Energy and Atmosphere

Buildings consume approximately 37% of the energy and 68% of the electricity produced in the United States annually, according to the U.S. Department of Energy. Electricity generated from fossil fuels—oil and coal—impact the environment in a myriad of adverse ways, beginning with their extraction, transportation, refining and distribution. Coal mining disrupts habitats and can devastate landscapes. Acidic mine drainage further degrades regional ecosystems. Coal is rinsed with water, which results in billions of gallons of sludge stored in ponds. Mining is a dangerous occupation in which accidents and the long-term effects of breathing coal dust result in shortened life spans of coal miners.

Conventional fossil-based generation of electricity releases carbon dioxide, which contributes to global climate change. Coal-fired electric utilities emit almost one-third of the country's anthropogenic nitrogen oxide, the key element in smog, and two-thirds the sulfur dioxide, a key element in acid rain. They also emit more fine particulate material than any other activity in the United States. Because the human body is incapable of clearing these fine particles from the lungs, they are contributing factors in tens of thousands of cancer and respiratory illness-related deaths annually.

Natural gas, nuclear fission and hydroelectric generators all have adverse environmental impacts as well. Natural gas is a major source of nitrogen oxide and greenhouse gas emissions. Nuclear power increases the potential for catastrophic accidents and raises significant waste transportation and disposal issues. Hydroelectric generating plants disrupt natural water flows, resulting in disturbance of habitat and depletion of fish populations.

Green buildings address these issues in two primary ways: by reducing the amount of energy required, and by using more benign forms. The better the energy performance of a project, the lower the operations costs. As world competition for the available supply of fuels heightens, the rate of return on energy-efficiency measures improves. Electrical generation using sources other than fossil fuels reduces environmental impacts.

Energy & Atmosphere Credit Characteristics

Table 1 shows which credits were substantially revised for LEED-NC Version 2.2, which credits are eligible to be submitted in the Design Phase Submittal, and which project team members are likely to carry decision-making responsibility for each credit. The decision-making responsibility matrix is not intended to exclude any party, rather to emphasize those credits that are most likely to require strong participation by a particular team member.

Overview of LEED® Prerequisites and Credits

Table 1: EA Credit Characteristics

Credit	Significant Change from LEED-NC v2.1	Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
EAp1: Fundamental Commissioning of the Building Energy Systems	*		*	*	*	*
EAp2: Minimum Energy Performance	*	*			*	
EAp3: Fundamental Refrigerant Management		*		*		
EAc1: Optimize Energy Performance	*	*			*	
EAc2: On-Site Renewable Energy	*	*			*	
Eac3: Enhanced Commissioning	*			*	*	*
Eac4: Enhanced Refrigerant Management	*	*			*	
EAc5: Measurement & Verification	*		*		*	
EAc6: Green Power	*		*	*		

Fundamental Commissioning of the Building Energy Systems

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Required

Intent

Verify that the building's energy related systems are installed, calibrated and perform according to the owner's project requirements, basis of design, and construction documents.

Benefits of Commissioning

Benefits of commissioning include reduced energy use, lower operating costs, reduced contractor callbacks, better building documentation, improved occupant productivity, and verification that the systems perform in accordance with the owner's project requirements.

Requirements

The following commissioning process activities shall be completed by the commissioning team, in accordance with this LEED-NC 2.2 Reference Guide.

1) Designate an individual as the Commissioning Authority (CxA) to lead, review and oversee the completion of the commissioning process activities.
   a) The CxA shall have documented commissioning authority experience in at least two building projects.
   b) The individual serving as the CxA shall be independent of the project's design and construction management, though they may be employees of the firms providing those services. The CxA may be a qualified employee or consultant of the Owner.
   c) The CxA shall report results, findings and recommendations directly to the Owner.
   d) For projects smaller than 50,000 square feet, the CxA may include qualified persons on the design or construction teams who have the required experience.
2) The Owner shall document the Owner's Project Requirements (OPR). The design team shall develop the Basis of Design (BOD). The CxA shall review these documents for clarity and completeness. The Owner and design team shall be responsible for updates to their respective documents.
3) Develop and incorporate commissioning requirements into the construction documents.
4) Develop and implement a commissioning plan.
5) Verify the installation and performance of the systems to be commissioned.
6) Complete a summary commissioning report.

Commissioned Systems

Commissioning process activities shall be completed for the following energy-related systems, at a minimum:

- ❑ Heating, ventilating, air conditioning, and refrigeration (HVAC&R) systems (mechanical and passive) and associated controls

- ❑ Lighting and daylighting controls
- ❑ Domestic hot water systems
- ❑ Renewable energy systems (wind, solar, etc.)

Potential Technologies & Strategies

In order to meet this prerequisite, owners are required to use qualified individuals to lead the commissioning process. Qualified individuals are identified as those who possess a high level of experience in the following areas:

- ❑ Energy systems design, installation and operation
- ❑ Commissioning planning and process management
- ❑ Hands-on field experience with energy systems performance, interaction, start-up, balancing, testing, troubleshooting, operation, and maintenance procedures
- ❑ Energy systems automation control knowledge

Owners are encouraged to consider including water-using systems, building envelope systems, and other systems in the scope of the commissioning plan as appropriate. The building envelope is an important component of a facility which impacts energy consumption, occupant comfort and indoor air quality. While it is not required to be commissioned by LEED, an owner can receive significant financial savings and reduced risk of poor indoor air quality by including building envelope commissioning.

This LEED-NC 2.2 Reference Guide provides guidance on the rigor expected for this prerequisite for the following:

- ❑ Owner's Project Requirements
- ❑ Basis of Design
- ❑ Commissioning Plan
- ❑ Commissioning Specification
- ❑ Performance Verification Documentation
- ❑ Commissioning Report

Summary of Referenced Standard

There is no standard referenced for this prerequisite.

Approach and Implementation

Relationship Between Fundamental and Enhanced Commissioning

LEED-NC addresses building commissioning in two places, EA Prerequisite 1 and EA Credit 3. For any given LEED project, the scope of services for the CxA and project team should be based on the Owner's Project Requirements (OPR). To meet the requirements of this prerequisite, the commissioning process activities must, at a minimum, address the commissioned systems noted in the prerequisite. Other systems, including the building envelope, stormwater management systems, water treatment systems, information technology systems, etc., may also be included in the commissioning process at the owner's discretion.

Table 1 outlines the team members primarily responsible to perform each project requirement; and also which requirements are common to EA Prerequisite 1 and EA Credit 3. All individuals on the project team are encouraged to participate in the commissioning activities as part of a larger commissioning team.

Strategies

The commissioning process is a planned, systematic quality-control process that involves the owner, users, occupants, operations and maintenance staff, design professionals and contractors. It is most effective when begun at project inception.

An explanation of the steps satisfying this LEED-NC prerequisite is summarized in the following sections.

Table 1: Primary Responsibilities Chart for EA Prerequisite 1 and EA Credit 3

Tasks	Responsibilities	
	If you are only meeting EAp1...	If you are meeting the EAp1 AND EAc3...
Designate Commissioning Authority (CxA)	Owner or Project Team	Owner or Project Team
Document Owner's Project Requirements (OPR)	Owner	Owner
Develop Basis of Design	Design Team	Design Team
Incorporate commissioning requirements into the construction documents	Project Team or CxA	Project Team or CxA
Conduct commissioning design review prior to mid-construction documents	N/A	CxA
Develop and implement a commissioning plan	Project Team or CxA	Project Team or CxA
Review contractor submittals applicable to systems being commissioned	N/A	CxA
Verify the installation and performance of commissioned systems	CxA	CxA
Develop a systems manual for the commissioned systems	N/A	Project Team and CxA
Verify that the requirements for training are completed	N/A	Project Team and CxA
Complete a summary commissioning report	CxA	CxA
Review building operation within 10 months after substantial completion	N/A	CxA

SS	WE	EA	MR	EQ	ID

Prerequisite 1

1. **Designate an individual as the Commissioning Authority (CxA) to lead, review and oversee the completion of the commissioning process activities.**

   It is recommend for the project to designate an individual as the CxA as early as possible in the project timeline, ideally during pre-design. The qualified individual designated as the CxA serves as an objective advocate for the owner, and is responsible for 1) directing the commissioning team and process in the completion of the commissioning requirements 2) coordinating, overseeing, and/or performing the commissioning testing and 3) reviewing the results of the systems performance verification.

   For LEED-NC projects a qualified CxA should have experience with two other projects of similar managerial and technical complexity. The owner may want to develop additional experience or qualifications requirements in selecting the CxA, depending on the scope and nature of the commissioning. There are a number of CxA certification programs administered by various industry groups.

   For projects larger than 50,000 sq.ft. the individual serving as the CxA on a LEED-NC project shall be independent of the project's design and construction teams. The CxA may be a qualified staff member of the Owner, an Owner's consultant to the project, or an employee of one of the firms providing design and/or construction management services. The CxA shall not, however, have responsibility for design (e.g., engineer-of-record) or for construction. The CxA shall report results, findings and recommendations directly to the Owner.

   For projects smaller than 50,000 sq.ft., the CxA may be a qualified staff member of the Owner, an Owner's consultant to the project, or an individual on the design or construction, and may have additional project responsibilities beyond leading the commissioning services.

2. **The Owner shall document the Owner's Project Requirements (OPR). The design team shall develop the Basis of Design (BOD). The CxA shall review these documents for clarity and completeness. The Owner and design team shall be responsible for updates to their respective documents.**

   Clear and concise documentation of the Owner's Project Requirements and the Basis of Design is a valuable part of any successful project delivery and commissioning process. These documents are utilized throughout the Commissioning Process to provide an informed baseline and focus for validating systems' energy and environmental performance.

Owner's Project Requirements (OPR)

The OPR shall be completed by the Owner, Commissioning Agent, and Project Team prior to the approval of contractor submittals of any commissioned equipment or systems. Subsequent updates to the OPR during the design and construction process are the primary responsibility of the Owner.

The OPR should detail the functional requirements of a project and the expectations of the building's use and operation as it relates to the systems to be commissioned. It is recommended that the OPR address the following issues, as applicable to the project:

- ❑ *Owner and User Requirements*—Describe the primary purpose, program, and use of the proposed project (e.g., office building with data center) and any pertinent project history. Provide any overarching goals relative to program needs, future expansion, flexibility, quality of materials, and construction and operational costs.

- *Environmental and Sustainability Goals*—Describe any specific environmental or sustainability goals (e.g., LEED-NC certification).
- *Energy Efficiency Goals*—Describe overall project energy efficiency goals relative to local energy code or ASHRAE Standard or LEED. Describe any goals or requirements for building siting, landscaping, façade, fenestration, envelope and roof features that will impact energy use.
- *Indoor Environmental Quality Requirements*—As applicable and appropriate, for each program/usage area describe the intended use; anticipated occupancy schedules; space environmental requirements (including lighting, space temperature, humidity, acoustical, air quality, ventilation and filtration criteria); desired user ability to adjust systems controls; desire for specific types of lighting; and accommodations for after-hours use.
- *Equipment and System Expectations*—As applicable and appropriate, describe the desired level of quality, reliability, type, automation, flexibility, and maintenance requirements for each of the systems to be commissioned. When known, provide specific efficiency targets, desired technologies, or preferred manufacturers for building systems.
- *Building Occupant and O&M Personnel Requirements*—Describe how the facility will be operated, and by whom. Describe the desired level of training and orientation required for the building occupants to understand and use the building systems.

Basis of Design

The design team must document the Basis of Design (BOD) for the systems to be commissioned prior to approval of contractor submittals of any commissioned equipment or systems. Subsequent updates to this document during the design and construction process are the responsibility of the design team. The Commissioning Agent shall review the BOD to ensure that it reflects the OPR.

The BOD shall provide a narrative describing the design of the systems to be commissioned and outlining any design assumptions that are not otherwise included in the design documents. The BOD should be updated with each subsequent design submission with increasing specificity as applicable.

The BOD shall, at a minimum, include the following as applicable:

- *Primary Design Assumptions*—including space use, redundancy, diversity, climatic design conditions, space zoning, occupancy, operations and space environmental requirements
- *Standards*—including applicable codes, guidelines, regulations, and other references that will be followed
- *Narrative Descriptions*—including performance criteria for the HVAC&R systems, lighting systems, hot water systems, on-site power systems, and other systems that are to be commissioned

3. **Develop and incorporate commissioning requirements into the construction documents.**

   Typically the project specifications are used to inform the contractor(s) of their responsibilities in the commissioning process. These specifications may describe the components listed in **Table 2**.

   Often, all commissioning requirements are outlined in one section of the general conditions of the construction specifications. Placing all commissioning requirements in one location puts

Table 2: Commissioning Requirements in Construction Documents

- ❑ Commissioning team involvement
- ❑ Contractors' responsibilities
- ❑ Submittals and submittal review procedures for Cx process/systems
- ❑ Operations and maintenance documentation, system manuals
- ❑ Meetings
- ❑ Construction verification procedures
- ❑ Start-up plan development and implementation
- ❑ Functional performance testing
- ❑ Acceptance and closeout
- ❑ Training
- ❑ Warranty review site visit

responsibility for commissioning work with the prime contractor, who can then appropriately assign responsibility to sub-contractors. It is also valuable to reference commissioning requirements on the drawings, in any bid forms, and in specification sections related to the systems to be commissioned.

