Connectivity	—	Circulation network, intersections
		2. Internal Connectivity	Circulation network, intersections	Circulation network, intersections
C	Walkable Streets	a. 25-Foot Setback	Buildings	Buildings
		b. 18-Foot Setback	Buildings	Buildings
		c. 1-Foot Setback	Buildings	Buildings
		d. Entries Every 75 Feet	Buildings	Buildings
		e. Entries Every 30 Feet	Buildings	Buildings
		f. Ground-Level Glass	Buildings	Buildings
		g. Minimal Blank Walls	Buildings	Buildings
		h. Unshuttered Retail Windows	Buildings	Buildings
		i. On-street Parking	Circulation network	Circulation network
		j. Continuous Sidewalks	Circulation network	Circulation network
		k. Ground-Floor Dwelling Units	Buildings	Buildings
		l. Ground-Floor Retail	Buildings	Buildings
		m. Building-Height-to-Street-Width Ratio	Buildings	Buildings
		n. 20-mph Streets	Circulation network	—
		o. 25-mph Streets	Circulation network	—
		p. Minimal Driveways	Circulation network	Circulation network
C	Compact Development	All Projects	Land-use densities	Land-use densities
C	Mixed-Use Neighborhoods	All Projects	Dwellings, uses	Dwellings, uses
		Projects with >150,000 ft² (13 935 m²) Retail	Buildings, transit	Buildings, transit

TABLE 6 (CONTINUED). Applicability of requirements to planned versus existing features

Prerequisite/ Credit	Credit name	Case or option	Planned features	Existing features
NPD (continued) Neighborhood Pattern and Design				
C	Housing Types and Affordability	1. Diversity of Housing Types	Dwellings	Dwellings
		2. Affordable Housing	Dwellings	—
C	Reduced Parking Footprint	All Projects	Buildings	—
C	Connected and Open Community	All Projects	Culs-de-sac, intersections, circulation network	Intersections, circulation network
C	Transit Facilities	All Projects	Transit	Transit
C	Transportation Demand Management	3. Vehicle Sharing	Buildings	Buildings
		4. Unbundling of Parking	Buildings	Buildings
C	Access to Civic and Public Space	All Projects	Buildings	Buildings
C	Access to Recreation Facilities	Proximity to Outdoor Facilities	Buildings	Buildings
C	Visitability and Universal Design	1. Projects with Dwelling Units	Dwellings	—
		2. Projects with Noncompliant ROWs	Circulation network	Circulation network
C	Local Food Production	1. Neighborhood Gardens	Dwellings	—
		2. Community-Supported Agriculture	Dwellings	—
		3. Proximity to Farmers Market	Buildings	Buildings
C	Tree-Lined and Shaded Streetscapes	All Projects	Buildings, block length	Buildings, block length
C	Neighborhood Schools	All Projects	Schools, buildings, circulation network	Buildings, circulation network
GIB Green Infrastructure and Buildings				
P	Certified Green Building	All Projects	Buildings	Major renovations
P	Minimum Building Energy Performance	All Projects	Buildings	Major renovations
P	Indoor Water Use Reduction	All Projects	Buildings	Major renovations
C	Certified Green Buildings	1. Projects with 10 or Fewer Habitable Buildings	Buildings	Buildings
		2. Projects of All Sizes	Buildings	Buildings
C	Optimize Building Energy Performance	All Projects	Buildings	Renovations
C	Indoor Water Use Reduction	All Projects	Buildings	Renovations
C	Building Reuse	All Projects	—	Major renovations
C	Historic Resource Preservation and Adaptive Reuse	All Projects	—	Buildings
C	Minimized Site Disturbance	2. Undeveloped Area Is Undisturbed	Land uses	Land uses
C	Heat Island Reduction	1. Nonroof Measures	Nonroof hardscape	Nonroof hardscape
		2. High-Reflectance and Vegetated Roofs	Buildings	—
		3. Mixed Roof and Nonroof Measures	Nonroof hardscape, buildings	Nonroof hardscape, buildings
C	Solar Orientation	1. Block Orientation	Blocks	Blocks
		2. Building Orientation	Buildings	—
C	Renewable Energy Production	All Projects	Buildings	—
C	District Heating and Cooling	All Projects	Buildings	—
C	Infrastructure Energy Efficiency	All Projects	Infrastructure	—
C	Wastewater Management	All Projects	Buildings	—
C	Light Pollution Reduction	All Projects	Land uses, buildings	Land uses, buildings

TABLE 7. Cross-cutting calculations

Prerequisite/ Credit	Credit name	Walking, biking distances	Land-use density	Development footprint	Transit service	Intersection density	Project geographic center	ROW boundary intersects	Circulation network, block frontage
SLL Smart Location and Linkage									
P	Smart Location	X		X	X	X	X	X	
P	Wetland and Water Body Conservation		X						
P	Agricultural Land Conservation		X	X	X				
C	Preferred Locations					X			
C	Access to Quality Transit	X			X				
C	Bicycle Facilities	X							
C	Housing and Jobs Proximity	X					X		
C	Steep Slope Protection			X					
C	Restoration of Habitat or Wetlands and Water Bodies			X					
NPD Neighborhood Pattern and Design									
P	Walkable Streets								X
P	Compact Development		X						
P	Connected and Open Community					X		X	
C	Walkable Streets								X
C	Compact Development		X						
C	Mixed-Use Neighborhoods	X			X				
C	Housing Types and Affordability						X		
C	Reduced Parking Footprint			X					X
C	Connected and Open Community					X		X	
C	Transit Facilities				X				
C	Transportation Demand Management	X			X				
C	Access to Civic and Public Space	X							
C	Access to Recreation Facilities	X							
C	Local Food Production	X	X				X		
C	Neighborhood Schools	X							
GIB Green Infrastructure and Buildings									
C	Minimized Site Disturbance		X	X					
C	Rainwater Management		X	X					

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.

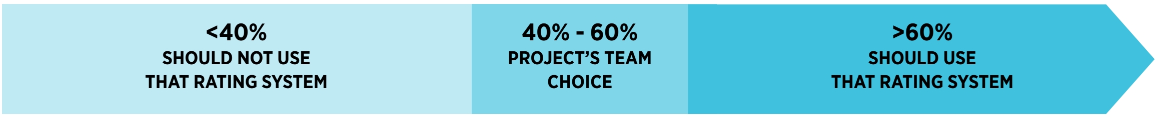
- **LEED ND: Plan.** Projects in conceptual planning or master planning phases, or under construction.
- **LEED ND: Built Project.** Completed development projects.

CHOOSING BETWEEN RATING SYSTEMS

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

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

PERCENTAGE OF FLOOR AREA APPROPRIATE FOR A PARTICULAR RATING SYSTEM



- 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.

Smart Location and Linkage (SLL)

OVERVIEW

Smart Location and Linkage focuses on selection of sites that minimize the adverse environmental effects of new development and avoid contributing to sprawl and its consequences. Typical sprawl development—low-density, segregated housing and commercial uses located in automobile-dependent outlying areas—can harm the natural environment: it can consume forestland, destroy or fragment wildlife habitat, degrade water quality by draining wetlands and increasing rainwater runoff, pollute the air and emit greenhouse gases through increased automobile travel, and often displace agriculture from prime farmland to locations where food production requires more energy and chemical inputs. In addition to these direct environmental effects, leapfrog development (a land-use pattern in which new development does not connect coherently to existing development, often leaving haphazard tracts of undeveloped land) can also harm the environment indirectly by promoting additional development in previously undeveloped areas.

Increased automobile travel is one of the most damaging consequences of sprawl. People living and working in outlying areas tend to drive greater distances, spend more time driving, own more cars, face a greater risk of traffic fatalities, and walk less. Vehicle emissions contribute to climate change, smog, and particulate pollution, which all are harmful to human health and natural ecosystems. In addition, the parking and roadway surfaces required to support vehicular travel consume land and nonrenewable resources, disrupt natural rainwater flow, and enlarge urban heat islands.

Choosing a smart location can make a substantial difference. Transportation surveys conducted by many metropolitan planning organizations across the country show that residents of close-in locations may drive only a third to half as much, on average, as residents of the most far-flung locations in a metro region.

To reduce the effects of sprawl and create more livable communities, preference should be given to locations close to existing town and city centers, sites with good transit access, infill sites, previously developed sites, and sites adjacent to existing development. Selecting these sites avoids development of outlying greenfield sites. In addition, these sites often have utilities, roads, and other infrastructure in place, reducing the need to build new infrastructure and minimizing the expansion of impervious surfaces that increase harmful rainwater runoff. In the locations that perform better environmentally, the benefits can often be multiple and reinforcing: convenient transportation choices, such as buses, light rail, heavy trains, car and van pools, bicycle lanes, and sidewalks, are generally more available near downtowns, neighborhood centers, and town centers, which are also the locations associated with shorter automobile trips. Research has shown that living in a mixed-use environment within walking distance of shops and services encourages walking and bicycling, which improve cardiovascular and respiratory health and reduce the risk of hypertension and obesity.

An additional benefit of locations that require less driving is that households may be able to own fewer automobiles and cut transportation expenses. For commercial development, fewer automobiles may mean less investment in parking infrastructure, which can reduce the amount of land needed for a project and lower construction costs. Abundant transportation choices can increase the value and marketability of a neighborhood development as well. More than 14.6 million households are expected to prefer housing within a half-mile of rail transit stops by 2025—more than double the number of households living in such locations today.[1]

Beyond the environmental damage caused by increased automobile dependence, fragmentation and loss of habitat to sprawl are major threats to many imperiled species. Selection of sites that are within or adjacent to existing development can minimize habitat fragmentation and also help preserve areas for recreation. Wetlands and floodplains tend to be biologically rich, and their conversion presents particularly serious environmental challenges: in addition to altering wildlife habitat, it can reduce water quality and increase the likelihood of flooding and associated consequences, such as erosion and loss of property. Left alone, these natural areas retain rainwater and floodwater for slow release into river systems and aquifers, and they protect lakes and streams by trapping sediment.

Another important concern is development intrusion onto prime agricultural lands, which typically require less fertilization and irrigation and are therefore the most resource efficient and environmentally sound locations for farming. Leapfrog patterns of development not only take these lands out of agricultural production but can also fragment farming communities and consequently reduce the economic viability of the local agricultural economy.

Many potential building sites in urban locations have been abandoned because of real or potential contamination from previous industrial or municipal activities. Remediation and reclamation of contaminated brownfield sites make them safer for the community and can also contribute to social and economic revitalization of depressed or disadvantaged neighborhoods. Development of these sites spares greenfields and makes use of existing infrastructure.

Finally, smart location choice also offers opportunities to repair the fabric of communities that are disjointed and sprawling. Suburban locations typically contain excellent redevelopment opportunities on grayfield sites, such as old airports, abandoned or underutilized shopping malls, and closed factories.

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[1] *Center for Transit-Oriented Development, Hidden in Plain Sight: Capturing the Demand for Housing Near Transit* (2004).

Neighborhood Pattern and Design (NPD)

OVERVIEW

Neighborhood Pattern and Design emphasizes the creation of compact, walkable, mixed-use neighborhoods with good connections to nearby communities. These vibrant neighborhoods provide many important benefits to residents, employees, and visitors and to the environment.

In particular, because compact neighborhoods use land and infrastructure efficiently, they avoid fragmentation of wildlife habitat and farmland loss, conserve economic resources, and slow the spread of low-density development across a region's landscape. Residents enjoy convenient access to shops, services, and public spaces within walking and bicycling distance, and when people choose to drive, they take shorter automobile trips, saving time and avoiding emissions. Compact development also facilitates access to public transportation because transit becomes more economically viable when supported by higher concentrations of population.

In addition, the small block sizes associated with compact neighborhoods encourage walking and bicycling because of increased connectivity, shorter travel distances, slower automobile traffic, and a more inviting pedestrian environment. The slower traffic speeds typically found in dense developments also can reduce injury rates. The environmental and public health benefits that accompany increased transportation choices and reduced rates of driving are further discussed in the introduction to Smart Location and Linkage.

Features such as sidewalks and trails, street trees, inviting building façades, small setbacks, minimal parking lot area, and measures to slow automobiles also increase pedestrian activity. Public spaces, such as parks, plazas, and playing fields, can encourage social interaction and active recreation while helping control rainwater runoff and reducing urban heat island effects. Community gardens also promote social interaction and physical activity while increasing access to fresh, locally grown produce.