4. **Develop and implement a Commissioning Plan.**

Unique to a particular project, the Commissioning Plan is the reference document that identifies the strategies, aspects and responsibilities within the commissioning process for each phase of a project, for all of the project team members. This document outlines the overall process, schedule, organization, responsibilities and documentation requirements of the commissioning process.

The Commissioning Plan is developed at the start of the commissioning process, preferably during design development. The Commissioning Plan is updated during the course of a project to reflect changes in planning, schedule, or other supplemental information added as warranted.

The following outlines recommended components of the Commissioning Plan:

- ❑ Commissioning Program Overview
  - Goals and objectives
  - General project information
  - Systems to be commissioned
- ❑ Commissioning Team
  - Team members, roles and responsibilities
  - Communication protocol, coordination, meetings and management
- ❑ Description of Commissioning Process Activities
  - Documenting the Owner's Project Requirements
  - Preparing the Basis of Design
  - Developing systems functional test procedures
  - Verifying systems performance
  - Reporting deficiencies and the resolution process
  - Accepting the building systems

Project teams pursuing the enhanced commissioning credit (EA Credit 3) may need to expand the Commissioning Plan to include the following commissioning process activities:

- ❑ Documenting the commissioning review process
- ❑ Reviewing contractor submittals
- ❑ Developing the systems manual
- ❑ Verifying the training of operations personnel
- ❑ Reviewing building operation after final acceptance

5. Verify the installation and performance of the systems to be commissioned.

The purpose of commissioning is to verify the performance of commissioned systems as installed to meet the OPR, BOD, and contract documents.

Verification of the installation and performance of commissioned systems typically includes the following steps for each commissioning system:

- ❑ Installation Inspection
- ❑ Systems Performance Testing
- ❑ Evaluation of Results Compared to OPR/BOD

Installation Inspections—(sometimes referred to as pre-functional inspections) are a systematic set of procedures intended to identify whether individual components of the systems to be commissioned have been installed properly. Often this process occurs at start-up of individual units of equipment and may use "pre-function checklists" or "start-up and check-out forms" to insure consistency in the inspections and to document the process. Installation inspections may be performed by the CxA, the installing contractor, or by others, depending on the procedures outlined in the Commissioning Plan. Installation inspections provide quality control to insure that relatively minor issues (e.g., a mis-wired sensor, a control valve installed backwards) are discovered and corrected prior to systems performance testing.

Systems Performance Testing—(sometimes referred to as functional performance testing) occurs once all system components are installed, energized, programmed, balanced and otherwise ready for operation under part and full load conditions. Testing should include each sequence in the sequence of operations under central and packaged equipment control; including startup, shutdown, capacity modulation, emergency and failure modes, alarms and interlocks to other equipment. Systems performance testing typically relies on testing procedures developed by the CxA specifically for the system to be tested. Systems performance testing may use a wide variety of means and methods to simulate and evaluate that the system being tested performs as expected (per the OPR, BOD, and contract documents) in all modes of operation. Systems performance testing may be performed by some combination of the CxA, the installing contractor, and others, depending on the procedures outlined in the commissioning specifications and the Commissioning Plan.Systems performance testing may yield minor or significant issues with the performance of the commissioned systems and may require significant follow-up and coordination between members of the project team to address and resolve these issues.Evaluation of Results Compared to OPR/BOD—at each point in the process of Installation Inspections and Systems Performance Testing the CxA and the commissioning team should evaluate whether the installed systems meet the criteria for the project as set forth by the owner in the OPR and the designers in the BOD. Any discrepancies or deficiencies should be reported to the owner and the team should work collaboratively to find an appropriate resolution.

6. Complete a summary commissioning report.

Upon completion of installation inspections and performance verification items, the results are tabulated and assembled into a summary commissioning report. The summary report should include confirmation from the CxA indicating whether individual systems meet the requirements of the OPR, BOD, and Contract Documents. The summary commissioning report should include the following:

- ❑ Executive summary of the process and the results of the commissioning program —including observations, conclusions and any outstanding items
- ❑ A history of any system deficiencies identified and how they were resolved— including any outstanding issues or seasonal testing scheduled for a later date
- ❑ Systems performance test results and evaluation (Any other supporting information can be complied as a Cx record but is not required in the summary report.)

In addition, for projects pursuing EA Credit 3, the commissioning report should include the following:

- ❑ A summary of the design review process
- ❑ A summary of the submittal review process
- ❑ A summary of the O&M documentation and training process

Calculations

There are no calculations associated with this prerequisite.

Exemplary Performance

There is no exemplary performance point available for this prerequisite.

Submittal Documentation

This prerequisite is submitted as part of the **Construction Submittal**.

The following project data and calculation information is required to document prerequisite compliance using the v2.2 Submittal Templates:

- ❑ Provide the name and company information for the CxA.
- ❑ Confirm that the 6 required tasks have been completed.
- ❑ Provide a narrative description of the systems that were commissioned and the results of the commissioning process.

Considerations

Economic Issues

Implementation of a commissioning process maintains the focus on quality control and high performance building principles from project inception through operation. Commissioning typically results in optimized mechanical, electrical and architectural systems—maximizing energy efficiency and thereby minimizing environmental impacts. A properly designed and executed Commissioning Plan may reduce errors and omissions in the design and installation process, improve coordination, reduce change orders, and generate substantial operational cost savings compared to systems that are not commissioned. Successful implementation of the commissioning process often yields improvements in energy efficiency of 5% to 10%.

In addition to improved energy performance, improved occupant well-being and productivity are potential benefits when commissioning results in building systems functioning as intended. Such benefits include avoiding employee illness, tenant turnover and vacant office space, liability related to indoor air quality and premature equipment replacement.

Researchers at Lawrence Berkeley National Lab completed a meta-analysis of 85 new construction commissioning projects in 2004. LBNL developed a detailed and uniform methodology for characterizing, analyzing, and synthesizing the results. For new construction, this study found that median commissioning costs were $1.00/sq.ft. (0.6% of total construction costs), yielding a median payback time of 4.8 years from quantified energy savings alone (excluding savings from non-energy impacts and other benefits of commissioning). This study further concludes—

"Some view commissioning as a luxury and 'added' cost, yet it is only a barometer of the cost of errors promulgated by other parties involved in the design, construction, or operation of buildings. Commissioning agents are just the 'messengers'; they are only revealing and identifying the means to address pre-existing problems. We find that commissioning is one of the most cost-effective means of improving energy efficiency in commercial buildings."

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

www.ashrae.org

(800) 527-4723

Building Commissioning Association (BCxA)

www.bcxa.org

(877) 666-BCXA (2292)

Promotes building commissioning practices that maintain high professional standards and fulfill building owners' expectations. The association offers a five-day intensive course focusing on how to implement the commissioning process, intended for Commissioning Authorities with at least two years' experience.

California Commissioning Collaborative (CCC)

www.cacx.org

(503) 595-4432

The CCC is a nonprofit 501(c)3 organization committed to improving the performance of buildings and their systems. The CCC is made up of government, utility and building services organizations and professionals who have come together to create a viable market for building commissioning in California.

Cx Assistant Commissioning Tool

www.ctg-net.com/edr2002/cx/

This web-based tool provides project-specific building commissioning information to design teams and enables users to evaluate probable commissioning cost, identify an appropriate commissioning scope, and access sample commissioning specifications related to their construction project.

Portland Energy Conservation Inc. (PECI)

www.peci.org

PECI develops the field for commissioning services by helping building owners understand the value of commissioning, and producing process and technical information for commissioning providers. Their focus includes both private and public building owners, and a wide range of building types. PECI manages the annual National Conference on Building Commissioning.

Department of Engineering Professional Development University of Wisconsin, Madison

www.engr.wisc.edu

(800) 462-0876

Offers commissioning process training courses for building owners, architects, engineers, operations and maintenance staff, and other interested parties. The program also offers accreditation of commissioning process providers and managers.

Print Media

ASHRAE Guideline 0-2005: The Commissioning Process, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 2005

www.ashrae.org

(800) 527-4723

"The purpose of this Guideline is to describe the Commissioning Process capable of verifying that a facility and its systems meet the Owner's Project Requirements. The procedures, methods, and documentation requirements in this guideline describe each phase of the project delivery and the associated Commissioning Processes from pre-design through occupancy and operation, without regard to specific elements, assemblies, or systems, and provide the following: (a) overview of Commissioning Process activities, (b) description of each phase's processes, (c) requirements for acceptance of each phase, (d) requirements for documentation of each phase, and (e) requirements for training of operation and maintenance personnel. These Commissioning Process guideline procedures include the Total Building Commissioning Process (TBCxP) as defined by National Institute of Building Sciences (NIBS) in its Commissioning Process Guideline 0."

ASHRAE Guideline 1-1996: The HVAC Commissioning Process, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1996.

www.ashrae.org

(800) 527-4723

"The purpose of this guideline is to describe the commissioning process to ensure that heating, ventilating and air-conditioning (HVAC) systems perform in conformity with design intent. The procedures, methods and documentation requirements in this guideline cover each phase of the commissioning process for all types and sizes of HVAC systems, from pre-design through final acceptance and post-occupancy, including changes in building and occupancy requirements after initial occupancy."

ASHRAE Guideline 4-1993: Preparation of Operations & Maintenance Documentation for Building Systems, American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1993.

www.ashrae.org

(800) 527-4723

"The purpose of this guideline is to guide individuals responsible for the design, construction and commissioning of HVAC building systems in preparing and delivering O&M documentation."

Building Commissioning Guide, Office of Energy Efficiency and Renewable Energy Federal Energy Management Program, U.S. Department of Energy

www.eere.energy.gov

(800) DIAL-DOE

The Energy Policy Act of 1992 requires each federal agency to adopt procedures necessary to ensure that new federal buildings meet or exceed the federal building energy standards established by the U.S. Department of Energy (DOE). DOE's Federal Energy Management Program, in cooperation with the General Services Administration, developed the Building Commissioning Guide.

Commissioning for Better Buildings in Oregon, Oregon Office of Energy

http://egov.oregon.gov/ENERGY/CONS/BUS/comm/bldgcx.shtml

(503) 378-4040

This document (and website of the same name) contains a comprehensive introduction to the commissioning process, including research, financial benefits and case studies.

The Cost-Effectiveness of Commercial Buildings Commissioning: A Meta-Analysis of Existing Buildings and New Construction in the United States, available at:

http://eetd.lbl.gov/emills/PUBS/Cx-Costs-Benefits.html

PECI Model Building Commissioning Plan and Guide Specifications, Portland Energy Conservation Inc

www.peci.org

(503) 248-4636

Details the commissioning process for new equipment during design and construction phases for larger projects. In addition to commissioning guidelines, the document provides boilerplate language, content, format and forms for specifying and executing commissioning. The document builds upon the HVAC Commissioning Process, ASHRAE Guideline 1–1996, with significant additional detail, clarification and interpretation.

Commissioning Fact Sheets Coalition For High Performance Schools (CHPS)

www.chps.net/manual/index.htm

These fact sheets explore how commissioning can help school districts ensure their schools are built as high performance.

The Building Commissioning Handbook, Second Edition by John A. Heinz & Rick Casault, The Building Commissioning Association, 2004

www.bcxa.com

"This popular handbook has been revised by the original authors to include the most up-to-date information on all aspects of building commissioning. This is your guide to: Staying on Budget; Improving the Quality of your Buildings; Meeting your Schedule; Increasing Energy Efficiency. Chapters outline the commissioning process from pre-design to occupancy and explain the economics of commissioning and retro-commissioning."

Definitions

Basis of Design (BOD) includes design information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, other pertinent design assumptions (such as weather data), and references to applicable codes, standards, regulations and guidelines.

Commissioning (Cx) is the process of verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements.

Commissioning Plan is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

Commissioning Report is the document that records the results of the commissioning process, including the as-built performance of the HVAC system and unresolved issues.

Commissioning Specification is the contract document that details the commissioning requirements of the construction contractors.

The **Commissioning Team** includes those people responsible for working together to carry out the commissioning process.

Installation Inspection is the process of inspecting components of the commissioned systems to determine if they are installed properly and ready for systems performance testing.

Owner's Project Requirements (OPR) is a written document that details the functional requirements of a project and the expectations of how it will be used and operated.

Systems Performance Testing is the process of determining the ability of the commissioned systems to perform in accordance with the owner's project requirements, basis of design, and construction documents.

SS	WE	EA	MR	EQ	ID

Prerequisite 2

Required

Minimum Energy Performance

Intent

Establish the minimum level of energy efficiency for the proposed building and systems.

Requirements

Design the building project to comply with both—

- ❑ the mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) of ASHRAE/IESNA Standard 90.1-2004 (without amendments); and
- ❑ the prescriptive requirements (Sections 5.5, 6.5, 7.5 and 9.5) or performance requirements (Section 11) of ASHRAE/IESNA Standard 90.1-2004 (without amendments).

Potential Technologies & Strategies

Design the building envelope, HVAC, lighting, and other systems to maximize energy performance. The ASHRAE 90.1-2004 User's Manual contains worksheets that can be used to document compliance with this prerequisite. For projects pursuing points under EA Credit 1, the computer simulation model may be used to confirm satisfaction of this prerequisite.

If a local code has demonstrated quantitative and textual equivalence following, at a minimum, the U.S. Department of Energy standard process for commercial energy code determination, then it may be used to satisfy this prerequisite in lieu of ASHRAE 90.1-2004. Details on the DOE process for commercial energy code determination can be found at www.energycodes.gov/implement/determinations_com.stm.

Summary of Referenced Standard

ASHRAE/IESNA 90.1-2004: Energy Standard for Buildings Except Low-Rise Residential

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

Standard 90.1-2004 was formulated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), under an American National Standards Institute (ANSI) consensus process. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor of the standard.

Standard 90.1 establishes minimum requirements for the energy-efficient design of buildings, except low-rise residential buildings. The provisions of this standard do not apply to single-family houses, multi-family structures of three habitable stories or fewer above grade, manufactured houses (mobile and modular homes), or buildings that do not use either electricity or fossil fuel. Building envelope requirements are provided for semi-heated spaces, such as warehouses.

The standard provides criteria in the general categories shown in **Table 1**. Within each section, there are mandatory provisions that must always be complied with, as well as additional prescriptive requirements. Some sections also contain a performance alternate. The Energy Cost Budget option (section 11) allows the user to exceed some of the prescriptive requirements provided energy cost savings are made in other prescribed areas.

The Performance Rating Method option (Appendix G) provides a method for demonstrating performance beyond ASHRAE/IESNA 90.1-2004. In all cases, the mandatory provisions must still be met. See Design Strategies below for a more detailed summary of the requirements included in each section.

Approach and Implementation

LEED-NC addresses building energy efficiency in two places, EA Prerequisite 2 and EA Credit 1. EA Prerequisite 2 requires that the building comply with the mandatory provisions, and either the prescriptive or Energy Cost Budget Method performance requirements of ASHRAE/IESNA 90.1-2004 (Std. 90.1-2004). If energy simulations have been developed to document points earned for EA Credit 1, these energy simulations (based on Std. 90.1-2004 Appendix G) may be used rather than the Energy Cost Budget Method (Std. 90.1-2004 Section 11) to demonstrate compliance with the prerequisite.

Strategies

Each section of Std. 90.1-2004 describes the applicability of the provisions (e.g.,

Table 1: Scope of Requirements Addressed by ASHRAE 90.1-2004

ASHRAE/IESNA 90.1-2004 Components	
Section 5	Building Envelope (including semi-heated spaces such as warehouses)
Section 6	Heating, Ventilating and Air-Conditioning (including parking garage ventilation, freeze protection, exhaust air energy recovery, and condenser heat recovery for service water heating)
Section 7	Service Water Heating (including swimming pools)
Section 8	Power (including all building power distribution systems)
Section 9	Lighting (including lighting for exit signs, building exterior, grounds, and parking garage)
Section 10	Other Equipment (including all permanently wired electrical motors)

definitions and the building elements of interest), lists the mandatory provisions, and lists the prescriptive requirements for complying with the standard.

Building Envelope Requirements (Std. 90.1-2004 Section 5) apply to enclosed spaces heated by a heating system whose output capacity is equal to or greater than 3.4 Btu/hour-square foot, or cooled by a cooling system whose sensible output capacity is equal to or greater than 5 Btu/hour-square foot.

Std. 90.1-2004 Section 5.4 describes mandatory provisions for insulation installation (5.4.1); window, skylight and door ratings (5.4.2); and air leakage (5.4.3). Std. 90.1-2004 part 5.5 contains the prescriptive provisions for fenestration and opaque assemblies.

Each county in the United States is assigned into one of eight representative climate zones (Std. 90.1-2004 Table B-1). Climate zone assignments for Canadian cities can be determined from Std. 90.1-2004 Table B-2, and climate zone assignments for other international cities can be determined from Std. 90.1-2004 Table B-3.

Prescriptive building envelope requirements are determined based on the building's climate zone classification (Std. 90.1-2004 Tables 5.5-1 to 5.5-8). For projects following the prescriptive compliance method, all building envelope components must meet the minimum insulation and maximum U-factor and SHGC requirements listed for the project's climate zone. Also, window area must be less than 50% of the gross wall area, and the skylight area must be less than 5% of the gross roof area.

For projects following the Energy Cost Budget Method in Section 11, the project may exceed the envelope prescriptive requirements, provided that the design energy cost for the project does not exceed the energy cost budget for the entire building; OR provided that the project uses energy simulation to document points earned for EA Credit 1.

Heating Ventilation and Air Conditioning Requirements (Std. 90.1-2004 Section 6) apply for all building heating and air conditioning systems. Mandatory provisions for HVAC performance are documented in Std. 90.1-2004 Section 6.4, and include minimum system efficiency requirements (6.4.1); load calculation requirements (6.4.2); controls requirements (6.4.3); HVAC System Construction and Insulation requirements (6.4.4); and completion requirements (6.4.5).

The minimum system component efficiency requirements listed in Std. 90.1-2004 Tables 6.8.1A-G must be met even when using the Energy Cost Budget or Performance Rating methods.

Std. 90.1-2004 Section 6 lists minimum control schemes forthermostats (off-hours including setback and optimum start/stop), stairand elevator vents, outdoor air supply and exhaust vents, heat pumpauxiliary heat, humidification and dehumidification, freeze protection,snow/ice melting systems, and ventilation for high occupancy areas.

Std. 90.1-2004 Part 6.5 provides a prescriptive compliance option. Prescriptive provisions are included for air and water economizers (6.5.1); simultaneous heating and cooling limitations (6.5.2); air system design and control including fan power limitation and variable speed drive control (6.5.3); hydronic system design and control including variable flow pumping (6.5.4); heat rejection equipment (6.5.5); energy recovery from exhaust air and service water heating systems (6.5.6); kitchen and fume exhaust hoods (6.5.7); radiant heating systems (6.5.8); and hot gas bypass limitations (6.5.9).

For projects served by existing HVAC systems, such as a central plant on a campus or district heating and cooling, the exception to section 6.1.1.2 applies. The existing systems and existing equipment are not required to comply with the standard.

Service Water Heating Requirements (Std. 90.1-2004 Section 7) include mandatory provisions (7.4); and a choice of prescriptive (7.5) or performance based compliance (11). Mandatory provisions include requirements for load calculations (7.4.1); efficiency (7.4.2); piping insulation (7.4.3); controls 7.4.4); pool heaters and pool covers (7.4.5); and heat traps for storage tanks (7.4.6).

Power Requirements address mandatory provisions related to voltage drop (Std. 90.1-2004 Section 8.4.1).

Lighting Requirements (Std. 90.1-2004 Section 9) apply to all lighting installed on the building site including interior and exterior lighting. Mandatory provisions include minimum requirements for controls (9.4.1); tandem wiring (9.4.2); luminaire source efficacy for exit signs (9.4.3); exterior lighting power definitions (9.4.5); and luminaire source efficacy for exterior lighting fixture (9.4.6). Per 9.4.1.2, occupancy controls are required in classrooms, conference rooms and employee lunch and break rooms. Interior lighting compliance must be documented using either the Building Area Method (9.5) or the Space-by-Space Method (9.6).

Lighting power calculations for Performance Methods must use the Building Area Method or the Space-by-Space Method. For both methods, the total installed interior lighting power is calculated by summing the luminaire wattages for all permanently installed general, task and furniture lighting, where the luminaire wattage includes lamps, ballasts, current regulators and control devices.

Building Area Method calculations can only be used in cases where the project involves the entire building, or a single independent occupancy within a multi-occupancy building. Allowable lighting power for this method is calculated by multiplying the allowable lighting power density for the given building type (found in Std. 90.1-2004 Table 9.5.1) by the interior building area.

Allowable lighting for the Space-by-Space Method is determined by summing the product of the allowable lighting power density for each space function in the building (found in Std. 90.1-2004 Table 9.6.1) by the corresponding area for each space function. If the total installed interior lighting power is lower than the interior lighting power allowance calculated using either the Building Area or Space-by-Space Method, the project complies.

The exterior lighting power allowance is calculated by summing the product of the allowable lighting power allowance for each exterior surface (found in Std. 90.1-2004 Table 9.4.5) by the total area or length associated with that surface, and then multiplying this number by 1.05. For non-tradable exterior lighting surfaces, the allowed lighting power can only be used for the specific application and cannot be traded between surfaces or with other exterior lighting.

Other Equipment Requirements including requirements for electric motors are addressed in Std. 90.1-2004 Section 10. This section only contains mandatory provisions (10.4).

The Energy Cost Budget Method is presented in Std. 90.1-2004 Section 11 and describes the process to set up and execute a building simulation to demonstrate compliance. This is the alternate to following the prescriptive provisions of this standard.

The Performance Rating Method is presented in Std. 90.1-2004 Appendix G, and is the required method for claiming credit under EA Credit 1: Optimize Energy Performance. If the project is using the Performance Rating Method to achieve points under EA Credit 1, the EA Credit 1 documentation can be used to prove compliance with the performance requirements (the second part) of this Prerequisite. The Performance Rating Method does not, however, exempt the project from also meeting the mandatory ASHRAE/IESNA Standard 90.1-2004 requirements listed for this prerequisite.

EA Credit 1 includes a more detailed discussion of the Performance Rating Method.

Calculations

Follow the calculation and documentation methodology as prescribed in Std. 90.1-2004. Record all calculations on the appropriate forms. These forms (see **Table 2**) and further information regarding the calculation methodology are available with the ASHRAE/IESNA Standard 90.1-2004 User's Guide.

Exemplary Performance

There is no exemplary performance point available for this prerequisite.

Submittal Documentation

This prerequisite is submitted as part of the **Design Submittal**.

The following project data and calculation information is required to document prerequisite compliance using the v2.2 Submittal Templates:

- ❑ Confirm that the project meets the requirements of ASHRAE Std. 90.1-2004.
- ❑ Provide an optional narrative regarding special circumstances or considerations regarding the project's prerequisite approach.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Advanced Buildings

www.advancedbuildings.org

Hosted by a Canadian public/private consortium, this site provides explana-

Table 2: Forms for documenting compliance with ASHRAE Std. 90.1-2004

ASHRAE/IESNA 90.1-2004 Compliance Forms
Mandatory Measures – All Projects:
Building Envelope Compliance Documentation (Part I) – Mandatory Provisions Checklist HVAC Compliance Documentation (Part II) – Mandatory Provisions Checklist Service Water Heating Compliance Documentation (Part I) – Mandatory Provisions Checklist Lighting Compliance Documentation (Part I) – Mandatory Provisions Checklist
Prescriptive Requirements – Projects Using Prescriptive Compliance Approach:
Building Envelope Compliance Documentation (Part II) HVAC Compliance Documentation Part I (for small buildings < 25,000 square feet using the simplified approach), and Part III (for all other buildings) Service Water Heating Compliance Documentation
Performance Requirements – Projects Using Performance Compliance Approach:
Energy Cost Budget Compliance Report (when credit is not being sought under EA Credit 1) Performance Rating Report (when credit is being sought under EA Credit 1) Table documenting energy-related features included in the design, and including all energy features that differ between the Baseline Design and Proposed Design models

tions, costs, and information sources for 90 technologies and practices that improve the energy and resource efficiency of commercial and multi-unit residential buildings.

American Council for an Energy Efficient Economy

www.aceee.org

(202) 429-8873

ACEEE is a nonprofit organization dedicated to advancing energy efficiency as a means of promoting both economic prosperity and environmental protection.

Buildings Upgrade Manual

ENERGY STAR®

www.energystar.gov/index.cfm?c=business.bus_upgrade_manual

(888) 782-7937

This document from the EPA is a guide for ENERGY STAR Buildings Partners to use in planning and implementing profitable energy-efficiency upgrades in their facilities and can be used as a comprehensive framework for an energy strategy.

New Buildings Institute, Inc.

www.newbuildings.org

(509) 493-4468

The New Buildings Institute is a nonprofit, public-benefits corporation dedicated to making buildings better for people and the environment. Its mission is to promote energy efficiency in buildings through technology research, guidelines and codes.

Building Energy Codes Program

U.S. Department of Energy

www.energycodes.gov

(800) DIAL-DOE

The Building Energy Codes program provides comprehensive resources for states and code users,including news, compliance software, code comparisons and the Status of State Energy Codes database. The database includes state energy contacts, code status, code history, DOE grants awarded and construction data. The program is also updating the COM*Check*EZ™ compliance tool to include ANSI/ASHRAE/IESNA 90.1-2004. This compliance tool includes the prescriptive path and trade-off compliance methods. The software generates appropriate compliance forms as well.