Communities with diverse housing types that accommodate a range of incomes, ages, and physical abilities permit residents to live closer to their workplaces, help the community retain residents, and allow families to remain in the neighborhood as their circumstances change over time.

A community's involvement in project design and planning can help the project complement adjacent neighborhoods, meet the needs of residents and workers, and nurture a cooperative relationship with the project's neighbors.

Green Infrastructure and Buildings (GIB)

OVERVIEW

Green Infrastructure and Buildings focuses on measures that can reduce the environmental consequences of the construction and operation of buildings and neighborhood infrastructure. In the U.S., buildings account for large shares of energy consumption and water use. Globally, construction consumes a major part of the stone, gravel, sand, and virgin wood used in the world. Sustainable building technologies reduce waste and use energy, water, and materials more efficiently than conventional building practices.

Including certified green buildings in projects is one way to reduce negative environmental effects. These buildings achieve substantially better performance across a range of environmental measures, and in many cases the cost per square foot can be comparable to that of conventional buildings.

Energy efficiency is an essential strategy for reducing pollution and greenhouse gas emissions, which are possibly the most negative environmental consequences of building and infrastructure operation. Production of electricity from fossil fuels is responsible for air pollution, water pollution, and more than one-third of U.S. greenhouse gas emissions; hydroelectric generation plants can degrade river habitats; and nuclear power presents waste disposal problems and safety concerns. Building systems—electrical, lighting, heating, ventilation, air-conditioning, and others—can be designed to significantly reduce energy consumption compared with conventional designs and practices. The same gains are possible with neighborhood-scale infrastructure components like street lights, traffic signals, and water and wastewater pumps.

District heating and cooling systems are an example of neighborhood-scale infrastructure that can improve energy efficiency because large plants are typically more efficient than building-based equipment. District systems can also take advantage of waste heat from on-site energy generation, improving efficiency.

On-site power generation is another energy management strategy for either individual buildings or neighborhood-scale installations. These systems reduce transmission losses, and they may increase power reliability and decrease energy costs by supplementing or replacing utility-supplied electricity. Use of renewable energy in on-site generation further reduces environmental harms.

Solar orientation can also reduce energy consumption in buildings through passive or active systems. And applications like photovoltaic systems can be scaled up to neighborhood levels.

The environmental consequences of building construction can be lessened through the reuse of existing buildings. Reuse avoids the environmental effects associated with the extraction, manufacture, and transportation of raw materials, and it reduces the volume of construction and demolition waste, lowering disposal costs and extending landfill life. Reuse of existing components and infrastructure systems can also reduce the cost of construction.

Using materials with recycled content conserves raw materials and supports recycling of construction wastes so that they can be diverted from landfills. Many commonly used products are now available with recycled content, including metals, concrete, masonry, acoustic tile, carpet, ceramic tile, and insulation. Most recycled-content products exhibit performance similar to products containing only virgin materials and can be easily incorporated into building projects at little or no additional cost.

Conventional building practices typically alter watershed hydrology and impair local water resources and ecosystems. Changes to hydrology may deplete aquifers, reduce stream base flow, and cause thermal stress, flooding, and stream channel erosion. New developments can be designed to minimize changes to natural hydrology and stream health by reducing the velocity, volume, temperature, and pollutant content of rainwater runoff.

Urban heat islands are another consequence of standard development patterns and practices. The use of dark, nonreflective materials for parking, roofs, walkways, and other surfaces raises ambient temperatures when radiation from the sun is absorbed and transferred through convection and conduction back to surrounding areas. As a result, ambient temperatures in urban areas can be artificially elevated by more than 10°F (5.5°C) compared with surrounding undeveloped areas. This increases cooling loads in summer, requiring larger HVAC equipment and consuming additional electricity, which in turn exacerbates air pollution and contributes to the formation of smog. Heat islands are also detrimental to wildlife habitat: plants and animals are sensitive to high temperatures and may not thrive when temperatures increase.

Water use can also be reduced through improved design and technologies that conserve water and ease demands on water supply. Indoors, potable water consumption can be reduced by using low-flow plumbing fixtures and waterless urinals. Outdoor water use, primarily for landscape maintenance, accounts for a large share of U.S. water consumption and can be reduced through careful plant selection and landscape design. Wastewater can also be reused for landscape maintenance.

Water conservation protects the natural water cycle and saves water resources for future generations by reducing amounts withdrawn from rivers, streams, underground aquifers, and other water bodies. Another benefit of water conservation is reduced energy and chemical use at wastewater treatment facilities. In addition to conserving precious potable water, wastewater reuse reduces the amount of wastewater released into environmentally stressed streams and rivers and lessen demands on overburdened wastewater treatment systems.

Site design provides another opportunity to reduce the environmental consequences of development. Site plans should preserve the existing tree canopy and native vegetation to the extent possible while accommodating compact development. Preserving existing vegetation can reduce rainwater runoff, mitigate the urban heat island effect, reduce the energy needed for heating and cooling, and reduce landscaping installation and maintenance costs. Trees also reduce air pollution, provide wildlife habitat, and make outdoor areas more pleasant for walking and recreation.

The construction process itself is often damaging to site ecology, indigenous plants, and animal populations. This problem can be minimized by confining construction activities to certain areas on the site and restricting the development footprint. Protection of open space and sensitive areas through the use of strict boundaries reduces damage to the site ecology and preserves trees, native vegetation, and wildlife habitat. Construction can also cause soil erosion by wind and water, and soil that leaves the site can cause water and air pollution. Loss of topsoil may increase rainwater runoff, which pollutes nearby water bodies, and may necessitate use of more irrigation, fertilizer, and pesticides. These problems can be prevented by implementing an erosion and sedimentation control plan.

Innovation (IN)

OVERVIEW

Sustainable design strategies and measures are constantly evolving and improving. The purpose of this LEED category is to recognize projects for innovative planning practices and sustainable building features.

Occasionally, a strategy results in a project's 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.

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.

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.

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:

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- 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) $13 \leq V < 28$ 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 $\leq V$	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/m^2	33%	8.35 kW/m^2
Hot food holding cabinets (excluding drawer warmers and heated display) 0 < V < 0.368 m^3 (V = volume)	Elec	Cooking	na	1.4 kW/m^3	na	(21.5*V)/0.0283 kW/m^3
Hot food holding cabinets (excluding drawer warmers and heated display) 0.368 ≤ V < 0.793 m^3	Elec	Cooking	na	1.4 kW/m^3	na	(2.0*V + 254)/0.0283 kW/m^3
Hot food holding cabinets (excluding drawer warmers and heated display) 0.793 m^3 ≤ V	Elec	Cooking	na	1.4 kW/m^3	na	(3.8*V + 203.5)/0.0283 kW/m^3
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, $1.42 \leq V\ m^3$	Elec	Refrig	26.50V + 4.1 kWh/day	na	≤ 15.90V + 3.50 kWh/day	na
Glass-door reach-in refrigerator, $0 < V < 0.42\ m^3$	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 4.169V + 1.382 kWh/day	na
Glass-door reach-in refrigerator, $0.42 \leq V < 0.85\ m^3$	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 4.947V + 1.050 kWh/day	na
Glass-door reach-in refrigerator, $0.85 \leq V < 1.42\ m^3$	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 3.109V + 2.625 kWh/day	na
Glass-door reach-in refrigerator, $1.42 \leq V\ m^3$	Elec	Refrig	4.24V + 3.34 kWh/day	na	≤ 3.887V + 1.500 kWh/day	na
Solid-door reach-in freezer, $0 < V < 0.42\ m^3$	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 8.834V + 1.25 kWh/day	na
Solid-door reach-in freezer, $0.42 < V < 0.85\ m^3$	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 4.819V – 1.000 kWh/day	na
Solid-door reach-in freezer, $0.85 \leq V < 1.42\ m^3$	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 5.760V + 6.125 kWh/day	na
Solid-door reach-in freezer, $1.42 \leq V\ m^3$	Elec	Refrig	14.13V + 1.38 kWh/day	na	≤ 5.583V + 6.333 kWh/day	na
Solid-door reach-in refrigerator, $0 < V < 0.42\ m^3$	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 3.145V + 1.411 kWh/day	na
Solid-door reach-in refrigerator, $0.42 \leq V < 0.85\ m^3$	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 1.307V + 2.200 kWh/day	na
Solid-door reach-in refrigerator, $0.85 \leq V < 1.42\ m^3$	Elec	Refrig	3.53V + 2.04 kWh/day	na	≤ 1.979V + 1.635 kWh/day	na
Solid-door reach-in refrigerator, $1.42 \leq V\ m^3$	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

APPENDIX 4. BUILDING ENERGY PERFORMANCE GUIDELINES

INTRODUCTION

This appendix guides teams through the details of meeting GIB Prerequisite Minimum Building Energy Performance and earning points under GIB Credit Optimize Building Energy Performance.

The first section below, for teams using Option 1, Whole-Building Energy Simulation, explains how to create the baseline and proposed models, lists common errors in energy modeling, and discusses special cases, including building type variations and district energy systems.

The sections on Options 2 and 3, the prescriptive approaches, provide details on complying with the ASHRAE 50% Advanced Energy Design Guide and the Advanced Buildings Core Performance Guide.

ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata, is the basis for the LEED energy efficiency requirements; projects outside the U.S. may use a USGBC-approved equivalent standard. Read through Sections 5.4, 6.4, 7.4, 8.4, 9.4, and 10.4 to understand how the building design must address these requirements.

Typically, the architect is responsible for Section 5.4, Building Envelope; the mechanical engineer and plumbing designer are responsible for Sections 6.4, HVAC, and 7.4, Service Water Heating; and the electrical engineer is responsible for Sections 8.4, Power, and 9.4, Lighting. Compliance with Section 10.4 requires coordination across multiple disciplines.

Ensure that the project complies with the mandatory measures throughout the design, construction, and commissioning process, particularly when major design decisions are implemented. Confirm that compliant components are included in the final construction documents.

OPTION 1. WHOLE-BUILDING ENERGY SIMULATION

Before undertaking energy modeling (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 comes from using energy modeling as a tool in an integrated design process to inform the selection of cost-effective 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. Ask the project's energy modeler to provide a schedule that integrates energy modeling into the design process, with appropriate milestones.

The energy modeler should 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 *ASHRAE 90.1–2010 versus 90.1–2007*, below). The energy modeler should also consider reading the ASHRAE 90.1–2010 User's Manual, which expands on the Appendix G requirements.

STEP-BY-STEP GUIDANCE

Step 1. Identify energy modeler

Engage an energy modeler to perform the energy analysis.

- It is recommended that the qualifications of the energy modeler be carefully reviewed to ensure that the simulation will be performed accurately and according to the prerequisite requirements.

- Qualified energy modelers who have experience with numerous simulations for a variety of building types can help the design team interpret the results and develop an efficient building design (see *Energy Modeler's Qualifications*, below).

Step 2. Develop preliminary energy model or models
Buildings of the same type (new construction, major renovation, or core and shell) may be grouped into separate models. Analyze all buildings in a single model if the building type is consistent across the project, or if the team wishes to achieve the average improvement required by this prerequisite.

- Consider creating preliminary energy models to analyze building design strategies that may be applied to each group of buildings. The preliminary models use information from the design to roughly project energy usage in various scenarios (see *Developing a Preliminary Energy Model*, below).
- A preliminary energy model is not required; however, developing an early model of the proposed design will help the design team explore the energy consequences of design options and will provide an early estimate of overall energy performance for each group of buildings.
- An analysis of various efficiency measures, which may take the form of a preliminary model, is necessary for the achievement of the related credit.
- When evaluating energy usage in different scenarios, consider strategies for lighting and daylighting, envelope, orientation, and passive conditioning and ventilating systems in terms of projected energy savings and capital costs as they relate to all building systems.

Step 3. Model potential HVAC system types
After building design configuration and load reduction strategies have been assessed and implemented, use the energy model to analyze the performance of HVAC system alternatives (see *Modeling HVAC Systems*, below).

- For best HVAC system performance, ensure that the system is properly sized. More effective system types, such as radiant heating and cooling or displacement ventilation, may be feasible when loads are smaller, so begin the analysis by exploring ways to reduce the load.
- Analysis of HVAC systems in early design is optional for this prerequisite but is required for achievement of the related credit.

Step 4. Develop energy model for proposed design
Once the HVAC system and other design parameters are established, build or update the proposed building energy model to reflect the anticipated design (see *Building the Proposed Energy Model*, below).

- Update the proposed model to reflect changes that occur throughout the design process to optimize energy performance and assist with design decisions.
- Ensure that all efficiency strategies are analyzed well before design documents are finalized.

Step 5. Create baseline energy model
Build a baseline model that reflects the minimum requirements in ASHRAE 90.1–2010, Appendix G (see *Building the Baseline Energy Model*, below).

- When modifications are made to the proposed energy model, update the baseline accordingly.
- Consider constructing the baseline model early in the design process so that the design team can see the effect of design changes on the percentage savings relative to ASHRAE 90.1.
- Use the energy modeling inputs and quality control checklists spreadsheet (Appendix G) to help create the baseline model. This tool was designed to help project teams create a baseline model that aligns with Appendix G requirements.

Step 6. Update baseline and proposed models based on final design
Update the proposed energy model to reflect final construction details and specifications and make any necessary corresponding updates to the baseline model (see *Finalizing the Energy Models*, below).

- For elements or systems that cannot be readily modeled, use the exceptional calculation method or COMNET modeling guidelines for unregulated loads (see *Modeling with the Exceptional Calculation Method* and *Common Issues with Energy Modeling*, below).

ASHRAE 90.1–2010 VS. 90.1–2007

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 Table 1 and 2.

TABLE 1. Comparison of ASHRAE 90.1 mandatory requirements, 2007 and 2010

Building envelope requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Air barriers 5.4.3.1.2	NA	Continuous on entire building envelope

HVAC requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Garage fans 6.4.3.4.5	NA	Auto-adjust fan speed with contaminant levels to 50% or less of capacity
Chiller efficiencies 6.4.1.1	NA	Increased for all chiller types
Single-zone VAV 6.4.3.10	NA	Required to have VFD or two-speed motors for DX >9.2 tons (32.3 kW), and chilled water AHUs >5 hp (3.7 kW) fan motors
Water and evaporatively cooled unitary AC units and heat pump efficiency Table 6.8.1A and B	NA	3–5% more stringent
PTAC and PTHP efficiency increased 6.4.1.1; Table 6.8.1D	12 EER (3.52 COP)	13.8 EER (4.05 COP)
Water to water heat pump, CRAC, and VRF Table 6.8.1B; Table 6.8.1K; Table 6.8.1J respectively	Not covered	Now covered by 90.1

Power requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Automatic receptacle control 8.4.2	NA	At least 50% of all receptacles installed in private offices, open offices, and computer classrooms must be controlled by automatic control device

Lighting requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Threshold for retrofit compliance 9.1.2	Alterations that involve less than 50% of connected lighting load in space or area need not comply with lighting power density or auto-shutoff requirements, provided that such alterations do not increase installed LPD	Less than 10% of connected load
Lighting power density 9.4.5; 9.4.6	NA	Reduced; average 17% in space types, more for retail display lighting
Automatic shutoff 9.4.1.1	Required in buildings >5,000 ft^2 (465 m^2)	Required in all spaces
Additional control 9.4.1	All spaces to have general lighting controls, manual or automatic	All spaces are required to have vacancy sensors or occupancy sensors to 50% or less of lighting power
Space controls 9.4.1.2	Classrooms, conference rooms, and break rooms must have occupancy sensor or time switch that turns light off within 30 minutes	More space types added, including offices, restrooms, dressing rooms, and training, copy, and storage rooms
Light level reduction 9.4.1.2	None	Spaces must have controls that reduce power level by 30–70% of connected load in addition to off mode.
Lighting in daylit zones 9.4.1.4	None	Automatic, multilevel daylighting controls installed in sidelit areas >250 ft^2 (23 m^2) and toplit areas >900 ft^2 (84 m^2)
Parking garage lighting 9.4.1.3	None	Auto-shutoff, power must be reduced by 30% when no motion for 30 minutes, auto-daylight control on perimeter
Exterior lighting 9.4.1.7	Lighting must be controlled by photosensor or time switch	At night light must either be off or operated at reduced level
Functional testing 9.4.4	None	All installed controls must be tested

TABLE 2. Comparison of ASHRAE 90.1 prescriptive requirements, 2007 and 2010

Requirement	ASHRAE 90.1–2007	ASHRAE 90.1–2010
Economizer exemptions Table 6.3.2	Only for unitary equipment, EER/SEER (COP/SCOP) rating	For all HVAC system types, must meet % efficiency improvement, now required in most climate zones
Lighting power density 9.2.1	NA	Reduced, average 17% in space types, more for retail display lighting

ENERGY MODELER'S QUALIFICATIONS

The energy modeler should have the following competences:

- Comprehensive understanding of all the building systems related to energy performance and the information needed to construct a model using the selected software
- Ability to understand and explain capabilities and limitations of modeling software for the strategies the team would like to pursue
- Awareness of how much time the design team needs to provide information, feedback, and responses to the modeling exercise
- Experience with design phase modeling
- Ability to demonstrate how energy modeling can be used to perform cost-benefit analysis
- Experience in modeling projects using ASHRAE 90.1, Appendix G, or a thorough understanding of this approach
- Ability to perform quality control to ensure that the modeling inputs accurately reflect the proposed design and Appendix G baseline
- Ability to evaluate the simulation results for reasonableness in relation to the energy modeling inputs, including energy consumption by end use, cost, and the performance savings claimed
- Ability to validate the model through review of actual utility bills during occupancy

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 ASHRAE Advanced Energy Design Guides, may also be used to inform decision making, though the results will be less project specific. A preliminary model includes design elements identified during schematic design and design development and generates a preliminary estimate of energy consumption and an end-use profile.

Evaluate how changes to the following elements affect HVAC sizing, energy consumption, lighting, renewable energy opportunities, and other aspects of energy performance:

- Program and operations (multifunction spaces, operating schedules, space allotment per person, teleworking, reduction of building area, operations and maintenance)
- Site conditions (shading, exterior lighting, hardscape, landscaping, adjacent site conditions)
- Massing and orientation
- Envelope (insulation values, window-to-wall ratios, glazing characteristics, shading, and window operability)
- Lighting levels and interior surface reflectance
- Thermal comfort range options
- Passive conditioning and natural ventilation strategies

When examining alternative strategies, also consider the effect on human performance and comfort. For example, increasing daylighting may cause glare.

Typical steps in preliminary energy modeling are as follows:

1. Gather information about building loads and systems. Investigate case studies of similar buildings in similar climates and contact local utilities for energy rates and demand charges. Determine applicable building energy codes, including any local variations. For existing buildings, review drawings, specifications, operations and maintenance manuals, commissioning reports, energy audit reports, and utility bills. The AEDGs provide useful information regarding design practices specific to some building types and climate zones.

2. Engage the design team early to investigate opportunities for load reduction. Coordinate with the architect to identify options for envelope insulation values, building orientation, and shading—variables that can affect load, especially on external load–dominated buildings. Some strategies, such as building massing and orientation, are most effectively evaluated during the concept phase of design, before the preliminary energy model, and are not required for this prerequisite.
3. Analyze several design alternatives to investigate the combined load reduction potential of multiple strategies. How strategies alter energy consumption varies by building type and climate zone. Examine energy consumption by end use and heating and cooling load distribution to identify effective load reduction and energy efficiency opportunities.
4. Investigate interconnected strategies. The additional costs of high-performance envelope elements may be offset by smaller, less costly HVAC systems. For example, energy modeling could evaluate the effect of a fenestration and shading configuration, with daylight harvesting controls, on cooling, heating and fan loads, HVAC system capacities, and total building energy consumption and cost. A life-cycle cost analysis for this scenario would indicate the net increase or decrease in capital costs and the potential savings over time. When evaluating the capital cost, consider trade-offs between the higher capital cost for the shading and daylight harvesting controls and the lower capital cost for a smaller HVAC system.
5. Use the model to compare potential performance with the project's energy goals.

MODELING HVAC SYSTEMS

Although not required for the energy performance prerequisite, an evaluation of HVAC system alternatives can help the design team optimize energy consumption. This exercise is a requirement for achievement of points under the related credit.

The modeler should analyze the performance of several efficient HVAC systems to understand the potential energy savings associated with each one. This information enables the design team to compare life-cycle costs, rather than just first costs. The life-cycle cost analysis should follow the analysis of load reductions, which may affect the life-cycle cost.

The chosen HVAC system can then be further optimized through additional energy modeling that analyzes the potential efficiency gains of the system components and/or assigns different systems to different zones.
Typical steps for HVAC system type modeling include the following:

- 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 cost of more efficient equipment. Evaluate the potential for reducing the first cost of HVAC equipment by reducing the loads. Include not only the smaller equipment but also the infrastructure related to HVAC—ductwork, piping, controls, and in some cases, building volume or floor area for these components.
- For the selected system, analyze and optimize additional HVAC energy efficiency measures, including equipment efficiency, energy recovery, economizers, and demand-controlled ventilation.
- Coordinate with the architect and structural engineer, since different system types may influence space, height, or structural requirements. For example, under-floor air-conditioning may influence the exterior envelope design and could increase or decrease the height of the building.

BUILDING THE PROPOSED ENERGY MODEL

An energy model of the proposed design is required for prerequisite compliance under Option 1. A team that has already prepared a preliminary model may update it throughout the project.

Create or update proposed building characteristics based on the latest design and specifications for systems, assemblies, and equipment. The initial model can be created as early as design development to estimate projected savings, then be updated when the construction documents are complete. 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 the baseline energy model is a detailed process that requires a good working knowledge of ASHRAE 90.1–2010, Appendix G, and the associated sections of the standard. The baseline model represents a typical design for a building of the same size and use as the proposed building. This hypothetical building meets but does not exceed the performance requirements of ASHRAE 90.1–2010 and is used as a comparison to calculate the percentage energy cost savings for the project design.

In general, baseline development begins by changing the inputs for all the components, assemblies, and systems of the proposed design to minimally compliant input values, in accordance with Appendix G. Determine or update baseline values for each system, assembly, and piece of equipment for the project's 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 *Common Issues with Energy Modeling*, below).

Preparation of the initial baseline model is best undertaken 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 building design.

FINALIZING THE ENERGY MODELS

Update the proposed model based on the information and specifications for systems, assemblies, and equipment in the final construction documents. Confirm that all efficiency measures claimed have been incorporated into the design. Include all energy consumption and costs associated with the building.

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 *Modeling Schedules*, below).

Perform a quality control check to verify that all Appendix G and LEED modeling guidelines have been followed. Record both the proposed and baseline values in the Appendix G energy modeling inputs and quality control checklists spreadsheet. This record of energy conservation measures is a good tool for confirming that proposed building characteristics and baseline values have been selected properly.

Document the input assumptions for receptacle and process loads. These loads should be modeled accurately to reflect the actual expected energy consumption of the building. Per ASHRAE 90.1–2010, Table G3.1-12, receptacle and process loads must be modeled identically in both the baseline and the proposed 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 *Modeling with the Exceptional Calculation Method*, below).

Verify the energy modeling results. Evaluate the energy savings by end use for reasonableness based on the differences in the modeling inputs between the baseline and proposed models. Use Figure 1 to perform a step-by-step verification.