Office of Energy Efficiency and Renewable Energy

U.S. Department of Energy

www.eere.energy.gov

(800) DIAL-DOE

A comprehensive resource for Department of Energy information on energy efficiency and renewable energy, including access to energy links and downloadable documents.

Print Media

ASHRAE 90.1 User's Manual

The 90.1 User's Manual was developed as a companion document to the ANSI/ASHRAE/IESNA Standard 90.1-2004 (Energy Standard for Buildings Except Low-Rise Residential Buildings). The User's Manual explains the new standard and includes sample calculations, useful reference material, and information on the intent and application of the standard. The User's Manual is abundantly illustrated and contains numerous examples and tables of reference data. The manual also includes a complete set of compliance forms and worksheets that can be used to document compliance with the standard. The User's Manual is helpful to architects and engineers applying the standard to the design of buildings; plan examiners and field inspectors who must enforce the standard in areas where it is adopted as code; and contractors who must construct buildings in compliance with the standard. A compact disc containing electronic versions of the compliance forms found in the User's Manual is included.

SS | WE | EA | MR | EQ | ID

Prerequisite 3

Required

Fundamental Refrigerant Management

Intent

Reduce ozone depletion.

Requirements

Zero use of CFC-based refrigerants in new base building HVAC&R systems. When reusing existing base building HVAC equipment, complete a comprehensive CFC phase-out conversion prior to project completion. Phase-out plans extending beyond the project completion date will be considered on their merits.

Potential Technologies & Strategies

When reusing existing HVAC systems, conduct an inventory to identify equipment that uses CFC refrigerants and provide a replacement schedule for these refrigerants. For new buildings, specify new HVAC equipment in the base building that uses no CFC refrigerants.

Summary of Referenced Standard

There is no standard referenced for this prerequisite.

Approach and Implementation

Replace or retrofit any CFC-based refrigerants in existing base building HVAC&R and fire suppression systems. If the building(s) is connected to an existing chilled water system, that system must be CFC-free; or a commitment to phasing out CFC-based refrigerants, with a firm timeline of five years from substantial completion of the project, must be in place. Prior to phase-out, reduce annual leakage of CFC-based refrigerants to 5% or less using EPA Clean Air Act, Title VI, Rule 608 procedures governing refrigerant management and reporting.

An alternative compliance path for buildings connected to a central chilled water system requires a third party (as defined in the LEED-EB Reference Guide) audit showing that system replacement or conversion is not economically feasible. The definition of the required economic analysis is: the replacement of a chiller(s) will be considered to be not economically feasible if the simple payback of the replacement is greater than 10 years. To determine the simple payback, divide the cost of implementing the replacement by the annual cost avoidance for energy that results from the replacement and any difference in maintenance costs, including make-up refrigerants. If CFC-based refrigerants are maintained in the central system, reduce annual leakage to 5% or less using EPA Clean Air Act, Title VI, Rule 608 procedures governing refrigerant management and reporting, and reduce the total leakage over the remaining life of the unit to less than 30% of its refrigerant charge.

Consider the characteristics of various CFC substitutes. Refrigerants have varying applications, lifetimes, ozone-depleting potentials (ODPs) and global-warming potentials (GWPs). **Table 1** shows the Ozone Depleting Potential (ODP) and direct Global Warming Potential (GWP) of many common refrigerants. Refrigerants chosen should have short environmental lifetimes, small ODP values and small GWP values.

No “ideal” alternative for CFCs has been developed. See the EPA’s List of Substitutes for Ozone-Depleting Substances (www.epa.gov/ozone/snap) for a current listing of alternatives to CFC refrigerants. Note that some alternatives are not suitable for retrofits.

Calculations

There are no calculations associated with this prerequisite.

Exemplary Performance

There is no exemplary performance point available for this prerequisite.

Submittal Documentation

This prerequisite is submitted as part of the **Design Submittal**.

The following project data and calculation information is required to document prerequisite compliance using the v2.2 Submittal Templates:

❑ Confirm that the project does not use CFC refrigerants.

OR

❑ Confirm that the project has a phase-out plan for any existing CFC-based equipment.

❑ Provide a narrative description of the phase-out plan, including dates and refrigerant quantities as a percentage of the overall project equipment.

Table 1: Ozone-depletion and global-warming potentials of refrigerants (100-yr values)

Refrigerant	ODP	GWP	Common Building Applications
Chlorofluorocarbons			
CFC-11	1.0	4,680	Centrifugal chillers
CFC-12	1.0	10,720	Refrigerators, chillers
CFC-114	0.94	9,800	Centrifugal chillers
CFC-500	0.605	7,900	Centrifugal chillers, humidifiers
CFC-502	0.221	4,600	Low-temperature refrigeration
Hydrochlorofluorocarbons			
HCFC-22	0.04	1,780	Air conditioning, chillers,
HCFC-123	0.02	76	CFC-11 replacement
Hydrofluorocarbons			
HFC-23	~ 0	12,240	Ultra-low-temperature refrigeration
HFC-134a	~ 0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	~ 0	1,020	Insulation agent, centrifugal chillers
HFC-404A	~ 0	3,900	Low-temperature refrigeration
HFC-407C	~ 0	1,700	HCFC-22 replacement
HFC-410A	~ 0	1,890	Air conditioning
HFC-507A	~ 0	3,900	Low-temperature refrigeration
Natural Refrigerants			
Carbon Dioxide (CO2)	0	1.0	
Ammonia (NH3)	0	0	
Propane	0	3	

Considerations

Cost Issues

Renovations of some existing buildings will require additional first costs to convert or replace existing HVAC&R and fire suppression systems currently using CFCs. Replacement rather than conversion of HVAC systems may increase equipment efficiencies and enable projects to reap energy savings over the life of the building.

Environmental Issues

Older refrigeration equipment used chlorofluorocarbons (CFCs) in refrigerants. CFCs, when inevitably released to the atmosphere, cause significant damage to the protective ozone layer in the earth's upper atmosphere.

The reaction between a CFC and an ozone molecule in the earth's stratosphere destroys the ozone and reduces the stratosphere's ability to absorb a portion of the sun's ultraviolet (UV) radiation. Overexposure to UV rays can lead to skin cancer, cataracts and weakened immune systems. Increased UV can also lead to reduced crop yield and disruptions in the marine food chain.

CFCs fall into a larger category of ozone depleting substances (ODSs). Recognizing the profound human health risks associated with ozone depletion, 160 countries have agreed to follow the Montreal Protocol on Substances that Deplete the Ozone Layer since the late 1980s. This treaty includes a timetable for the phase-out of production and use of ODSs. In compliance with the Montreal Protocol, CFC production in the United States ended in 1995.

As part of the U.S. commitment to implementing the Montreal Protocol, Congress added new provisions to the Clean Air Act designed to help preserve and protect the stratospheric ozone layer. These amendments require the U.S. Environmental Protection Agency (EPA) to develop and implement regulations for the responsible management of ozone depleting substances in the United States. EPA regulations include programs that ended the domestic production of ODSs, identified safe and effective alternatives to ODSs, and require manufacturers to label products either containing or made with chemicals that have a significant ozone depleting potential.

Banning the use of CFCs in refrigerants has slowed the depletion of the ozone layer. Specification of non-CFC building equipment is now standard and CFC-based refrigerants are no longer available in new equipment.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Ozone Depletion

U.S. Environmental Protection Agency

www.epa.gov/ozone

Provides information about the science of ozone depletion, the regulatory approach to protecting the ozone layer (including phase-out schedules) and alternatives to ozone-depleting substances.

The Treatment by LEED of the Environmental Impact of HVAC Refrigerants

U.S. Green Building Council

www.usgbc.org/DisplayPage.aspx?CMSPageID=154

This report was prepared under the auspices of the U.S. Green Building Council's LEED Technical and Scientific Advisory Committee (TSAC), in response to a charge given TSAC by the LEED Steering Committee to review the atmospheric environmental impacts arising from the use of halocarbons as refrigerants in building heating, ventilating, and air conditioning (HVAC) equipment.

Print Media

CFCs, HCFC and Halons: Professional and Practical Guidance on Substances that Deplete the Ozone Layer, ASHRAE, 2000.

The Refrigerant Manual: Managing The Phase-Out of CFCs, BOMA International, 1993.

Definitions

Chlorofluorocarbons (CFCs) are hydrocarbons that deplete the stratospheric ozone layer.

Hydrochlorofluorocarbons (HCFCs) are refrigerants that cause significantly less depletion of the stratospheric ozone layer compared to CFCs.

Refrigerants are the working fluids of refrigeration cycles. They absorb heat from a reservoir at low temperatures and reject heat at higher temperatures.

SS	WE	EA	MR	EQ	ID

Credit 1

1–10 points

Optimize Energy Performance

Intent

Achieve increasing levels of energy performance above the baseline in the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.

Requirements

Select one of the three compliance path options described below. Project teams documenting achievement using any of the three options are assumed to be in compliance with EA Prerequisite 2.

OPTION 1 — WHOLE BUILDING ENERGY SIMULATION (1–10 Points)

Demonstrate a percentage improvement in the proposed building performance rating compared to the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2004 (without amendments) by a whole building project simulation using the Building Performance Rating Method in Appendix G of the Standard. The minimum energy cost savings percentage for each point threshold is as follows:

New Buildings	Existing Building Renovations	Points
10.5%	3.5%	1
14%	7%	2
17.5%	10.5%	3
21%	14%	4
24.5%	17.5%	5
28%	21%	6
31.5%	24.5%	7
35%	28%	8
38.5%	31.5%	9
42%	35%	10

Appendix G of Standard 90.1-2004 requires that the energy analysis done for the Building Performance Rating Method include ALL of the energy costs within and associated with the building project. To achieve points using this credit, the proposed design—

- ❑ must comply with the mandatory provisions (Sections 5.4, 6.4, 7.4, 8.4, 9.4 and 10.4) in Standard 90.1-2004 (without amendments);
- ❑ must include all the energy costs within and associated with the building project; and
- ❑ must be compared against a baseline building that complies with Appendix G to Standard 90.1-2004 (without amendments). The default process energy cost is 25% of the total energy cost for the baseline building. For buildings where the process energy cost is less than 25% of the baseline building energy cost, the LEED submittal must include supporting documentation substantiating that process energy inputs are appropriate.

For the purpose of this analysis, process energy is considered to include, but is not limited to, office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, lighting exempt from the lighting power allowance (e.g., lighting integral to medical equipment) and other (e.g., waterfall pumps). Regulated (non-process) energy includes lighting (such as for the interior, parking garage, surface parking, façade, or building grounds, except as noted above), HVAC (such as for space heating, space cooling, fans, pumps, toilet exhaust, parking garage ventilation, kitchen hood exhaust, etc.), and service water heating for domestic or space heating purposes.

For EA Credit 1, process loads shall be identical for both the baseline building performance rating and for the proposed building performance rating. However, project teams may follow the Exceptional Calculation Method (ASHRAE 90.1-2004 G2.5) to document measures that reduce process loads. Documentation of process load energy savings shall include a list of the assumptions made for both the base and proposed design, and theoretical or empirical information supporting these assumptions.

OR

OPTION 2 — PRESCRIPTIVE COMPLIANCE PATH (4 Points)

Comply with the prescriptive measures of the ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004. The following restrictions apply:

- ❑ Buildings must be under 20,000 square feet
- ❑ Buildings must be office occupancy
- ❑ Project teams must fully comply with all applicable criteria as established in the Advanced Energy Design Guide for the climate zone in which the building is located

OR

OPTION 3 — PRESCRIPTIVE COMPLIANCE PATH (1 Point)

Comply with the Basic Criteria and Prescriptive Measures of the Advanced Buildings Benchmark™ Version 1.1 with the exception of the following sections: 1.7 Monitoring and Trend-logging, 1.11 Indoor Air Quality, and 1.14 Networked Computer Monitor Control. The following restrictions apply:

- ❑ Project teams must fully comply with all applicable criteria as established in Advanced Buildings Benchmark for the climate zone in which the building is located.

Potential Technologies & Strategies

Design the building envelope and systems to maximize energy performance. Use a computer simulation model to assess the energy performance and identify the most cost-effective energy efficiency measures. Quantify energy performance as compared to a baseline building.

If a local code has demonstrated quantitative and textual equivalence following, at a minimum, the U.S. Department of Energy standard process for commercial energy code determination, then the results of that analysis may be used to correlate local code performance with ASHRAE 90.1-2004. Details on the DOE process for commercial energy code determination can be found at www.energycodes.gov/implement/determinations_com.stm.

Summary of Referenced Standard

OPTION 1—ASHRAE/IESNA 90.1-2004: Energy Standard for Buildings Except Low-Rise Residential, and Informative Appendix G – Performance Rating Method.

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

Standard 90.1-2004 was formulated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE), under an American National Standards Institute (ANSI) consensus process. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor of the standard. ASHRAE 90.1 Standards form the basis for many of the commercial requirements in codes that states consider for adoption.