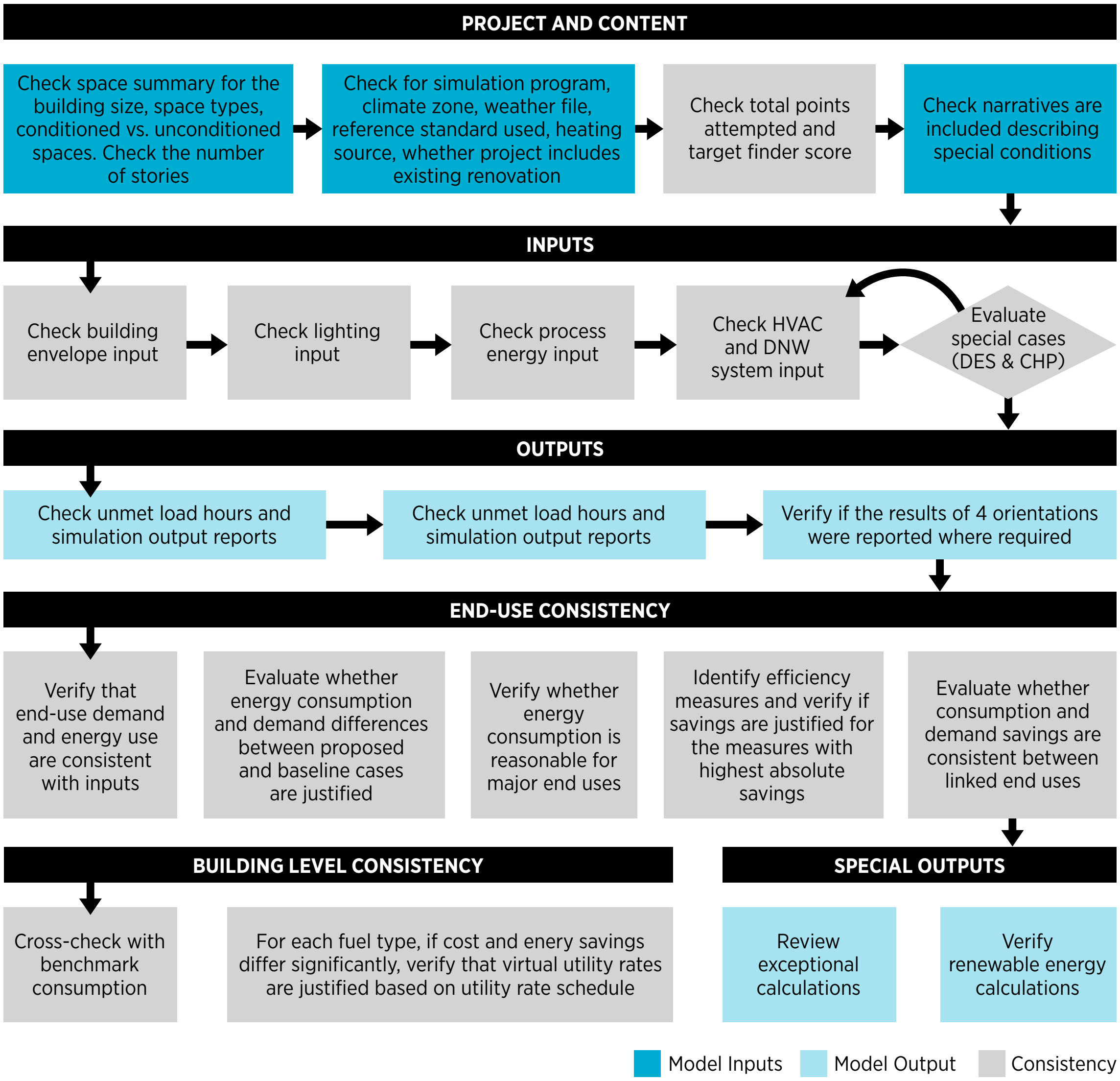

Figure 1. Steps to verify proposed energy savings

MODELING WITH THE 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 representing an element that cannot be modeled directly by the chosen energy modeling software. Examples include innovative external shading devices, under-floor air systems, and the heat recovery performance of a variable refrigerant flow system. Whether a particular strategy warrants 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 explaining the simulation and provide any calculations for the energy savings.

Documentation for nonregulated loads. Examples of nonregulated load savings include manufacturing equipment not regulated by ASHRAE 90.1–2010, a unique manufacturing process, or any refrigeration or kitchen equipment (including operation) not specifically covered in *Appendix 3, Retail Process Load Baselines, Tables 1–4*. Energy savings for nonregulated loads require additional documentation. ASHRAE 90.1–2010, Table G3.1-12, indicates that "variations of the power requirements, schedules, or control sequences" are allowed by the "rating authority," provided the proposed design "represents a significant verifiable departure from documented conventional practice." Project teams must document the following information to prove that the savings represent a departure from conventional practice and are not required by local code:

- A narrative describing all baseline and proposed assumptions
- The methodology used to calculate 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, or 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 utility company or government program that provides incentives for the measure in new construction
    - A document showing the systems used to perform the same function in similar facilities built within the past five years; these systems are treated as the baseline system in the analysis, and evidence must show how the energy use for the baseline and proposed buildings is determined

Alternatively, the project team may use any of the prescriptive requirements from ASHRAE 90.1–2010 as the baseline requirement without further justification to substantiate conventional practice, but only for the specific component.

Additional guidance. Sources of typical efficiency measures include the COMNET manual, which has a methodology for calculating savings for process or receptacle loads, especially savings from ENERGY STAR equipment. Refer to the manual's Section 6.4.5, Receptacle and Process Loads, and Appendix B.

Provide a narrative explanation of the methodology used to calculate savings for any exceptional calculation methods. Separate calculations are not necessary when the energy savings are apparent in the modeling results.

Changes from earlier versions of ASHRAE and LEED. Some efficiency measures that no longer need to be modeled using an exceptional calculation method include garage fan demand-controlled ventilation, low-flow water fixtures, kitchen equipment, and kitchen ventilation.

- **Enclosed parking garage ventilation.** Modulating fan airflow rates based on contaminant levels are now required to be installed, unless certain exceptions apply, per Section 6.4.3.4.5. Any design that goes beyond these minimum baseline requirements may be counted. Two factors can affect the energy consumption:
    - The baseline fan power (in energy per flow) must be consistent with the proposed installed fan power at full-load conditions. The project team may count higher fan motor efficiencies in the proposed building.
    - The ventilation rate, and thus fan power, can also be reduced if the design allows the fans to reduce the ventilation rate below 50%. The baseline ventilation rate must be set at the minimum requirement of ASHRAE 62.1–2010, which is 0.75 cfm per square foot (3.8 L/s per square meter). This must be the baseline ventilation rate, regardless of any local code.

The same requirements apply to demand-controlled ventilation for outdoor air control sequences that provide ventilation for building occupants.

- **Low-flow service water-heating fixtures.** The flow rates given in GIB Credit 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. See *Appendix 3, Retail Process Load Baselines, Tables 1–4*, for the defined 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's 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 cases 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.

COMMON ISSUES WITH ENERGY MODELING

Thoroughly review both ASHRAE 90.1–2010 and the 90.1–2010 User's Manual. The manual presents extended explanations and also includes examples of the concepts and requirements within the standard. Table 3 addresses many of the most common issues but is not a comprehensive list.

TABLE 3. Common issues with energy modeling, by ASHRAE 90.1 section

Scope	
Inclusion of unfinished spaces in project scope	Unfinished spaces must be included in the energy model if they are part of the project scope of work. In core and shell projects, a large portion of the space may be unfinished; in new construction and major renovation projects these spaces must not make up more than 40% of the total space. In addition, all projects other than core and shell that have incomplete spaces must submit a letter of commitment, signed by the owner, confirming that the remaining incomplete spaces will satisfy the requirements of each prerequisite and credit achieved by this project if and when completed by the owner.
Modeling HVAC, lighting, hot water systems for unfinished spaces	Refer to ASHRAE 90.1–2010, Tables G3.1.6(c), G3.1.10(c) and (d), and G3.1.11(c), for unfinished space modeling requirements. If a lighting, HVAC, or service hot water system has not yet been designed, the system required in the baseline building for that unfinished space must also be modeled in the proposed building. Refer to Table G3.1.8 on how to model thermal zones for such space. Example 1. A two-story office building has a ground-floor retail area that is entirely unfinished. The building contains a chase for future ductwork and a location on the roof for the mechanical equipment for the future tenant, but no system exists or has been specified. In this case, the proposed HVAC system for that space must be modeled using the same HVAC system type, capacity ratios, efficiencies, and controls as those modeled for the baseline building. Example 2. The same hypothetical two-story office building now includes chilled and hot water connections for the future unfinished retail space. A portion of the HVAC system has been designed. The proposed building may be modeled as a system that uses the chilled and heating hot water (e.g., 4-pipe fan coil unit). However, because the air-handling units and terminal distribution have not yet been designed, the cooling and heating capacities, design fan volume, minimum volume, fan power, fan controls, etc., must be modeled identically in both the baseline and proposed model, and equal to the requirements of the baseline model.
Additions to existing buildings	Project teams wishing to certify an addition to an existing building must follow the Appendix G requirements in Table G3.1.2, the most important of which is (b). If the existing building will be excluded, then the HVAC system serving the addition to the building must be entirely separate from the systems serving the existing building. Refer to the table for all requirements.
Building envelope	
Baseline building envelope	Construction type and maximum U-factors for baseline walls, roofs, and floors are specified by Table G3.1-5 Baseline (b). The constructions for walls, roofs, and floors are specified by the standard and do not depend on the proposed design. For example, if a building will have concrete masonry walls, the baseline model will still have steel-framed walls.
Existing building envelope	For an existing building that was conditioned before major renovation and will be conditioned postrenovation, the baseline building envelope should reflect the existing conditions, before the scope of work (Table G3.1-5 Baseline (f)). However, for an existing building (or spaces in the building) that was previously unconditioned and is being renovated to include conditioning, the baseline building envelope (or the envelope for any previously unconditioned spaces in the building) must be modeled as if the building is new construction (i.e., according to Table 5.5).
Proposed model U-values	The proposed model must reflect the building as designed or built. To the extent possible, construction assemblies need to match the dimension and U-value inputs in the model. Apply Appendix A to the proposed envelope. Provide the assembly U-value, rather than a point U-value, by determining the overall construction assembly U-value that takes into account for thermal bridging as shown in Appendix A. Ensure that window U-values are input as the assembly U-value, which takes into account the U-value of the framing system. The center-of-glass value is not acceptable.
Baseline model U-values, semi-exterior surfaces	For the baseline envelope properties, use the semiheated requirements to model surfaces that adjoin unconditioned spaces to conditioned spaces (e.g., a wall separating a semiheated warehouse from a conditioned office) or semiheated space to conditioned space (e.g., the slab separating an unconditioned parking garage from the conditioned ground floor of the building). Figure 5.1 in 90.1–2010 illustrates this requirement.

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section

HVAC	
Baseline HVAC system selection	The HVAC system for the baseline model must be selected based on requirements in ASHRAE 90.1–2010, Section G3.1.1. The system selected will depend on the proposed building type, size, and heat source. Building type must be based on predominant conditions (i.e., those that account for the majority or plurality of the building area), and no space types can be excluded from the model. Building size is determined from conditioned area. Once the floor area of the predominant condition is known, consult Table G3.1.1A to determine the predominant baseline HVAC system. Section G3.1.1 also specifies whether HVAC systems must be modeled with a system per floor or a system per thermal block. Systems 1–4 are modeled with one system per thermal block and systems 5–10 with one system per floor, using systems 9 and 10 where applicable. When multiple floors have identical thermal blocks, those floors may be combined in the energy model. Note that a floor with a roof and a floor without a roof do not have identical thermal blocks and cannot be combined. A multistory building with identical thermal blocks would need to be modeled with no fewer than three floors: a ground floor, a middle floor with appropriate multiplier, and a top floor. There are six exceptions to the baseline HVAC system determination. These exceptions are mandatory and must be taken if they are applicable to the project. G3.1.1 exception (a). Check for nonpredominant conditions, such as nonresidential in a primarily residential building, or where a portion of a building is supplied by electric heat but the rest is from fossil fuels. The area of nonpredominant conditions can be deducted from the total area when determining the baseline HVAC system. If nonpredominant conditions apply to more than 20,000 ft^2 (1860 m^2), use exception (a) and select an additional baseline HVAC system type to serve those spaces. Example. A 210,000 ft^2 (19 510 m^2) multifamily high-rise has 23,000 ft^2 (2140 m^2) of ground-floor retail space. The residential units are served by heat pump units with supplemental electric heat, and the retail areas are served by a split DX unit with fossil fuel furnace. The required baseline HVAC system for the residential spaces would be System 2–PTHP, but for the retail areas it would be System 3–Packaged DX with fossil fuel furnace, since the nonresidential spaces meet the 20,000 ft^2 (1860 m^2) exception (a) in G3.1.1. G3.1.1 exception (b). If using systems 5, 6, 7, 8, 9 or 10, individual zones with atypical thermal loads or occupancy profiles must be modeled with individual single-zone systems of type 3 or 4, according to exception (b). Examples for this include computer server rooms, natatoriums, and school gymnasiums. If this exception is not properly incorporated into the baseline model, the model results may show an unusually high number of unmet load hours or significantly oversize the baseline case systems. A good practice is to check the baseline output reports and verify that the thermal loads for each thermal block do not vary by more than 10 Btuh/ft^2 (31.5 W/m^2) from the average of the other thermal zones on the floor, and adjust the baseline model as necessary to include this exception.
Baseline HVAC system selection (laboratory spaces)	G3.1.1 exception (c). If laboratory spaces in the building have a total laboratory exhaust rate greater than 5,000 cfm (2360 L/s), a single system of type 5 or 7 must be modeled to serve only those spaces. Section G3.1.2.11 requires exhaust air energy recovery in accordance with Section 6.5.6.1, which is likely to include laboratories.
Baseline HVAC system selection (kitchens)	G3.1.1 exception (d). If kitchens in the building have a total exhaust hood airflow rate greater than 5,000 cfm (2360 L/s), system type 5 or 7 must be modeled and must include demand-controlled ventilation.
Baseline HVAC system selection: heated-only storage or circulation spaces	G3.1.1 exception (e). Heating-only systems serving rooms not exhausting or transferring air from mechanically cooled spaces, such as storage rooms, stairwells, or mechanical rooms, should be modeled as system 9 or 10. G3.1.1 exception (f). When the predominant system is type 9 or 10, any fully conditioned spaces (such as an small, fully conditioned office in a heated-only warehouse) should be modeled using the appropriate system type for the size, number of floors, occupancy type, and heating type for the nonpredominant area of the building.
Baseline HVAC system fuel type	Any project with a combination of fossil fuel and electric heat serving the same space must use the fossil fuel baseline HVAC system (systems 1, 3, 5, and 7) unless it meets one of the exceptions to G3.1.1. Example. A building has been designed with electric water-source heat pumps for the space loads. A 100% outdoor air gas-fired rooftop unit provides ventilation. The spaces are served by both electric heating from the heat pumps and ventilation air from the gas-fired unit; therefore, the spaces are considered hybrid heating and must model the baseline HVAC system type as “Fossil Fuel, Fossil/Electric Hybrid, and Purchased Heat” (from Table G3.1.1a). In the case of electric heating equipment designed with a fossil fuel preheat coil, or a backup fossil fuel boiler, the intent is that the equipment will be used; thus it is considered hybrid heating, and the team must use the fossil fuel baseline heating system.

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section

HVAC (Continued)	
Baseline fan power	The baseline fan power is calculated according to Section G3.1.2.10, which indicates that the system fan power is based on the supply airflow and distributed to supply, return, exhaust, and relief fans. If the proposed system has additional return, exhaust, and/or relief fans, the team may not adjust the baseline model to account for the additional fan power. Section G3.1.2.10 also includes Table G3.1.2.9, whose value A is calculated according to Section 6.5.3.1.1 using pressure drop adjustments. Pressure drop adjustments may not be taken for system types 1, 2, 9, or 10. The calculations are straightforward, but a common issue involves pressure credits. Table G3.1.2.9 allows pressure drop adjustments for evaporative coolers or heat recovery devices only when they are required in the baseline building system. Also, the pressure drop adjustment is applicable only to the design airflow through each device. For example, if only the ventilation air is filtered with a MERV 13 filter, then only the ventilation airflow rate may apply the 0.9 in. w.c. (224.2 Pa) adjustment, not the entire supply airflow rate. Pressure credit may be taken only for those systems present in the proposed building. For fully ducted return or exhaust air systems, the credit for fan power allowance cannot be based on plenum return. The credit can be applied only when the return is fully ducted; systems that have a combination of ducted and nonducted may not use this pressure credit. For return or exhaust airflow control devices (which maintain a specific pressurization relative to other spaces), a project team claiming this credit in spaces other than a laboratory, hospital, or similar space type must provide evidence of this control device. The credit may be applied only for the amount of airflow passing through the control device. A project team using the modeling software to automatically determine the baseline building fan power must ensure that the correct allowance has been calculated. Publicly available fan power calculators can be used to verify and determine the correct fan power.
Proposed HVAC system sizing	Table G3.1.1(a) requires that the proposed building be consistent with the design documents, including envelope, lighting, HVAC, and service hot water systems. Additionally, all end-use load components within and associated with the building must be modeled. Table G3.1.10(b) requires that the HVAC model be consistent with the design documents. All modeled HVAC system parameters (e.g., fan volumes, fan powers, efficiencies, heating and cooling capacities) must be consistent with the mechanical schedules and drawings. The simulation should never be allowed to automatically size the HVAC system for the proposed case model when there is a complete design.
Heat pumps (operation)	Section G3.1.3.1 describes the operation of baseline building heat pumps. The heat pump and auxiliary heat should operate together at low-temperature conditions, with the compressor as the lead machine. The outside air cutoff temperature for the compressor must be no greater than the temperature associated with the low-temperature heating efficiency requirements of Table 6.8.1B (17°F) (–8.3°C). The HSPF rating for packaged heat pump units smaller than 65,000 Btu/h (19 kW) and packaged terminal heat pumps accounts for electric auxiliary operation and includes test conditions at 17 degrees F (–8.3°C). The heat pump efficiency curves in the model should reflect the heat pump ratings that account for simultaneous operation of the electric resistance and heat pump elements below 40°F (4.4°C).
Unitary heating and cooling efficiencies	Use the correct Table 6.8.1 to determine equipment efficiencies: Table 6.8.1A for system types 3, 5 and 6 Table 6.8.1B (with electric resistance heating section) for system Type 4 Table 6.8.1D for system types 1 and 2 These efficiencies are based on the capacity of each system individually, not a sum of all units. It is important to correctly adjust efficiencies of each piece of equipment to separate fan power at AHRI rating conditions, per Section G3.1.2.1. Most simulation software programs can perform this step automatically.
Humidity controls	Humidification must be modeled identically in the baseline and the proposed models, since it is not addressed in Appendix G. Use the exceptional calculation method if claiming savings. If the proposed design includes dehumidification controls, they must be modeled as designed. Dehumidification controls may be modeled in the baseline only if one of the exceptions to Section 6.5.2.3 applies. Exception (d) for process dehumidification does not apply to computer rooms. Table G3.1.4 requires that identical schedules be used in both models, and this includes humidity setpoints. A problem may arise if the proposed building has a dedicated outdoor air system (DOAS) that maintains proper humidity. PTAC or small DX systems in the baseline design may not be able to maintain both temperature and humidity simultaneously in the same way that the proposed system can. The project team may then incur a penalty for higher humidity levels in the baseline building. In this situation, model a DOAS in the baseline design using the same volume of outdoor air as for the proposed design, but with the same efficiency and efficiency curves as the baseline HVAC systems. Additionally, the baseline fan power allowance would be separated between the DOAS and the baseline system using the same ratio as the proposed system.

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section

Ventilation	
Ventilation rate inputs	Table G3.1.10(b) requires that the proposed building ventilation rate be consistent with the rate indicated on the mechanical schedule. Section G3.1.2.6 requires that the ventilation rate be identical between the proposed and baseline buildings and states that reduced ventilation "is not considered an opportunity for energy savings under the Performance Rating Method"; ventilation is energy neutral, per the User's Manual. However, there are exceptions to this requirement.
Ventilation (above minimum required)	Exception (c) penalizes projects for providing more ventilation air to the space than is required by ASHRAE 62.1–2010 or a local code, whichever requires more ventilation air. If the proposed project provides outdoor air in excess of the amount required, the baseline must be modeled with the required ventilation rates, which will be lower than the proposed ventilation rate. This creates an "energy penalty" for the additional fan and conditioning energy. For various reasons, however, it is common practice to specify slightly more ventilation air than required. A project team that has specified up to 5% more total ventilation air than required may model identical ventilation rates. If exhaust requirements dictate the amount of ventilation air that must be provided to the building, as indicated in Section 5.9.2 of ASHRAE 62.1–2010, provide an explanation, documentation, and calculations as necessary to show that exhaust requirements exceed the minimum ventilation flows, and model the ventilation rate identically in both buildings.
Demand-control ventilation and nighttime ventilation requirements	Exception (a) allows credit for demand-control ventilation when it is not required by Sections 6.3.2(p) or 6.4.3.9. If demand-control ventilation is being modeled for credit, Table G3.1.4 (baseline) indicates that schedules may be modified and allowed to differ to take it into account, provided the schedules are approved by the rating authority. In this instance, project teams must submit both proposed and baseline ventilation schedules. ASHRAE 90.1, Section 6.4.3.4.3, requires shutoff dampers that automatically shut during unoccupied periods when the HVAC system cycles on and off to meet loads except when ventilation reduces energy costs (e.g., night purge), or when ventilation must be supplied to meet local requirements (such as minimum flow requirements for hospital or chemical storage rooms during unoccupied periods). Therefore, the demand-control ventilation schedules presented for both the baseline and proposed cases should show zero outside airflow during unoccupied periods unless the supplemental documentation supports that ventilation during unoccupied periods reduces energy cost or is required by local code, in which case the baseline and proposed ventilation rates during unoccupied periods must be modeled with identical flow rates. Additionally, the baseline ventilation flow must be modeling using minimum required rates.
Ventilation (zone air distribution effectiveness)	Exception (b) allows for lower ventilation rates in the proposed building for efficient ventilation system designs that have high zone air distribution effectiveness (E_z >1.0), as determined by ASHRAE 62.1–2010. In this case, the baseline ventilation levels can be based on the proposed calculations, only with reduced zone air distribution effectiveness (E_z = 1.0). This makes the baseline outdoor airflow rates higher than the proposed outdoor airflow rates, so ventilation calculations must be submitted to claim the exception for a higher E_z in the proposed case. If a lower ventilation flow rate is an aspect of the design, the project team must provide ventilation rate procedure calculations for both the proposed and baseline designs, with the proposed design using the actual E_z value and the baseline design using an E_z value of 1.0 in each zone where the E_z value is greater than 1.0, but equal to the proposed building for all other zones where the E_z value is not greater than 1.0. If ASHRAE 62.1, Section 6.2, Ventilation Rate Procedure, is not used for the ventilation design, then this exception may not be used. Credit may not be taken, via ventilation flows, for any other ventilation design, such as a 100% outdoor air unit. Additionally, credit may not be taken for increased system ventilation efficiency, E_v, of a proposed ventilation system compared with a baseline ventilation system; Appendix G does not allow this. The only exception would be a different E_v value due to an E_z greater than 1.0, as described above.
Natural ventilation	The ASHRAE User's Manual indicates that an exceptional calculation method is not required for natural ventilation and gives some further examples. Perform sufficient analysis to document that loads can be met when credit is taken for passive cooling and natural ventilation using a simulation tool capable of ensuring thermal conditions are met with natural ventilation. A simple load calculation is not sufficient.