Standard 90.1 establishes minimum requirements for the energy-efficient design of buildings, except low-rise residential buildings. The provisions of this standard do not apply to single-family houses, multi-family structures of three habitable stories or fewer above grade, manufactured houses (mobile and modular homes), buildings that do not use either electricity or fossil fuel, or equipment and portions of building systems that use energy primarily for industrial, manufacturing or commercial processes. Building envelope requirements are provided for semi-heated spaces, such as warehouses.

Appendix G is an informative appendix for rating the energy efficiency of building designs. This appendix is NOT to be included as part of the minimum requirements to comply with code; instead, Appendix G is used to "quantify performance that substantially exceeds the requirements of Standard 90.1" (G1.1).

For EA Credit 1, LEED relies extensively on the Performance Rating Method explained in Appendix G. The method provides performance criteria for the components listed in **Table 1**.

The Performance Rating Method is intended to demonstrate performance beyond ASHRAE/IESNA 90.1-2004 through an interactive model that allows comparison of the total energy cost for the Proposed Design and a Baseline Design. To accomplish this efficiently, a number of restrictions on the modeling process are imposed by the method. Examples include simplified climate data, the fact that both buildings must have a mechanical system, and that process loads are to be included in both designs. Important restrictions that must be addressed to achieve compliance with the credit are highlighted in the Calculations section.

OPTION 2—ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004

American Society of Heating, Refrigerating and Air-Conditioning Engineers

Table 1: Scope of Requirements Addressed by ASHRAE/IESNA 90.1-2004

ASHRAE/IESNA 90.1-2004 Components	
Section 5	Building Envelope (including semi-heated spaces such as warehouses)
Section 6	Heating, Ventilating and Air-Conditioning (including parking garage ventilation, freeze protection, exhaust air energy recovery, and condenser heat recovery for service water heating)
Section 7	Service Water Heating (including swimming pools)
Section 8	Power (including all building power distribution systems)
Section 9	Lighting (including lighting for exit signs, building exterior, grounds, and parking garage)
Section 10	Other Equipment (including all permanently wired electrical motors)

www.ashrae.org

(800) 527-4723

Advanced Energy Design Guide for Small Office Buildings 2004 was formulated by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) to provide a simplified approach in small office buildings for exceeding ASHRAE 90.1-1999 standards. The guide provides climate-specific recommendations relative to the building envelope, interior lighting, and HVAC systems that will improve building energy performance beyond ASHRAE 90.1-1999 by approximately 30%.

OPTION 3—Advanced Buildings Benchmark™ Version 1.1

New Buildings Institute

Advanced Buildings Benchmark™ Version 1.1 was formulated by the New Buildings Institute to provide a method for exceeding national codes and standards, and to provide a standardized method for determining building performance.

For EA Credit 1—OPTION 3, LEED requires full compliance with all applicable criteria in the Sections of the Advanced Buildings Benchmark Version 1.1 shown in **Table 2**.

Approach and Implementation

Option 1

The ASHRAE/IESNA Standards 90.1-2004 Informative Appendix G Performance Rating Method is an effective method for rating building energy performance, and for evaluating the relative costs and benefits of different energy efficiency strategies.

The terminology used by the Performance Rating Method is used in this LEED credit. The term "Proposed Building Performance" refers to the "the annual energy cost calculated for a proposed design." The term "Baseline Building Performance" refers to "the annual energy cost for a building design intended for

Table 2: Scope of Requirements Addressed by Advanced Buildings Benchmark™ Version 1.1 as pertaining to LEED Credit 1 Option 3

Advanced Buildings Benchmark™ Version 1.1 Criteria	
Section 5	
Required 1.1	Design Certification
Required 1.2	Construction Certification
Required 1.3	Operations Certification
Required 1.4	Energy Code Compliance
Required 1.5	Air Barrier Performance
Required 1.6	Window, Skylight and Door Certification
Required 1.8	Energy Efficient Transformers
Required 1.9	Lighting Controls
Required 1.10	Outdoor Lighting
Required 1.12	Below-Grade Exterior Insulation
Required 1.13	Refrigeration and Icemaker Efficiency Requirements
Section 6	
Required 2.1	Opaque Envelope Performance
Required 2.2	Fenestration Performance
Required 2.3	Cool Roofs and Ecoroofs
Required 2.4	Mechanical System Design
Required 2.5	Mechanical Equipment Efficiency Requirements
Required 2.6	Variable Speed Control
Required 2.7	Lighting Power Density

use as a baseline for rating above standard design." The modeling methodology addressed in Appendix G of ASHRAE/IESNA 90.1-2004 describes procedures for establishing the Proposed Building Performance and the Baseline Building Performance in order to evaluate the Percentage Improvement in energy cost for the project.

The Performance Rating Method requires the development of an energy model for the Proposed Design, which is then used as the basis for generating the Baseline Design energy model. As the design progresses, any updates made to the Proposed Design energy model (such as changes to the building orientation, wall area, fenestration area, space function, HVAC system type, HVAC system sizing, etc.) should also be reflected in the Baseline Design energy model as dictated by Appendix G.

The Performance Rating Method described in Appendix G is a modification of the Energy Cost Budget (ECB) Method in Section 11 of ASHRAE 90.1-2004. A model using the Energy Cost Budget Method will NOT be accepted for credit under EA Credit 1.

The major differences between the ECB method and the Performance Rating Method are as follows:

1. **Building Schedules** (Table G3.1.4):

   In the Performance Rating Method, building occupancy, lighting, and other schedules may be altered to model efficiency measures as long as these modifications are both reasonable and defensible. In the Energy Cost Budget Method, schedules may not be altered.

2. **Baseline Building Envelope** (Table G3.1.5):

   a. **Orientation:** The Performance Rating Method requires that the Baseline Building be simulated one time for each of four distinct building orientations, and that the results be averaged to calculate the Baseline Building Performance. The Energy Cost Budget requires that the Budget Building be modeled with an orientation identical to the Proposed Building.

   b. **Opaque Assemblies:** The Performance Rating Method specifies the type of assembly required for the Baseline Building wall, roof, and floor construction. The ECB method varies the construction assembly type modeled in the Budget Building Design based on the actual construction assembly type modeled in the Proposed Design.

   c. **Vertical Fenestration:** The Performance Rating Method limits the total fenestration modeled for the Baseline Building to 40% of the gross wall area or the actual fenestration percentage, whichever is less; and requires that this fenestration be uniformly distributed across all four orientations. The Energy Cost Budget Method limits the fenestration modeled to 50% of the gross wall area or the actual fenestration percentage, whichever is less; and requires that the fenestration be distributed similarly to the Proposed Design.

3. **Baseline Building HVAC System**:

   a. **HVAC System Type Selection** (Table G3.1.10, and Section G3.1.1, G3.1.2 and G3.1.3): Baseline Building system type selection using the Performance Rating Method is determined based on building type, building area, quantity of floors and the heating fuel source for the proposed design. This method allows credit for selecting inherently efficient HVAC system types. In the Energy Cost Budget Method, Budget Building system type is determined based on the proposed design condenser cooling source, heating system classification, and single zone versus multi-zone classification. This method allows much less variation between the Proposed and Baseline Design Systems.

b. **Baseline Fan Power:** With the Performance Rating Method, total fan power for the Baseline System is fixed based on total supply air volume, and system classification as constant volume or variable volume. This method reflects the savings achieved through an improved duct design that reduces static pressure. With the Energy Cost Budget Method, the fan static pressure remains the same in the budget and the proposed case.

c. **Baseline System Sizing:** With the Performance Rating Method, the Baseline System is sized using default ratios. This allows credit for systems that are appropriately sized, and penalizes oversized systems. With the Energy Cost Budget Method, Budget Systems are sized with the same sizing factors as the Proposed Design.

Starting the energy modeling early in the project design can provide insights for design decisions and can provide an early indication of what it will take to achieve certain levels of energy cost reductions (and associated EA Credit 1 points) for a particular project.

The modeling methodology outlined in the Performance Rating Method enables the design team to identify the interactive effects of energy efficiency measures across all the building systems. For example, when the proposed lighting power is changed, this affects both the heating and cooling energy consumption. When building lighting power density is decreased in a hot climate with little or no heating, the model will indicate the quantity of additional cooling energy savings (due to lower internal loads) and how much the peak cooling equipment can be downsized (for first cost savings). For a cold climate, the model will reflect lower cooling energy savings, and an increase in heating energy (due to a lower internal load). In almost all cases, there will be savings beyond that of the lighting alone, with the greatest savings in the hottest climates and the least savings in the coldest climates.

The Performance Rating Method requires that annual energy cost expressed in dollars be used to calculate the percentage improvement in energy usage. Annual energy costs are determined using rates for purchased energy such as electricity, gas, oil, propane, steam and chilled water that are based on actual local utility rates, or that are based on the state average prices published annually by the U.S. Department of Energy's Energy Information Administration (EIA) at www.eia.doe.gov.

Strategies

Four fundamental strategies can increase energy performance: reduce demand, harvest free energy, increase efficiency, and recover waste energy.

- ❑ Accomplish demand reduction by optimizing building form and orientation, by reducing internal loads through shell and lighting improvements, and by shifting load to off-peak periods.
- ❑ Harvesting site energy includes using free resources such as daylight, ventilation cooling, solar heating and power, and wind energy to satisfy needs for space conditioning, service water heating and power generation.
- ❑ Increasing efficiency can be accomplished with more efficient envelope, lighting, and HVAC systems, and by appropriately sizing HVAC systems. More efficient systems reduce energy demand and energy use.

- ❑ Finally, waste energy can be recovered through exhaust air energy recovery systems, graywater heat recovery systems, and cogeneration. When applying these strategies, it is important to establish and document energy goals and expectations, and apply modeling techniques to reach these goals.

Option 2

For small office buildings less than 20,000 sq.ft., the ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004 provides an effective means of limiting building energy usage, and documenting improved building energy performance without the need for a building energy model. The climate-specific recommendations listed in the ASHRAE Advanced Energy Design Guide should be incorporated into the project early in the building design in order to optimize building performance with minimal impact on capital costs.

To comply with the prescriptive measures of the ASHRAE Advanced Energy Design Guide, the project team must first identify the climate zone where the building is located. Section 3 includes a United States map defining the eight climate zones by county borders.

The project team can then find the appropriate Climate Zone Recommendation table identifying all of the prescriptive criteria required for their project. These criteria include recommendations for roofs, walls, floors, slabs, doors, vertical glazing, skylights, interior lighting, ventilation, ducts, energy recovery, and service water heating. To achieve EA Credit 1, project teams must fully comply with all recommendations established in the Advanced Energy Design Guide for the climate zone in which the building is located.

Option 3

The Basic Criteria and Prescriptive Measures of the Advanced Buildings Benchmark™ Version 1.1 provide a prescriptive means of improving building energy performance. To comply with some of these measures, the project team must identify the climate zone where the building is located. The Advanced Buildings Benchmark™ Section 6.1 includes a United States map defining the eight climate zones by county borders. To achieve EA Credit 1, project teams must fully comply with all Advanced Buildings Benchmark v1.1 Criteria listed in **Table 2** above in the Summary of Referenced Standards.

Calculations

Option 2 and Option 3 of the EA Credit 1 credit use a prescriptive approach and do not require a software energy simulation of the project.

Option 1 relies entirely upon the ASHRAE 90.1-2004 Appendix G Performance Rating Method, and requires extensive calculations using an approved energy simulation program. The Performance Rating Method in 90.1 Appendix G is NOT equivalent to the Energy Cost Budget (ECB) Method in 90.1 Section 11, and the ECB Method will not be accepted for credit under LEED-NC v2.2 EA Credit 1.

A total of five energy simulation runs are required in order to demonstrate compliance using the Performance Rating Method. This includes one Proposed Design simulation which models the building as designed (with some minor exceptions), and four Baseline Design simulations. The four Baseline Design energy models are identical to each other, except that the building orientation for each model is modified as described in ASHRAE Std. 90.1 Table G3.5.1(a), and the window SHGCs are revised to reflect the minimum ASHRAE Building Envelope Requirements for the revised building orientation.

The total annual energy cost projected by the Proposed Design simulation is called the "Proposed Building Performance." The average of the total projected annual energy costs for the four Baseline Design simulations is called the "Baseline Building Performance."

The basic method for demonstrating compliance is to first model and simulate the Proposed Design, and then revise the model parameters for the Baseline Design as described in Appendix G, and simulate the Baseline Design using each of the four prescribed orientations. A major difference between the Proposed Design and the Baseline Design is that the windows are distributed equally around the building in the Baseline Design.

Both the Baseline Building model and the Proposed Building model must include all building energy components including, but not limited to, interior and exterior lighting, cooling, heating, fan energy (including garage ventilation and exhaust fans), pumping, heat rejection, receptacle loads, freeze protection, elevators and escalators, swimming pool equipment, refrigeration, and cooking equipment.

Schedules of operation must be the same for the Proposed and Budget Building models unless schedule changes are necessary to model non-standard efficiency measures such as lighting controls, natural ventilation, demand control ventilation, or service water heating load reductions (ASHRAE Std. 90.1 Table G3.1.4). If there are schedule of operation differences between the Baseline Building model and the Proposed Building model these differences should be clearly and explicitly described in the EA Credit 1 submittal narrative.