TABLE 3 (CONTINUED). Common issues with energy modeling, by ASHRAE 90.1 section

Service water heating	
Hot water demand	Hot water demand savings from low-flow fixtures must be derived from WE Prerequisite or Credit Indoor Water Use Reduction calculations.
Lighting	
Lighting power density, method	Lighting power must be determined using the same categorization procedure (building area or space-by-space method) in both the proposed and baseline designs.
Lighting power density, multifamily	ASHRAE 90.1–2010 does not allow credit for lighting within dwelling units. Therefore, the lighting within these units must be modeled identically in both cases unless an exceptional calculation method is pursued. If credit is attempted, the lighting must meet prescribed illuminance levels. Refer to the ENERGY STAR's Multifamily High Rise Program Simulation Guidelines for examples.
Lighting power density, luminaire wattage	Table G3.1.6 requires that the proposed lighting power include all components shown on the plans and be determined in accordance with Sections 9.1.3 and 9.1.4. Ensure that the lighting calculations include all task lighting except where specifically exempted by ASHRAE 90.1 and that all power used by the luminaires, including lamps, ballasts, transformers, and controls, is taken into account. For track and other flexible lighting systems, use the specified wattage of the transformer supplying the system. The sum of lamp wattages will not necessarily meet the requirements of G3.1.6.
Lighting power density, additional lighting power	ASHRAE 90.1, Section 9.6.2, addresses the use of additional lighting power for decorative lighting, in retail areas, or when additional controls have been installed. Additional lighting is allowed only when using the space-by-space method and if it is "installed and automatically controlled, separately from the general lighting, to be turned off during nonbusiness hours." Therefore, the general lighting system must be separate and capable of providing general illumination to the space, and the additional lighting must have automated controls that shut it off during nonbusiness hours even when the general lighting remains on. In retail applications, a common mistake is that the lighting may not be used for any purpose other than to highlight the merchandise. Project teams can model the additional lighting power up to what has actually been designed, and no more; the baseline building must be modeled equal to what has been designed or up to the lighting allowance from ASHRAE 90.1, Section 9.6.2, whichever is less (i.e., credit may not be taken for unclaimed additional lighting power). Note that only the sales area can be used in the lighting power allowance. For example, do not use the entire project floor area (which may include space with other purposes, such as checkout areas, corridors, or dressing rooms) to determine the allowance. ASHRAE 90.1–2010 now allows an additional lighting power allowance based on the application of additional controls and using the control factors found in Table 9.6.2. This additional allowance may be used anywhere in the building and is based on the total wattage in the given space to which the control method is being applied. Unlike the retail allowance, this allowance is earned with the application of the control methods and may be added to the baseline whether or not the project designs up to the full allowance.
Automatic lighting controls	ASHRAE 90.1, Table G3.1(g), indicates that only automatic lighting controls, such as occupancy sensors, that are in addition to the required minimum control (Section 9.4.1) may be taken for credit. One of the most common errors is taking credit for an occupancy sensor located in a conference room; this is already a requirement of the baseline building. ASHRAE 90.1–2010 lists additional spaces that must have occupant sensors or timer switches that automatically turn off lighting. ASHRAE 90.1–2010 has added requirements for the lighting system and controls for buildings. Project teams are encouraged to read the standard, the User's Manual, and the lighting compliance forms to ensure that all mandatory measures have been met; these are prerequisites to LEED certification.
Exterior lighting	Exterior lighting is divided into allowances for tradable and nontradable surfaces. No credit may be taken for lighting reductions on nontradable surfaces. A lighting power allowance cannot be claimed in the baseline building for surfaces that are not provided with lighting in the actual design, and lighting fixtures cannot be double-counted for different exterior surfaces.
Energy rates	
Energy rates	Project teams must consistently use either actual utility rates or their state's average energy prices, published by the U.S. Department of Energy's Energy Information Administration for commercial building customers. The sources may not be mixed.

MODELING SCHEDULES

For optimal results, ensure that the schedule inputs into the model accurately reflect the project building's operation. If anticipated operating schedules are unknown, helpful guidance for determining model inputs for occupancy, lighting, HVAC system, receptacle power, and service hot water consumption values can be found in the ASHRAE 90.1–2010 User's Manual, Appendix G.

Schedules must be identical in both the baseline and the proposed cases unless documented in an exceptional calculation or specifically allowed by ASHRAE 90.1–2010, Appendix G (see *Modeling with the Exceptional Calculation Method*, above).

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 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.

MODELING BUILDING TYPE VARIATIONS

Core and Shell

Energy cost savings are based on a building's total annual energy consumption, rather than on the owner's scope of work, so the owner of a core and shell project may have only a limited opportunity to improve energy savings.

In a typical core and shell building, the owner provides base-building HVAC, whereas the tenant often installs light fixtures and other equipment. If the energy use of the base-building HVAC accounts for only a third of the overall building energy use, the building owner must find sufficient savings within that third to meet the prerequisite or require additional savings of the tenant in the lease agreement (see *Common Issues with Energy Modeling*, above).

Because the owner cannot control the effect of future improvements on the total energy consumption of the core and shell project, for LEED energy modeling, items such as lighting or equipment loads for areas that are under the tenants' control must be identical in the proposed building and in the baseline, as specified by Appendix G. However, projects can claim credit for energy reductions in tenant spaces if those reductions (such as lighting power density reductions or improved HVAC efficiency) are required through a tenant lease agreement or other legally binding document. For example, if a 20% reduction in lighting power density is required by the tenant lease agreement, those savings can be claimed in the proposed model.

Zoning must be identical between the baseline and the proposed models. If HVAC zones are not defined in a tenant space, energy modelers should follow ASHRAE 90.1–2010, Table G.3.1.8:

- A typical rectangular floor plate must have at least five zones: one perimeter zone for each orientation and one interior zone.
- Spaces that can be confidently identified as differing from typical tenant use, such as mechanical rooms or bathrooms, should be separately zoned.
- To easily distinguish between energy use from owner and tenant spaces, projects must model separate electric meters for tenant lighting and plug loads.

Retail

For projects using whole-building energy simulation, include all relevant process loads in the energy model and ensure that they are modeled accurately. Typical retail process loads include refrigeration equipment, cooking and food preparation, ice machines, display lighting for merchandise, clothes washing, and other major support appliances. Compare the energy consumption of each piece of equipment with the value indicated in Appendix 3, Tables 1–4. If the item is not included and the project team wishes to take credit, the exceptional calculation method must be followed.

For hard-wired refrigeration, the modeling software may be used if the system can be modeled explicitly. Otherwise, a thermodynamically similar component model must be used, in accordance with Table G3.1.13. An example of this would be an analysis prepared using 8760 hourly weather data.

For commercial kitchen equipment and refrigeration defined 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.

Data Centers

The guidance in this section is geared toward dedicated data centers and is not applicable to server closets or other small computer rooms. Mixed-use data centers, in which the data center takes up only a portion of the building space, may use this information as the basis for an exceptional calculation method.

The power requirements and energy use of the IT equipment in a data center typically dwarf the energy use of the cooling system and must be considered for optimizing energy performance. The energy consumption of a data center's cooling system typically ranges from 15% to 25% of its total energy use, whereas in other commercial buildings, the HVAC energy consumption approaches 50% of the total energy consumption.[1]

Data centers use special systems and equipment, such as large uninterruptible power supply (UPS), whose energy efficiency requirements are not defined by ASHRAE 90.1. Some of these systems will cause inefficiencies that can cascade through the power delivery chain, leading to increased energy usage in systems beyond those that support IT and, in most cases, creating additional cooling loads.

Stipulations for equipment reliability and maintenance often result in redundant equipment and systems. And the typical phased installation schedule for IT equipment (e.g., servers, storage, and networking gear) results in power and cooling systems that operate at a fraction of the design load. To gain a more accurate understanding of energy usage, teams should demonstrate the effects of partial-load conditions on the overall energy efficiency of the data center.

Modeling requirements for IT equipment. Because of the high process loads associated with IT equipment and its electrical infrastructure, many project teams look to these traditionally unregulated uses for energy savings. Though not required, if the project team is attempting to claim energy savings from these end uses, the data center calculator (see below) may provide a simplified method.

The reduced energy consumption of the IT and electrical equipment can help reduce HVAC energy usage. Project teams have the option of claiming the process load savings in isolation or creating an additional energy model based on the adjusted loads to capture the associated HVAC energy savings.

To determine total energy cost savings, it may be necessary to create one or more of the following, in addition to the required two energy models. The specific requirements of each model are detailed below.

1. Proposed model with full IT loading (normal performance rating method model)
2. ASHRAE model with full IT loading (normal performance rating method model)
3. ASHRAE model with "baseline" IT loading (optional)

If the project team is claiming energy savings related to the IT systems, the total energy savings are calculated as the difference between models 1 and 3.

Model 1. Proposed model with full IT loading. The model of the building's energy cost must include all regulated energy end uses as listed in the prerequisite criteria, as well as any unregulated energy that is specific to the building. The proposed design must use the IT loads and schedule developed for the project. The IT loads should be at the values for the intended final build-out of the facility. All electrical system components—examples include incoming transformers, switchgear, UPS systems, and power distribution units—must be modeled. Power losses associated with this equipment should be assigned to the spaces that house the equipment as an electrical load and as a thermal load input to the energy model. Model the quantity of power and cooling equipment designed to run during normal operation to include the effects of operating redundant equipment at partial loading on energy use.

In addition to the ASHRAE 90.1 mandatory compliance requirements, provide energy efficiency data for the following items:

- Generator block heaters (wattage required to keep the block at the design temperature)
- Power distribution wiring
- Battery charging

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[1] *U.S. Department of Energy, 2011 Buildings Energy Data Book (March 2012).*

Submit documentation for the following items, showing efficiency data at initial and full system loading points (loading values are a percentage of total IT load):

- Service transformers
- Switchgear
- Uninterruptible power systems
- Power distribution units

Model 2. ASHRAE model with full IT loading. For the baseline models, the air temperature at the inlet of the server should be within ASHRAE's recommended values, from 80.6°F (27°C) dry bulb and 59.0°F (15°C) dew point to 64.4°F (18°C) dry bulb and 41.9°F (5.5°C) dew point, unless justification is provided for an alternative minimum supply air temperature at the server inlet. The baseline system airflow must be sized based on a 20°F (approximately 11°C) difference between the supply air and the return air.

Model 3. ASHRAE model with "baseline" IT loading. This model is used to calculate IT energy savings due to low-energy servers, virtualization, and efficient electrical system design. In contrast to the standard application of exceptional calculation methods to the proposed model, for data center projects, the exceptional calculation is applied to the baseline (model 3). Rather than reducing the energy used in the proposed design, the baseline is increased to reflect the energy usage typical of a data center.

For IT equipment, the USGBC data center calculator provides baseline documentation; if used, additional justification for the baseline IT loads is not necessary. IT equipment input is defined as the IT load as measured at the point of connection of the IT device to the electrical power system. IT equipment input captures the actual power load of the IT device exclusive of any power distribution losses and loads beyond IT devices, such as rack-mounted fans.

The losses associated with all UPS equipment, including that which serves mechanical equipment to achieve continuous cooling during a loss of power (e.g., pumps, air-handling units, and compressors), are considered not part of the IT energy usage but part of the energy consumption required to operate the data center.

If a hydronic cooling system is used for IT cabinets or computers, the energy consumed by the fans built into the cabinet and coolant distribution pumps should be considered HVAC energy use, not IT energy use.

USGBC data center calculator. The data center calculator provided by USGBC creates a representative IT energy baseline based on the proposed design. The calculator consists of two main modules: one for the efficiency of the server equipment that comprises the IT system and one for the efficiency of the electrical system that delivers power to the IT system.

The calculator provides values that can be used as inputs for the electrical system energy consumption and heat loss for the proposed model with initial IT loading to calculate the initial power usage effectiveness (PUE). The calculator generates the following two sets of values that may be used to determine energy savings:

- Annual energy consumption savings values, which can then be claimed directly, in isolation of any effects the reduced electrical load would have on the HVAC system
- Input values for the ASHRAE model with "baseline" IT loading and the ASHRAE model with initial IT loading that can then be used during simulation

The calculator's IT systems module compares energy use of a proposed IT equipment design with a predefined baseline. The calculator analyzes energy use of computer servers only. Mainframes, storage, and networking equipment are not included in the overall energy demand calculation (as it relates to the reduction in energy). To claim savings from other types of IT equipment, teams must use the exceptional calculation method.

Based on the entered values for total IT load and percentage breakdowns, the calculator generates kilowatt (kW) values for servers, storage, and networking equipment. The kW number for the servers, combined with the server utilization and the average power draw of the server, is used to calculate the number of physical servers that will be in the data center. Server power is based on ENERGY STAR's computer server qualified product list. If the number of physical servers and their power draw are known, enter these values.

Next, enter the percentage of servers that will host virtual machines in the data center and the average consolidation ratio. This rate of virtualization is used to calculate the server utilization percentage and then compared with a typical virtualization rate, which is used to calculate the number of servers in the baseline case.

Finally, indicate whether a power management strategy will be used. This input takes the percentage of servers that can go into sleep mode and the percentage of the time those servers can be in sleep mode. With these inputs, the calculator determines the energy demand for the IT system in kW and also generates the annual energy use in kWh of both the baseline case and the proposed case.

If desired, the calculated server demand value for the baseline IT load can be entered into the ASHRAE model, with baseline IT loading as the server demand in the data center. The baseline model should use the same schedules as the proposed model.

The data center calculator's electrical systems module uses the peak demand of the IT system to determine the size and power draw of the equipment. Peak IT demand values are automatically imported from the IT systems module. For the purposes of the calculator, the electrical system comprises the following elements:

- Incoming utility service transformer
- Uninterruptible power supply
- Power distribution unit

Based on the topology selected by the user, some of the energy that flows through the component is lost as heat, which must be included in the building energy model.

The heat loss differs at varying loads. Although it is important to benchmark operation at 100% load, it may be more important to benchmark at partial loads because electrical and cooling equipment, especially legacy equipment, will have much lower efficiencies at partial loads.

After determining the efficiency of the baseline electrical system, the calculator provides annual energy consumption in kWh. If desired, the losses associated with the system can be assigned to the supporting infrastructure rooms of the appropriate energy models.