Design criteria, including both climate data and interior temperature and humidity setpoints, must be the same for the Proposed and Baseline Building models. Furthermore, both heating and cooling must be modeled in all conditioned spaces of both the Proposed and Baseline Building energy models, even if no heating or cooling system will be installed. Buildings that have no mechanical heating and/or cooling system, can achieve some credit by modeling fan systems as "cycling" in the Proposed Design versus continuously operated fans in the Baseline Design (ASHRAE Std. 90.1 Table G3.1 No. 4 – Fan Schedules).

Building Envelope (ASHRAE Std. 90.1 Table G3.1.5) will likely vary significantly between the Proposed and Baseline Design models. The Performance Rating Method requires that the Proposed Design be modeled as designed with a few minor exceptions. For the Baseline Design of new buildings, the above-grade walls, roof, and floor assemblies must be modeled using light-weight assembly types (i.e., steel-framed walls, roofs with insulation entirely above deck, and steel-joist floors), with the ASHRAE Std. 90.1 prescriptive maximum U-factors for the building's climate. Even if the Proposed Design incorporates mass wall construction, the Baseline Design must be modeled using a steel-framed assembly.

The percentage of vertical fenestration modeled in the Budget Design should match that of the Proposed Design or 40% of the gross wall area, whichever is less. This fenestration must be equally distributed in horizontal bands across all four orientations.

"Cool roofs" (light colored roof finishes that have low heat absorption) can be modeled in the Proposed Design to show the impact of reduced heat gains. If the proposed roof is rated at a minimum initial solar reflectance of 0.70 and a minimum thermal emittance of 0.75, the Proposed Design can use a modeled reflectivity of 0.45 (accounting for degradation in actual reflectivity) versus the default reflectivity value of 0.30 which will be modeled for the Baseline Design.

Shading projections in the Proposed Design, which reduce the solar gains on the glazing, can also be modeled to demonstrate energy savings compared to the Baseline model which will have fenestration flush to the exterior wall. Manually controlled interior shading devices such as blinds and curtains should not be modeled in either the Proposed or Baseline Design. However, automatically controlled interior shading devices can be modeled for credit in the Proposed Design, per ASHRAE Std. 90.1 Appendix G.

For existing buildings that are being renovated, the building envelope design parameters for the Baseline Design should be modeled using the existing (pre-retrofit) building envelope thermal parameters rather than the ASHRAE Std. 90.1 prescriptive building envelope requirements for the specified climate. Any proposed changes to the building envelope (such as replacing windows or increasing roof insulation) should be modeled in the Proposed Design.

Lighting Systems for the Proposed Design should be modeled with the installed lighting power density, and should account for all installed lighting on the site including interior ambient and task lighting, parking garage lighting and exterior lighting.

Any daylight responsive lighting control systems can be directly modeled in the Proposed Design energy simulation. Credit can also be taken for occupant sensor lighting controls (ASHRAE Std. 90.1 Table G3.1, No.6); however, note that such controls are mandatory per 9.4.1.2 in classrooms, conference rooms and employee lunch and break rooms.

Lighting for the Baseline Design is modeled using the Building Area (9.5) or Space-by-Space (9.6) methods. The Baseline Design model should also include the Exterior Lighting Power Allowance (9.4.5).

Lighting excepted from the interior lighting power allowance should still be modeled in both the Proposed and Baseline Design; however, this lighting should be considered "Process" energy (ASHRAE Std. 90.1 Table G.3.1.6).

HVAC system types will often vary between the Proposed Design and the Baseline Design models. The Proposed Design HVAC system type, quantities, capacities and efficiencies should reflect the actual design parameters except in cases where either a heating system or a cooling system has not been specified.

If a heating system but no cooling system has been specified, the Proposed Design must include a cooling system modeled identically to the Baseline Design cooling system. If a cooling system, but no heating has been specified, the Proposed Design must include a heating system modeled identically to the Baseline Design heating system. For areas of the project without heating or cooling systems (such as parking garages), there is no need to model heating or cooling systems in either the Proposed or Baseline Designs.

HVAC systems in green buildings are sometimes hybrid or experimental in nature. It may be necessary to approximate some or all of the functional aspects of Proposed Design experimental systems using the Exceptional Calculation Method (ASHRAE Std. 90.1 G2.5).

The Baseline HVAC System Type shall be determined using the actual building area, quantity of floors, occupancy (residential or non-residential), and heating fuel source per ASHRAE Std. 90.1 Tables G3.1.1A and G3.1.1B. The same Baseline HVAC system type should be used for the entire building except for mixed use occupancies, areas where occupancy or process loads differ significantly from the rest of the building, or areas with varying pressurization, cross-contamination or air circulation requirements (ASHRAE Std. 90.1 G3.1.1).

For projects served by existing HVAC systems, such as a central plant on a campus, Section 10(a) of Table G.3.1 states that when there is an existing HVAC system, the model shall reflect the actual system type using actual component capacities and efficiencies.

When the Baseline HVAC system type is defined as a single zone system, the Baseline Design should model exactly one single zone HVAC system per thermal block. Preheat coils should be modeled identically in the Proposed and Baseline cases whenever preheat can be modeled for the given Baseline system type (ASHRAE Std. 90.1 G3.1.2.3). Baseline System fan supply air volume should be based on a supply-air-to-room-air temperature difference of 20°F (ASHRAE Std. 90.1 G3.1.2.8). This supply air volume is used to calculate the total Baseline System brake horsepower (i.e., the sum of the supply, return, relief, and exhaust fan brake horsepower), which is used to calculate the total fan power for the Baseline System design (ASHRAE Std. 90.1 G3.1.2.9).

HVAC equipment capacities for the Baseline system should be oversized 15% for cooling, and 25% for heating (ASHRAE Std. 90.1 G3.1.2.2 and G3.1.2.2.1).

Economizers and exhaust air energy recovery systems should be modeled in the Baseline HVAC systems when required for the given climate zone and system parameters (ASHRAE Std. 90.1 G3.1.2.6 and G3.1.2.10).

Fan energy is separated from the cooling system in the Performance Rating Method. Thus, if the HVAC manufacturer provides an overall efficiency rating, such as an energy efficiency ratio (EER), it must be separated into the component energy using the coefficient of performance (COP) or other conversion (Equations G-A, G-B and G-C, Pages G-24 and G-26 of the ASHRAE 90.1-2004 User's Manual).

Unmet load hours (occupied periods where any zone is outside its temperature setpoints) may not exceed 300 hours for either the Baseline or Proposed Design. Also, the difference in unmet load hours between the Baseline and Proposed Design must be no greater than 50 (G3.1.2.2).

Other systems regulated by ASHRAE/IESNA Standard 90.1-2004 include parking garage ventilation (ASHRAE Std. 90.1 6.4.3.3.5); freeze protection and snow/ice melting systems (6.4.3.7); exhaust air energy recovery, which applies to laboratory systems unless they comply with 6.5.7.2 (6.5.6.1); condenser heat recovery for service water heating, which applies primarily to high-rise residential occupancies, hotels, hospitals, and laundry facilities (6.5.6.2); kitchen hoods (6.5.7.1); laboratory fume hoods (6.5.7.2); swimming pools (7.4.2 and 7.4.5); all building power distribution systems (8.1); exit signs (9.4.3); exterior building grounds lighting (9.4.4); parking garage lighting (Table 9.5.1, 9.6.1); exterior lighting power (9.4.5); and all permanently wired electrical motors (10.4.1).

Where there are specific energy efficiency requirements for systems in ASHRAE Std. 90.1, the Baseline Design model shall reflect the lowest efficiency allowed by these requirements, and the Proposed Design shall reflect the actual installed efficiency.

Process energy is considered to include, but is not limited to, office and general miscellaneous equipment, computers, elevators and escalators, kitchen cooking and refrigeration, laundry washing and drying, lighting exempt from the lighting power allowance (e.g., lighting integral to medical equipment) and other (e.g., waterfall pumps).

Process energy cost shall be equal to at least 25% of the Baseline Building Performance. For buildings where the process energy cost is less than 25% of the baseline building energy cost, the LEED submittal must include supporting documentation substantiating that process energy inputs are appropriate.

Table G-B of the ASHRAE 90.1-2004 User's Manual provides acceptable receptacle power densities per occupancy type, which can be incorporated into the building energy models. Other process energy inputs such as elevators, escalators, data center and telecom room computing equipment, refrigeration, process lighting, and non-HVAC motors should be modeled based on actual power requirements, and assuming reasonable schedules of operation.

For EA Credit 1, process loads shall be identical for both the Baseline Building Performance rating and for the Proposed Building Performance rating. However, project teams may follow the Exceptional Calculation Method (ASHRAE Std. 90.1 G2.5) to document measures that reduce process loads. If credit is taken for process loads, the calculations must include reasonable assumptions for the baseline and proposed case.

Energy Rates are an important part of the Performance Rating Method. Rates from the local utility schedules are the default option to compute energy costs. The intent is to encourage simulations that provide owners value, and help them minimize their energy costs. The modeler needs to use the same rates for both the budget and proposed building designs.

In the absence of a local utility rate schedule, or of energy rate schedules approved by the local ASHRAE/IESNA 90.1-2004 adopting authority, the applicant may use the energy rates listed in the state average prices published annually by the DOE Energy Information Administration (EIA) at www.eia.doe.gov. Regardless of the source of the rate schedule used, the same rate schedule must be used in both the baseline and proposed simulations.

On-Site Renewable Energy and Site-Recovered Energy costs are not included in the Proposed Building Performance (this is a LEED-NC exception to ASHRAE Std. 90.1 G2.4); therefore, these systems receive full credit using the Performance Rating Method.

Examples of on-site renewable energy systems include power generated by photovoltaics or wind turbines, and thermal energy collected by solar panels. Examples of site-recovered energy include heat recovered with chiller heat recovery systems or waste heat recovery units on distributed generation systems.

When the actual building design incorporates on-site renewable or site-recovered energy, the Baseline Design should be modeled based on the backup energy source for the actual building design, or electricity if no backup energy source is specified. Proposed Building Performance can be determined using one of the following two methods when on-site renewable energy or site-recovered energy is incorporated into the building project:

1. *Model the systems directly in the Proposed Design energy model.* If the building simulation program has the capability of modeling the on-site renewable or site-recovered energy systems, these systems can be modeled directly within the building energy model. The model should reflect the cost savings achieved through the on-site renewable or site-recovered energy systems.
2. *Model the systems using the Exceptional Calculation Method.* If the building simulation program does not have the capability of modeling the on-site renewable or site-recovered energy systems, the energy saved by these systems can be calculated using the Exceptional Calculation Method. The renewable or site-recovered energy cost can then be subtracted from the Proposed Building Performance.

The Exceptional Calculation Method (ASHRAE Std. 90.1 G2.5) shall be used to document any measures that cannot be adequately modeled in a simulation program. Documentation of energy savings using the exceptional calculation method shall include a list of the assumptions made for both the Baseline and Proposed Design, theoretical or empirical information supporting these assumptions, and the specific energy cost savings achieved based on the exceptional calculation. Examples of measures that may be modeled using the Exceptional Calculation Method include, but are not limited to, improvements to laboratory or kitchen exhaust systems, improved appliance efficiencies in high-rise residential buildings, graywater heat recovery, flat panel LCD computer monitors, improvements to refrigeration equipment efficiency, and zone VAV occupant sensor controls.

Common mistakes made using the Performance Rating Method. The following is a list of common mistakes to avoid when using the Performance Rating Method for developing EA Credit 1 calculations and submittals:

1. The Energy Cost Budget Method (Section 11) is incorrectly used rather than the Performance Rating Method (Appendix G) to obtain EA Credit 1 credit.
2. Center-of-glass performance is incorrectly used rather than fenestration assembly U-factor and Solar Heat Gain Coefficient. The Building Envelope Requirements listed for each climate zone (ASHRAE Std. 90.1 Tables 5.5-1 through 5.5-8) refer to fenestration assembly maximum U-factors and SHGCs for glazing (also see ASHRAE Std. 90.1 Sections 5.2.8.4 and 5.2.8.5). The fenestration assembly performance accounts for the impacts of both the frame and the glazing. To determine the fenestration assembly U-factor and Solar Heat Gain Coefficient, Tables 8.1A and 8.2 should be used; OR the fenestration U-factors, SHGCs and visual light transmittance shall be certified and labeled in accordance with NFRC 100, 200 and 300 respectively (A8).
3. Baseline Design window area percentages are not calculated in accordance with the Performance Rating Method.
4. Baseline Design fenestration is not uniformly distributed across all four building orientations as required by the Performance Rating Method.
5. The Proposed Design does not account for portable (task) lighting.
6. Non-tradable surfaces (such as building facades) are incorrectly treated as tradable surfaces when determining the exterior lighting power allowance.
7. The Baseline HVAC System type is incorrectly determined.
8. The Baseline System Capacities, Design Supply Air Volume, or total fan power are incorrectly calculated.
9. Manufacturer's overall cooling energy efficiency ratings, (such as EERs) are not separated into the component energy using the coefficient of performance (COP) or other conversion factors in accordance with 90.1 requirements.
10. The quantities and/or types of chillers and boilers are not determined in accordance with the Performance Rating Method (ASHRAE Std. 90.1 G3.1.3.2, G3.1.3.7).
11. Insufficient information is provided for energy measures incorporating the Exceptional Calculation methodology.
12. Energy consumption is incorrectly used to calculate the Percentage Improvement rather than energy cost.