Power usage effectiveness. PUE is the metric for characterizing and reporting the overall infrastructure efficiency of a building. Determine the PUE value of the proposed design using Equation 2.

EQUATION 1. Power usage effectiveness

$$\text{PUE} = \frac{\text{Total data center energy consumption or power}}{\text{IT energy consumption or power}}$$

For example, if a facility uses 2,000,000 kWh of total energy, of which 1,600,000 kWh is attributable to IT equipment, its PUE is as follows:

$$\text{PUE} = \frac{2{,}000{,}000\text{ kWh}}{1{,}600{,}000\text{ kWh}} = 1.25$$

MODELING DISTRICT ENERGY SYSTEMS

All downstream equipment must be included in the scope of GIB Prerequisite Minimum Building Energy Performance and GIB Credit Optimize Building Energy Performance. Downstream equipment includes heat exchangers, steam pressure reduction stations, pumps, valves, pipes, building electrical services, and controls. Upstream equipment is included or excluded depending on the chosen option and path.

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.

Teams that are modeling DES can choose one of three paths.

Option 1, Path 1. ASHRAE 90.1–2010, Appendix G

Model the proposed and baseline designs using purchased energy according to ASHRAE 90.1–2010, Appendix G.

All virtual DES energy rates must be identical in the baseline and proposed cases. If tariffs or rates are not available from the district plant serving the project, such as for campus or military plants, calculate the rates based on the virtual electric and fossil fuel rates from the model.

If a flat rate structure, in which the cost per unit of energy is the same throughout the year and there are no demand charges, is being used for all energy sources, then those flat rates become the virtual energy rates for the project.

If all energy rate structures are not flat, a preliminary run of the Option 1 baseline case energy model must first be completed to identify the virtual electric and fossil fuel rates for the project. For this preliminary run only, the rate for the DES-supplied energy may be left blank or entered as any value.

Once all the virtual energy rates are known for electricity and fossil fuel, calculate the virtual DES rates for both the baseline and proposed cases per the values in the minimum energy performance calculator.

Exception: to obtain the virtual fuel rate when the connected building does not use fossil fuel but the DES central plant does, use a flat rate consistent with the central plant's rates or the historical average local market rates. No preliminary model run is needed. Input the virtual DES rates into the modeling software for each DES source and use them for the remainder of the process. Alternatively, calculate the DES energy costs directly by multiplying the DES energy consumption for each DES source by its virtual DES rate.

Option 1, Path 2. Full DES Performance Accounting

Path 2 is available if the project is connected to a DES and the team wishes to account for average efficiency across a smaller time step. The energy model scope accounts for both downstream and upstream equipment and requires calculation of the district energy average efficiencies using either modeling or monitoring.

Energy rates. All DES energy rates must be identical in both the baseline and the proposed cases. Use local rates as they would normally apply to the building for the energy sources under consideration. For energy sources used by the DES but not normally available to the building, such as diesel fuel, use the rates charged to the DES. If this information is not available, use representative market rates.

Exception: for DES plants that operate under specific and atypical rate structures and actively take advantage of those rates through strategies such as load management or energy storage, use the rate structures as they apply to the DES.

Baseline building plant. Model the baseline case with an on-site plant that is compliant with ASHRAE 90.1–2010, Appendix G, baseline requirements for site-generated thermal energy. Model the baseline building plant with conventional equipment using performance parameters and efficiencies per ASHRAE 90.1–2010, using energy sources corresponding to the DES.

Proposed building plant. Model the proposed case with a virtual DES-equivalent plant. Model a virtual plant with the same efficiencies as the entire upstream DES heating, cooling, and combined heat and power (CHP) systems, including all distribution losses and energy use. Equipment efficiencies, distribution losses, and distribution pumping energy may be determined using any of the following methods:

- Monitored data
- Engineering analysis
- Default values

Efficiencies and losses may be determined and modeled at any level of time resolution, from hourly to annual. However, the time resolution must be sufficiently granular to capture and reasonably represent any significant time- or load-dependent interactions between systems, such as thermal storage or CHP.

Monitoring and analytical methods may be combined as necessary and appropriate.

Monitoring data for heating, cooling, pumping, and cogeneration may be used only if the thermal loads that are monitored represent at least 90% of the predicted load on the campus or district plant after building occupancy.

Whether the team is using monitoring or an analytical method, the methodologies must be fully documented. The following specific requirements apply.

Heating and cooling plants. Efficiencies, whether determined through monitoring or analytically, must include all operational effects, such as standby, equipment cycling, partial-load operation, internal pumping, and thermal losses.

Thermal distribution losses. Use monitored data or an engineering analysis. Monitored data account for the distribution losses for the DES by comparing the total thermal energy leaving the plant with the total thermal energy used by the buildings connected to the DES. Rate the plant efficiency accordingly in the energy model:

$$\text{Modified plant efficiency} = \text{Plant efficiency (\%)} \times \left(\text{100\% — Distribution loss (\%)} \right)$$

An engineering analysis takes into consideration all distribution losses between the DES and the building. For distribution main losses, use a prorated amount based on load. For dedicated branch losses, use the total losses of the branch that feeds the building, including heat losses and steam trap losses. Compare the total losses with the total load of the building to get a percentage distribution loss relative to load and downgrade the plant's efficiency accordingly in the energy model.

Pumping energy. Whether through monitored data or engineering analysis, determine pumping energy for the project by prorating the total pump energy of the DES by the ratio of the annual thermal load of the building to the total annual DES thermal load. Model the pump energy as auxiliary electrical load. Pumping energy must be determined or estimated; there is no default value.

Default efficiencies and losses. Actual efficiency performance information on the DES serving the project building is preferred. If the project team cannot obtain or determine the actual performance data, use the following default values. These values are conservative and are intended to represent a DES with relatively low efficiency; a well-designed, well-operated DES generally performs better.

- DES heating plant: 70% (higher heating value) for the total boiler plant average efficiency
- DES cooling plant: coefficient of performance (COP) of 4.4 for the total cooling plant average efficiency (including cooling towers and primary pumps)
- Thermal distribution losses, including minor leaks or condensate losses:
    - Chilled water district cooling, 5%
    - Hot water district heating, 10%
    - Closed-loop steam systems, 15%
    - Open-loop steam systems, 25%

For steam systems that are partially open and partially closed, prorate between the above 15% and 25% losses in accordance with the fraction of expected or actual condensate loss.

The above guidance assumes that DES-generated heat is used for heat in the connected building, and DES-generated cooling is used for cooling in the connected building. If the DES produces heating that is then converted to cooling for the connected building using absorption chillers or other similar technology, this guidance must be modified (see *CHP Modeling Guidance*).

Option 1, Path 3. Streamlined DES Modeling

Path 3 is applicable for simple district energy systems. The energy model scope accounts for both downstream equipment and upstream equipment and also requires calculation of the district energy average efficiencies using either modeling or monitoring.

Energy rates. Use the streamlined DES modeling in the calculator provided by USGBC to allocate the energy costs to the results of the model for each district energy source, in lieu of the purchased energy rates, to determine the baseline and proposed case energy costs.

Baseline building plant. Calculate the average annual efficiency values for each district energy fuel source used to generate and distribute the thermal energy based on ASHRAE 90.1–2010, Appendix G, baseline case requirements. These values depend on the ASHRAE 90.1–2010 system type that would be selected for the building if the baseline case were modeled with on-site equipment. The calculations for baseline cost per district energy source are the same as those for the proposed case model, except that the average efficiency is constant.

Proposed building plant. Determine a single value for average annual efficiency, including thermal losses and distribution energy, for each district fuel energy source used to generate and distribute the thermal energy. For example, for chilled water:

$$COST(CHW)_{BUILDING} = CHW_{BUILDING} \times \sum_{i} (Cost_i \times \eta_i)$$

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

Combined Heat and Power Plants

The baseline case is modeled as described in ASHRAE 90.1, Appendix G, and as summarized in the steps for each path (above). The baseline model assumes separate production of electricity and thermal energy. Although not modeled as CHP, the baseline case is charged with extra energy use for CHP energy accounting purposes in some situations.

The proposed case may be modeled in various ways.

- The average electricity generation, fuel input, and heat recovery of the CHP must be determined, or the defaults for electric and thermal efficiency (below) must be used in conjunction with capacity ratings of the equipment.
- Calculate annual electricity generation using one of the following methods:
  - Monitor the total annual gross electricity generation. Also monitor the total annual parasitic loads, such as the annual electricity used for cooling the intake air for a turbine. Calculate the net annual electricity generation by subtracting all parasitic loads from the annual gross electricity generated.
  - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators. Apply measured or estimated load profiles as process loads to reflect the estimated total electric and thermal loads on the district energy CHP system. Use the total energy generated and total fuel input from this analysis. Any parasitic loads must be included in the analysis and subtracted from the annual electricity generation.
- Calculate annual fuel input using one of the following methods:
  - Monitor the total annual fuel input to the generators.
  - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators.
- Calculate waste heat recovery using one of the following methods:
  - Monitor the total waste heat recovered.
  - Model the generators in energy simulation software per Appendix G. Use peak electricity efficiencies and generator curves that match the installed generators. Model the thermal equipment served by the CHP waste heat, such as boilers and absorption chillers, using the installed equipment capacities, efficiencies, and efficiency curves, and reflecting the total heating and cooling loads on the plant as a process load. Use the energy modeling outputs to identify the total heat recovered.

For baseline CHP electricity output, follow the general procedures described in this section for the proposed case, and adjust the results as follows depending on the results of the DES electricity allocation and the total modeled electricity use of the building in the Path 2 or Path 3 proposed case, including the electricity consumption of district plant equipment serving the building:

- Scenario A. If the building's allocation of CHP-generated electricity is less than or equal to its modeled electricity consumption, no adjustment is necessary. The baseline building is charged with the energy used by its (non-CHP) systems at market rates using standard procedures.

- Scenario B. If the building's allocation of CHP-generated electricity exceeds its modeled electricity consumption, the amount of excess CHP electricity allocated to the building is considered process energy in the energy model. Adjust the input fuel associated with this excess CHP electricity in the baseline case as described in CHP fuel input.

For the proposed design's CHP electricity output, allocate the electricity generation to the building based on the fraction of thermal loads to the building for the DES sources that use recovered waste heat. For each DES source supplied to the building, determine the fraction of the recovered waste heat applied to that source as well as the amount serving the project building. For relatively simple DES systems, in which the recovered waste heat is used directly in the DES, and for which waste heat serves only heating loads in the connected buildings, use the formula for simple systems:

$$\text{CHP\_ELEC}_{\text{BLDG}}\text{(simple systems)} = (X_{\text{HEAT}} \times \text{BLDG}_{\text{HEAT}}) \times \text{CHP\_ELEC}_{\text{TOTAL}}$$

where

$\text{CHP\_ELEC}_{\text{BLDG}}$ = CHP electricity generation allocated to building
X_{HEAT} = fraction of CHP plant's total production of waste heat applied to the DES directly
$\text{BLDG}_{\text{HEAT}}$ = fraction of total district heat provided to building
$\text{CHP\_ELEC}_{\text{TOTAL}}$ = 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.

$$\text{CHP\_ELEC}_{\text{BLDG}}\text{ (heat recovery-driven chillers)} = (X_{\text{HEAT}} \times \text{BLDG}_{\text{HEAT}}) + (Y_{\text{CHW}} \times \text{BLDG}_{\text{CHW}}) + (Z_{\text{SOURCE}} \times \text{BLDG}_{\text{SOURCE}}) \times \text{CHP\_ELEC}_{\text{TOTAL}}$$

where

$\text{CHP\_ELEC}_{\text{BLDG}}$ = CHP electricity generation allocated to building
X_{HEAT} = fraction of CHP plant's total production of waste heat applied to the DES directly
$\text{BLDG}_{\text{HEAT}}$ = 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
$\text{BLDG}_{\text{SOURCE}}$ = fraction of third district energy source provided to building
$\text{CHP\_ELEC}_{\text{TOTAL}}$ = total CHP electricity generated at DES plant

When modeling CHP fuel input, allocate the CHP input fuel to the project building based on a proration and assignment of the total input fuel according to the results of the CHP electricity allocation described above for CHP electricity output. Use the prevailing energy rates as they apply to the project. Any additional energy used by the proposed design is also charged at market rates.

For the proposed case (all projects), calculate the CHP input fuel allocated to the building as follows:

$$\text{Proposed BLDG}_{\text{FUEL}} = \left(\frac{\text{CHP\_ELEC}_{\text{BLDG}}}{\text{CHP\_ELEC}_{\text{TOTAL}}} \right) \times \text{CHP}_{\text{FUEL}}$$

where

$\text{Proposed CHP\_ELEC}_{\text{BLDG}}$ = proposed case CHP input fuel allocated to building

$\text{CHP\_ELEC}_{\text{TOTAL}}$ = CHP electricity generation allocated to building (from previous calculations)

CHP_{FUEL} = total CHP electricity generated at DES plant

$\text{CHP\_ELEC}_{\text{TOTAL}}$ = 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:

$$\text{Baseline BLDG}_{\text{FUEL}} = \left(\frac{\text{PROCESS\_ELEC}_{\text{BLDG}}}{\text{CHP\_ELEC}_{\text{TOTAL}}} \right) \times \text{CHP}_{\text{FUEL}}$$

with

$$\text{PROCESS\_ELEC}_{\text{BLDG}} = \text{CHP\_ELEC}_{\text{BLDG}} - \text{PROPOSED\_ELEC}_{\text{BLDG}}$$

where

$\text{Baseline BLDG}_{\text{FUEL}}$ = baseline case CHP input fuel charged to building

$\text{PROCESS\_ELEC}_{\text{BLDG}}$ = amount of allocated CHP electricity in excess of building's modeled annual electricity consumption (treated as process energy in model)

$\text{CHP\_ELEC}_{\text{TOTAL}}$ = total CHP electricity generated at DES plant

CHP_{FUEL} = total CHP fuel input for electricity generation at DES plant

$\text{CHP\_ELEC}_{\text{BLDG}}$ = CHP electricity generation allocated to building (from previous calculations)

$\text{PROPOSED\_ELEC}_{\text{BLDG}}$ = modeled electricity consumption for building from proposed case

The model must include CHP generator default efficiencies. Actual efficiency performance data on the CHP serving the project building are preferred, based on either ongoing operations (existing CHP) or design specifications (new CHP). If the project team cannot obtain the actual performance data, use the following default seasonal performance values. These values are conservative, intended to represent a CHP system with relatively low efficiency. A well-designed, well-maintained CHP system will generally offer better performance.

- 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 DES-supplied heat, consider modeling the energy source as purchased energy to hold the DES cost-neutral for service water heating. If desired, project teams using Path 2 or Path 3 may use an exceptional calculation method to document DES-related savings from service water heating. Project teams that elect to document savings must fully justify and support the annual energy consumption and cost in both the baseline and the proposed models. Use a reasonable, well-founded purchased energy rate in the models, such as the actual rate paid to the DES supplier or a virtual rate.

Heating converted to cooling. Sometimes the district or campus system heating energy supply is converted to chilled water using absorption chillers or other similar technologies to serve cooling loads. In this circumstance, the equipment that converts heating to cooling may reside within the DES itself (i.e., DES provides cooling to the building) or within the connected buildings (i.e., DES provides heating to the building, and the building converts heating to cooling). When the equipment that converts DES-supplied heat into cooling is part of the LEED project's scope of work, the DES guidance is modified for Option 1, Whole Building Simulation.

- Model the district heating source servicing the chilled water generation equipment as follows:
  - For Path 1, use purchased heat in both the baseline and the proposed cases.
  - For Path 2 or 3, use a virtual upstream DES plant for the proposed case and compare it with code-compliant on-site equipment for the baseline case.
- For Path 1, model absorption chillers in the baseline case as follows:
  - When the purchased heating is hot water with average supply temperatures below 300°F (148.9°C), the chillers must be modeled as single-effect absorption chillers (0.7 COP).
  - When the purchased heating is steam or hot water with average temperatures of 300°F (148.9°C) or higher, the chillers must be modeled as double-effect absorption chillers (1.0 COP).
  - If the building peak cooling load is less than 300 tons (1050 kW), model one water-cooled absorption chiller.
  - If the building peak cooling load is 300 to 600 tons (1050 to 2100 kW), model two water-cooled absorption chillers, sized equally.
  - If the building peak cooling load is more than 600 tons (2100 kW), model a minimum of two water-cooled absorption chillers, with chillers added such that no chiller is larger than 800 tons (2800 kW), all sized equally.
  - For a project with both absorption chillers driven by purchased hot water and electric chillers on site, the type and quantity of absorption chillers must be as identified above, and the type and quantity of electric chillers must be as in ASHRAE 90.1–2010, Table G3.1.3.7 (or DX equipment as specified), but the total capacity ratio of electric to absorption cooling must be identical to that of the proposed design.
  - For a project with both district chilled water and absorption chillers on site driven by purchased heating, the type and quantity of absorption chillers must be as identified above, and purchased cooling must also be modeled in accordance with the district energy modeling guidance. However, the total capacity ratio of the on-site cooling to purchased cooling must be identical to that of the proposed design.
- Model the baseline case cooling towers, pumps, chilled water loop configurations, and loop temperature controls as indicated in ASHRAE 90.1–2010, Appendix G.
- Model the absorption chillers in the proposed case based on the as-designed type and capacity of chillers.

Other atypical systems. Incorporate any unconventional DES features, such as thermal storage, ground or surface water cooling, and waste heat recovery, into the proposed virtual plant to the greatest extent practical, using the general principles presented here.

OPTION 2. PRESCRIPTIVE COMPLIANCE: ASHRAE 50% ADVANCED ENERGY DESIGN GUIDE

STEP-BY-STEP GUIDANCE

Step 1. Select appropriate guide and ensure area requirements are met
Choose the appropriate building type (office, retail, school, or hospital) from the ASHRAE 50% Advanced Energy Design Guides (AEDGs) and review the area requirements. If any buildings do not meet both building type and size criteria, the team must select Option 1 or Option 3.

Step 2. Assess ASHRAE prescriptive requirements
Work with the architect and engineers to assess the prescriptive requirements of ANSI/ASHRAE/IESNA Standard 90.1–2010, with errata (or a USGBC-approved equivalent standard for projects outside the U.S.), and ensure that the design will comply with envelope, HVAC, service water-heating, and lighting requirements, per Sections 5.5, 6.5, 7.5, and 9.2.2.

- The ASHRAE 90.1–2010 prescriptive requirements should not be confused with the requirements of the AEDGs. Although projects must meet only the HVAC and service water-heating prescriptive requirements of the applicable AEDG to earn this prerequisite, all the ASHRAE 90.1–2010 prescriptive requirements must be met, including building envelope, HVAC, service water heating, and lighting.
- Ensure that the lighting calculations include all task lighting except where specifically exempted by ASHRAE 90.1, and appropriately account for the total luminaire wattage for each fixture consistent with ASHRAE 90.1 requirements. Note that the luminaire wattage is not necessarily the sum of the lamp wattages but accounts for the ballast factor (standard luminaires) and the total circuit power or current-limited power (track lighting).
- For retail buildings, if the project team intends to earn points under the related credit, also comply with the prescriptive measures in Appendix 3, Tables 1–4, for 90% of total energy consumption for all process equipment.

Step 3. Assess AEDG requirements for HVAC and service water-heating equipment
Work with the mechanical and plumbing engineer to ensure that the project's HVAC and service water-heating equipment will meet all the prescriptive AEDG requirements. Specify qualifying equipment in the construction documents.

- The HVAC scope includes equipment efficiency, economizers, ventilation, and ducts and dampers as discussed in AEDG, Chapter 4, Design Strategies and Recommendations by Climate Zone.
- Consider the capacity needs for the project and identify potential equipment that will meet those requirements. AEDG does not address some types and sizes of equipment, and these constraints may make certain equipment inappropriate for the project.
- As a best practice, use the AEDG compliance checklists to track the requirements, review this list with the project team, and include these requirements in the owner's project requirements.
- Once the design is complete, a project that cannot meet all AEDG requirements will find it difficult to switch to Option 1 or Option 3; therefore, these requirements should be established early in design.

Step 4. Confirm that credit criteria will be met, if applicable
If the project team is planning to achieve points using Option 2 under the related credit, consider the additional AEDG requirements not included in the prerequisite.

OPTION 3. PRESCRIPTIVE COMPLIANCE: ADVANCED BUILDINGS™ CORE PERFORMANCE™ GUIDE

STEP-BY-STEP GUIDANCE

Step 1. Assess ASHRAE prescriptive requirements

Work with the design team to understand the prescriptive requirements of ANSI/ASHRAE/IESNA Standard 90.1–2010 to ensure that the design will comply. This also includes Sections 5.5 (envelope), 6.5 (HVAC), 7.5 (service water heating), and 9.2.2 (lighting).

Step 2. Review requirements in Section 1, Design Process Strategies

Develop an implementation strategy for achieving the requirements for Section 1, Design Process Strategies, as outlined in the Core Performance Guide (CPG).

- Consider the scheduling necessary to accommodate additional meetings and design time during the design process.
- Consider the scheduling and resource implications of postconstruction activities, such as system verification, operator training and documentation, and ongoing measurement.
- Projects that select Option 3 must meet all criteria listed in Section 1 of the CPG.

Step 3. Discuss CPG requirements and implementation in design team meetings

Engage the design team in discussions about meeting the requirements of all three sections of the CPG, implementing strategies for achieving the ENERGY STAR Target Finder goal, and documenting the process to ensure that the design intent is clearly communicated.

Step 4. Review prescriptive requirements

Starting early in the design process, review the required prescriptive elements outlined in Section 2, Core Performance Requirements, and the three required elements from Section 3, Enhanced Performance Strategies. Consider alternatives for lighting, HVAC, envelope, and water-heating systems.

- Engage design team members to confirm compliance with each prescriptive criterion. Projects must meet all prescriptive requirements.
- Consider the effects of continuous air barriers, below-grade exterior insulation, and enhanced economizer operation as well as common upgrades, such as improved insulation for walls, roofs, and windows.
- In addition to meeting the requirements of the CPG, buildings must meet all local energy code requirements or the prescriptive requirements of ASHRAE 90.1–2010, whichever are more stringent. Where standards conflict, follow the more stringent requirements: either the CPG and ASHRAE 90.1–2010, or CPG and the local energy code.

Step 5. Analyze passive and active energy load reduction opportunities

As described in Section 1 of the CPG, as part of design development, analyze at least three alternative building configurations to maximize passive reduction of energy loads. When a preferred configuration has been selected, perform an analysis of the mechanical systems.

- Undertake and document load calculations. Consider referencing ASHRAE 55 to identify thermal comfort design conditions.
- In the first iteration of load calculations, include fan sizing calculations based on zone-by-zone loads.
- Perform a second set of load calculations using partial-load conditions. Describe features of the design that will enable efficient operation at these conditions.
- Conduct the passive and active analyses and calculations according to Sections 1.3 and 1.4 of the CPG.

Step 6. Design to meet Section 2, Core Performance Requirements
Select the optimal design indicated by the load calculations and confirm that each of the requirements listed in Section 2 of the CPG has been met or exceeded. If any design revisions require upgrades to envelope or lighting components, redo HVAC load calculations.

- Confirm with the architect that envelope-related efficiency measures included in the plans and specifications meet or exceed the CPG requirements.
- Confirm with the mechanical engineer that the specifications of the mechanical system meet or exceed the CPG requirements.
- Confirm with the electrical engineer or lighting designer that lighting power density calculations do not exceed the CPG requirements.
- Sections 2.7 and 2.9 are already mandated through the prescriptive requirements of ASHRAE 90.1–2010, as indicated in the criteria for Option 3 of this prerequisite.

Step 7. Design for compliance with Section 3, Enhanced Performance Strategies
Work with the mechanical engineer to include the following three strategies from the CPG Section 3, Enhanced Performance Strategies, in the plans and specifications, as applicable:

- 3.5 Supply Air Temperature Reset (VAV). Confirm that the selected air-handling units can reset temperature and that the building automation system (BAS) can process inputs that allow proper reset operation, such as humidity, outdoor air temperature, and VAV damper position.
- 3.9 Premium Economizer Performance. Confirm that the controls can accommodate a dedicated thermostat stage, that appropriate sensors are installed in the correct location within the air streams, and that the BAS can adequately implement the requirements.
- 3.10 Variable Speed Control. Confirm that pumps serving variable flow systems and VAV fans having a motor of 5 horsepower (3.73 kW) or larger can be upgraded to VFD with performance characteristics matching those listed in the standard.