Calculating the Percentage Improvement requires the following steps:

First, the whole-building simulations are used to produce economic reports that show the total cost for electricity, gas and possibly other energy sources such as steam and chilled water. The total annual energy cost calculated for the Proposed Design simulation is the Proposed Building Performance. The average total energy cost for the four orientations simulated for the Baseline Design is the Baseline Building Performance. ASHRAE Std. 90.1 also requires that the energy consumption and peak demand be reported for each building end-use. In DOE-2-based programs such as eQUEST or VisualDOE, this data can be found in the BEPS or BEPU and PS-E reports. In Trane® Trace™700, this information is reported in the Energy Consumption Summary. As with the Baseline Building Performance, the average of the four Baseline Building simulation results is used to calculate the energy consumption by end-use, and the peak demand by end-use.

NOTE: separate point scales are provided for New and Existing Buildings in recognition of the constraints inherent in renovating an existing shell compared to new construction.

Example

The following example shows how the Performance Rating Method is applied to a 100,000-sq.ft. project. The design case uses a high performance envelope with 23% glazing, "Super T8" direct/indirect ambient lighting with supplemental task lighting, a VAV air system that receives chilled water from a 400-ton variable speed electric chiller, and 20 kW of photovoltaic panels installed on the roof. Using the Performance Rating Method system map, the budget HVAC system type is modeled as a Packaged VAV System with hot water reheat, variable speed fan control, and direct expansion cooling.

To determine the Proposed Building Performance, the energy modeler creates a design building energy simulation model using DOE-2, Trane Trace™700, EnergyPlus, Carrier HAP-E20 II or another hourly load and energy-modeling software tool. The model parameters for all loads, including receptacle and process loads and the expected building occupancy profile and schedule, are adjusted to determine central system capacities and energy use by system. Through parametric manipulation, the energy modeler working with the design team increases component efficiencies to exceed the referenced standard. The energy generated by the photovoltaic panels is calculated using PV Watts Version 1 software using the ASHRAE Std. 90.1 Exceptional Calculation Method.

The Proposed Building Performance is calculated as the total projected energy cost for the Proposed Design Energy Model minus the energy generated by the photovoltaic panels as calculated in PV Watts Version 1.

The Baseline Building Performance is then calculated by adjusting the model parameters to meet the requirements listed in ASHRAE/IESNA Standard 90.1-2004 Appendix G. The Baseline model includes the same plug and process loads and an identical building occupancy

Figure 1: 3-D Rendering of Proposed Design

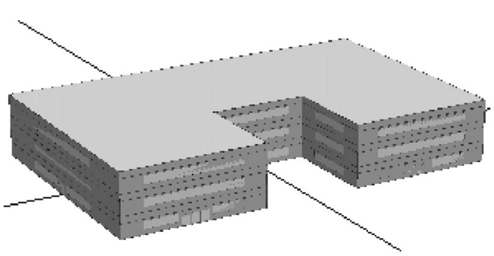
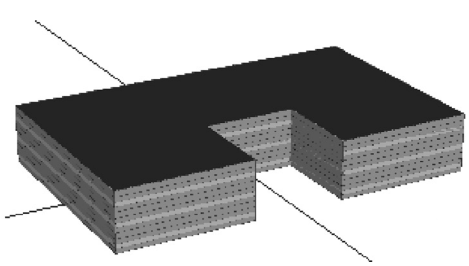


Figure 2: 3-D Rendering of Baseline Design



profile and schedule to the Proposed Design in order to accurately determine central system capacities and energy use by system.

For the Baseline Model, the energy modeler redistributes the glazing uniformly across all four building orientations, but otherwise models the Baseline glazing percentage identically to the Proposed Design, since the ratio of window to wall area for the Proposed Design is less than 40%. The energy modeler adjusts the construction assembly types in accordance with ASHRAE Std. 90.1 Table G3.1.5, and to meet minimal Building Envelope Requirements for the building's climate zone. The Baseline HVAC System Type is modeled as a Packaged Variable Air Volume system with Hot Water Reheat (ASHRAE Std. 90.1 Table G3.1.1.A). The energy modeler uses minimum/prescriptive ASHRAE Std. 90.1 HVAC system component efficiencies and performs sizing runs to determine the fan supply air volume; and then uses this to calculate the total Baseline Design fan brake horsepower, and total Baseline Design fan power respectively.

The energy modeled performs the Baseline Design simulation first with the actual building orientation, and then rotating the building 90°, 180° and 270° respectively. For each of the four Baseline Building Design orientations, the energy modeler revises the window SHGC to reflect the minimum ASHRAE prescriptive requirements for the revised building orientations. The energy modeler takes the average of the total annual energy cost simulated for the four Baseline simulations to establish the Baseline Building Performance.

In the example, the General Building Energy Model Information is summarized in **Table 3**, the Baseline and Proposed Design input parameters are summarized in **Table 4**, the Baseline Performance is calculated in **Table 5**, and the Baseline Design and Proposed Design results, as well as the Percentage Improvement (**Equation 1**) are summarized in Table 6. In **Tables 5 and 6**, energy is reported as site energy, not source energy. These four tables provide the format required for EA Credit 1 documentation submittal.

Exemplary Performance

There is no exemplary performance point available for this credit.

Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

The EA Credit 1 Submittal Template provides detailed tables and calculations to assist with the completion of this credit. Instructions are self-contained on the template and too lengthy to repeat here. Users are prompted for relevant project and model data, and the forms automatically generate percent savings and points achieved.

Considerations

Cost Issues

Some energy-efficiency measures may not require additional first costs. Many measures that do result in higher capital costs may generate cost savings from lower energy use, smaller equipment, reduced space needs for mechanical and electrical equipment, and utility rebates. These savings may vastly exceed the incremental capital costs associated with the energy efficiency measures.

The importance of even small energy-efficiency measures is significant. For instance, replacing one incandescent lamp

Equation 1

$$\text{Percentage Improvement} = 100 \times 1 - \frac{\text{Proposed Building Performance}}{\text{Baseline Building Performance}}$$

Table 3: General Building Energy Model Information

Performance Rating Method Compliance Report			**Page 1**
Project Name:	Midrastleton Office Building		
Project Address:	2850 W. Washington Ave.	Date:	October 5, 2006
Designer of Record:	Maddlestobum Architects	Telephone:	702-020-0400
Contact Person:	Fenray Constrablik	Telephone:	702-014-9284
City:	Las Vegas, NV	Principal Heating Source: ❑ Fossil Fuel ❑ Electricity ❑ Solar/Site Recovered ❑ Other	
Weather Data:	Las Vegas, NV (LAS-VENV.bin)		
Climate Zone:	3B		

Space Summary

Building Use	Conditioned Area (sf)	Unconditioned (sf)	Total (sf)
1. Office (Open Plan)	40,000		40,000
2. Office (Executive / Private)	30,000		30,000
3. Corridor	10,000		10,000
4. Lobby	5,000		5,000
5. Restrooms	5,000		5,000
6. Conference Room	4,000		4,000
7. Mechanical / Electrical Room	4,000		4,000
8. Copy Room	2,000		2,000
Total	100,000		100,000

Advisory Messages

	Proposed Building Design	Budget Building	Difference (Proposed Budget)
Number of hours heating loads not met (system / plant)	0	0	0
Number of hours cooling loads not met (system / plant)	0	0	0
Number of warnings	0	0	0
Number of errors	0	0	0
Number of defaults overridden	1	1	0

Description of differences between the budget building and proposed design not documented on other forms: ❑ Not Applicable ☒ Attached

Additional Building Information

Quantity of Floors	Three
Simulation Program	eQuest v. 3.55
Utility Rate: Electricity	Nevada Power Large General Service (average $0.0935/kWh)
Utility Rate: Natural Gas	Southwest Gas Medium General Service (average $1.04/therm)
Utility Rate: Steam or Hot Water	
Utility Rate: Chilled Water	
Utility Rate: Other	

Table 4: Baseline and Proposed Design Input Parameters

Performance Rating Method Compliance Report		**Page 2**
Comparison of Proposed Design versus Baseline Design Energy Model Inputs:		
Building Element	**Proposed Design Input**	**Baseline Design Input**
Envelope		
Above Grade Wall Construction(s)	1. Steel-frame Construction, R-19 insulation, 16 in. OC, 6” depth, U-factor = 0.109	Steel-frame Construction, R-13 insulation, U-factor = 0.124
Below Grade Wall Construction	Not applicable	Not Applicable
Roof Construction	Built-up Roof, Insulation entirely above deck, R-30 ci, U-factor = 0.032, Roof Reflectivity = 0.45 (cool roof)	Insulation entirely above deck, R-15ci, U-factor = 0.063, Roof Reflectivity = 0.30
Exterior Floor Construction	Not Applicable	Not Applicable
Slab-On-Grade Construction	Uninsulated, F-0.730	Uninsulated, F-0.730
Window-to-Gross Wall Ratio	23%	23%
Fenestration Type(s)	1. Dual-Pane Metal Frame tinted low-E glass doors with thermal break 2. Dual-Pane Metal-Frame low-E glass windows with thermal break	1. North Orientation 2. South, East, West Orientations
Fenestration Assembly U-factor	1. 0.61 2. 0.59	1. 0.57 2. 0.57
Fenestration Assembly SHGC	1. 0.25 2. 0.25	1. 0.39 2. 0.25
Fenestration Visual Light Transmittance	1. 0.44 2. 0.44	1. 0.44 2. 0.44
Fixed Shading Devices	1. None	1. None
Automated Movable Shading Devices	None	None
Electrical Systems & Process Loads		
Ambient Lighting Power Density, and Lighting Design Description	Average: 0.898 Watts/sf Super T8 direct/indirect linear flourescents with occiupant sensor controls (10% lighting credit); compact flourescents used for some hallways and lobbies; average task lighting power density of 0.10 W/sf for office spaces is included in the calculations.	1. Average: 1.05 Watts/sf (Space-by-Space Method) 2. Office (Enclosed or Open): 1.1 W/sf 3. Conference Rooms: 1.3 W/sf 4. Corridor: 0.5 W/sf 5. Restroom: 0.9 W/sf 6. Electrical/Mechanical Rooms: 1.5 W/sf 7. Lobby: 1.3 W/sf
Process Lighting	None	None
Lighting Occupant Sensor Controls	Installed in most spaces	Not installed
Daylighting Controls	None	None
Exterior Lighting Power (Tradable Surfaces)	3.7 kW	4.2kW
Exterior Lighting Power (Non-Tradable Surfaces)	0.8kW	0.8kW
Receptacle Equipment	0.75 W/sf	0.75 W/sf
Elevators or Escalators	Two elevators operated intermittently (5kW per elevator with 490 equivalent full load hours of operation per elevator)	Two elevators operated intermittently (5kW per elevator with 490 equivalent full load hours of operation per elevator
Refrigeration Equipment	None	None
Other Process Loads	Telecom rooms, one per floor, 2.3kW peak wirh 3,680 equivalent full load hours of operation	Telecom rooms, one per floor, 2.3kW peak wirh 3,680 equivalent full load hours of operation

Table 4 continued: Baseline and Proposed Design Input Parameters

Performance Rating Method Compliance Report		Page 3
Comparison of Proposed Design versus Baseline Design Energy Model Inputs (Continued):		
Building Element	**Proposed Design Input**	**Baseline Design Input**
Mechanical & Plumbing Systems		
HVAC System Type(s)	1. Variable Air Volume with Reheat (one per floor) 2. Packaged single Zone systems with gas furnace (gas furnace not in actual design) serving telecom rooms and elevator equipment room	System Type 5: Packaged Rooftop Variable Air Volume with Reheat. Packaged Single Zone systems with gas furnace serving telecom rooms and elevator equipment room.
Design Supple Air Temperature Differential	23 deg. F	20 deg. F
Fan Control	VSD Control	VSD Control
Fan Power	1. AH-1: 14.0 bhp supply; 5.6 bhp return 2. AH-2: 14.5 bhp supply; 5.8 bhp return 3. AH-3: 14.4 bhp supply; 5.8 bhp return	94.8 total brake horsepower; 75.3kW total fan power (Supply Fans + Return Fans)
Economizer Control	Differential Temperature Economizers with maximum temperature of 70 deg. F	None
Demand Control Ventilation	Outside air quantity based on DCV zone sensors; Minimum Outside Air Sizing method set by critical zone	None
Unitary Equipment Cooling Efficiency	1. 2. 12 SEER for two small PSZ systems	1. 8.8 EER for Packaged Rooftop VAV units 2. 12 SEER for two small PSZ systems
Unitary Equipment Heating Efficiency	80% furnace efficiency for two small PSZ units	80% furnace efficiency for two small PSZ units
Chiller Type, Capacity, and Efficiency	one 300-ton VSD centrifugal chiller: 0.58kW/ton full load-efficiency, variable speed control for part-load operation	Not Applicable
Cooling Tower	one two-cell cooling tower; each cell has a 15 hp fan with variable speed control	Not Applicable
Boiler Efficiency	one 85% efficient boiler, 2.0 MBTUH	two boilers, 75% thermal efficiency; 1.25 MBTUH each
Chilled Water Loop and Pump Parameters	Variable primary flow with 25 hp variable speed pump; Chilled Water Temperature reset from 42 to 50 deg. F	Not Applicable
Condenser Water Loop and Pump Parameters	Constant flow with 25 hp variable speed pump; Condenser Water Temperature reset from 70 to 85 deg. F	Not Applicable
Hot Water Loop and Pump Parameters	Variable primary flow with 3 hp variable speed pump; Hot Water temperature reset based on load between 150 deg. and 180 deg. F	Variable primary flow with 3 hp constant speed pump; Hot water supply temperature reset based on outdoor dry-bulb temperature using the following schedule: 180 deg. F at 20 deg. F and below, 150 deg. F at 50 deg. F and above, and ramped linearly between 180 deg. F and 150 deg. F at temperatures between 20 deg. F and 50 deg. F
Domestic Hot Water System(s)	100 gallon storage gas water heater with 80% thermal efficiency, 175,000 btuh capacity, and 1,319 Btuh standby losses	100 gallon storage gas water heater with 80% thermal efficiency, 175,000 btuh capacity, and 1,319 Btuh standby losses

Table 5: Baseline Performance

Performance Rating Method Compliance Report — **Page 4**

Baseline Building Performance Table

Baseline Building Energy Summary by End Use

End Use	Process?	Energy Type	0° rotation		90° rotation		180° rotation		270° rotation		Average		
			Energy [10^6 Btu]	Peak [10^6 Btuh]	Energy [10^6 Btu]	Peak [10^6 Btuh]	Energy [10^6 Btu]	Peak [10^6 Btuh]	Energy [10^6 Btu]	Peak [10^6 Btuh]	Energy [10^6 Btu]	Peak [10^6 Btuh]	Cost [$/yr]
Interior Lighting		Electricity	1,137.2	418.7	1,137.2	418.7	1,137.2	418.7	1,137.2	418.7	1,137.2	418.7	$31,990
Interior Lighting (Process)	X	Electricity											$0
Exterior Lighting		Electricity	54.4	17.1	54.4	17.1	54.4	17.1	54.4	17.1	54.4	17.1	$1,531
Space Heating (fuel 1)		Natural Gas	515.8	2,300.0	525.6	2,300.0	486.7	2,300.0	494.3	2,300.0	505.6	2,300.0	$4,916
Space Heating (fuel 2)		Electricity											$0
Space Cooling		Electricity	1,299.4	836.8	1,308.9	843.8	1,298.1	815.7	1,310.3	812.3	1,304.2	827.1	$36,687
Pumps		Electricity	3.2	3.1	3.3	3.1	2.9	3.1	2.9	3.1	3.1	3.1	$86
Heat Rejection		Electricity											$0
Fans - Interior		Electricity	222.5	106.9	228.1	108.6	223.8	106.8	223.5	106.5	224.5	107.2	$6,315
Fans - Parking Garage		Electricity											$0
Service Water Heating (fuel 1)		Natural Gas	57.3	10.4	57.3	10.4	57.3	10.4	57.3	10.4	57.3	10.4	$557
Service Water Heating (fuel 2)		Electricity											$0
Receptacle Equipment	X	Electricity	1,040.7	273.0	1,040.7	273.0	1,040.7	273.0	1,040.7	273.0	1,040.7	273.0	$29,276
Refrigeration (food, etc.)	X	Electricity											$0
Cooking (commercial, fuel 1)	X	Electricity											$0
Cooking (commercial, fuel 2)	X	Electricity											$0
Elevators and Escalators	X	Electricity	16.7	17.1	16.7	17.1	16.7	17.1	16.7	17.1	16.7	17.1	$470
Other Process	X	Electricity	28.9	7.8	28.9	7.8	28.9	7.8	28.9	7.8	28.9	7.8	$813
Total Building Consumption/Demand			**4,376.1**	**3,990.9**	**4,401.2**	**3,999.6**	**4,346.7**	**3,969.7**	**4,366.3**	**3,965.9**	**4,372.6**	**3,981.5**	**$112,641**
Total Process Energy			**1,086.3**	**297.9**	**1,086.3**	**297.9**	**1,086.3**	**297.9**	**1,086.3**	**297.9**	**1,086.3**	**297.9**	**$30,559**

Note: Energy Consumption is listed in units of site energy
10^3 Btu = kWh x 3.413 10^3 Btu = therms / 100

Baseline Building Energy Cost and Consumption by Fuel Type

Energy Type	0° rotation		90° rotation		180° rotation		270° rotation		Average	
	Energy Consumption [10^3 Btu]	Energy Cost [$/Yr]	Energy Consumption [10^3 Btu]	Energy Cost [$/Yr]	Energy Consumption [10^3 Btu]	Energy Cost [$/Yr]	Energy Consumption [10^3 Btu]	Energy Cost [$/Yr]	Energy Consumption [10^3 Btu]	Energy Cost [$/Yr]
Electricity	3,803.0	$107,174	3,818.3	$107.398	3,802.7	$107,021	3,814.7	$107,079	3,809.7	$107,168
Natural Gas	573.1	$5,563	582.9	$5,650	544.0	$5,305	551.6	$5,373	562.9	$5,473
Steam/Hot Water										
Other										
Total	**4,376.1**	**$112,737**	**4,401.2**	**$113,048**	**4,346.7**	**$112,326**	**4,366.3**	**$112,452**	**4,372.6**	**$112,641**

The process energy cost is 27% of the Baseline Building Performance. This meets the requirements of LEED EAc1.

Table 6: Percentage Improvement

Performance Rating Method Compliance Report						**Page 5**
Performance Rating Table				**EAc1 Points:**	**5**	
Energy Summary by End Use				**EAc2 Points:**	**1**	
		Proposed Building		**Baseline Building**		
End Use	**Energy Type**	**Energy [10^6 Btu]**	**Peak [10^3 Btu/h]**	**Energy [10^6 Btu]**	**Peak [10^3 Btu/h]**	**Energy [%]**
Interior Lighting (Ambient)	Electricity	955.3	418.7	1,137.2	418.7	16%
Interior Lighting (Process)	Electricity					
Exterior Lighting	Electricity	49.0	15.4	54.4	17.1	10%
Space Heating (fuel 1)	Natural Gas	360.2	1,600.0	505.6	2,300.0	29%
Space Heating (fuel 2)	Electricity					
Space Cooling	Electricity	452.0	331.1	1,304.2	827.1	65%
Pumps	Electricity	230.7	79.6	3.1	3.1	-7426%
Heat Rejection	Electricity	23.9	20.5			
Fans - Interior	Electricity	177.8	76.2	224.5	107.2	21%
Fans - Parking Garage	Electricity					
Service Water Heating (fuel 1)	Natural Gas	57.3	10.4	57.3	10.4	0%
Service Water Heating (fuel 2)	Electricity					
Receptacle Equipment	Electricity	1,040.7	273.0	1,040.7	273.0	0%
Refrigeration (food, etc.)	Electricity					
Cooking (commercial, fuel 1)	Natural Gas					
Cooking (commercial, fuel 2)	Electricity					
Elevators and Escalators	Electricity	16.7	17.1	16.7	17.1	0%
Other Process	Electricity	28.9	7.8	28.9	7.8	0%
Total Building Consumption		**3,392.5**	**2,849.8**	**4.372.6**	**3,981.5**	**22%**

Note: Energy Consumption is listed in units of site energy
10^3 Btu = kWh x 3.413 10^3 Btu = therms / 100

	Proposed Building		**Baseline Building**		**Percentage Improvement**	
Type	**Energy Use [10^6 Btu]**	**Energy Cost [$/yr]**	**Energy Use [10^6 Btu]**	**Energy Cost [$/yr]**	**Energy %**	**Cost %**
Nonrenewable (Regulated & Unregulated)						
Electricity	2,975.0	$81,485	3,809.7	$107,168	22%	24%
Natural Gas	417.5	$4,184	562.9	$5,473	26%	24%
Steam or Hot Water						
Chilled Water						
Other						
Total Nonrenewable (Regulated & Unregulated)	**3,392.5**	**$85,669**	**4,372.6**	**$112,641**	**22%**	**24%**

	Proposed Building		**Baseline Building**		**Percentage Improvement**	
Exceptional Calculation Method Savings (savings indicated as negative numbers)	**Energy Use [10^6 Btu]**	**Energy Cost [$/yr]**	**Energy Use [10^6 Btu]**	**Energy Cost [$/yr]**	**Energy %**	**Cost %**
Site-Generated Renewable (REC)	(96.4)	$ (2,639)			2%	2%
Site Recovered						
Exceptional Calculation #1 Savings						
Exceptional Calculation #2 Savings						
Exceptional Calculation #3 Savings						
Total including exceptional calculations	**3,296.2**	**$83,030**	**4,372.6**	**$112,641**	**25%**	**26%**
Percentage Improvement = 100 x [1 - (Proposed Building Performance / Baseline Building Performance)]						**26.29%**
Percent Renewable = REC / (Proposed Building Performance + REC)						**3.08%**

with a fluorescent lamp will result in $30 to $50 in energy cost savings over the operating lifetime of the lamp.

Environmental Issues

Commercial and residential buildings consume approximately 2/3 of the electricity and 1/3 of all energy in the United States. Conventional forms of energy production may have devastating environmental effects. Production of electricity from fossil fuels creates air and water pollution; hydroelectric generation plants can make waterways uninhabitable for indigenous fish; and nuclear power has safety concerns as well as problems with disposal of spent fuel.

Energy efficiency in buildings limits the harmful environmental side effects of energy generation, distribution and consumption. In an integrated design process, energy efficiency measures can be implemented in conjunction with indoor environmental quality measures to improve building comfort, while reducing facility operating costs.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

Advanced Buildings Technologies & Practices

Natural Resources Canada

www.advancedbuildings.org

This web resource supported by Natural Resources Canada presents energy efficient technologies and strategies for commercial buildings, along with pertinent case studies.

American Council for an Energy Efficient Economy (ACEEE)

www.aceee.org

(202) 429-8873

ACEEE is a nonprofit organization dedicated to advancing energy efficiency through technical and policy assessments; advising policymakers and program managers; collaborating with businesses, public interest groups, and other organizations; and providing education and outreach through conferences, workshops, and publications.

American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)

www.ashrae.org

(800) 527-4723

ASHRAE has developed a number of publications on energy use in existing buildings, including Standard 100-1995: Energy Conservation in Existing Buildings. This standard defines methods for energy surveys, provides guidance for operation and maintenance, and describes building and equipment modifications that result in energy conservation. Two publications referenced by this credit (ASHRAE 90.1-2004 and ASHRAE Advanced Energy Design Guide for Small Office Buildings 2004) are available through ASHRAE.

Building Energy Codes Program

U.S. Department of Energy

www.energycodes.gov

(800) DIAL-DOE

The Building Energy Codes program is updating the COMCheckEZ™ compliance tool to include ASHRAE/IESNA 90.1-2004. This compliance tool includes the prescriptive path and trade-off compliance methods. The software generates appropriate compliance forms as well.

Building Energy Use and Cost Analysis Software

www.doe2.com

Information and products from the developers of DOE-2 and DOE-2 based products including eQUEST, PowerDOE and COM*check*-Plus.

ENERGY STAR®

www.energystar.gov

(888) 782-7937

ENERGY STAR is a government/industry partnership managed by the U.S. Environmental Protection Agency and the U.S. Department of Energy. The program's website offers energy management strategies, benchmarking software tools for buildings, product procurement guidelines and lists of ENERGY STAR-labeled products and buildings.

Building Upgrade Manual

www.energystar.gov/index.cfm?c=business.bus_upgrade_manual&layout=print

This document is a guide for ENERGY STAR Buildings Partners to use in planning and implementing energy efficiency upgrades in their facilities, and can be used as a comprehensive framework for an energy strategy.

Energy-10TM Energy Simulation Software

National Renewable Energy Program (NREL)

www.nrel.gov/buildings/energy10>www.nrel.gov/buildings/energy10

(303) 275-3000

and

Sustainable Buildings Industry Council (SBIC)

www.Energy-10.com

(202) 628-7400 ext. 210

Energy-10TM is an award-winning software tool for designing low-energy buildings. Energy-10TM integrates daylighting, passive solar heating, and low-energy cooling strategies with energy-efficient shell design and mechanical equipment. The program is applicable to small commercial and residential buildings with up to two zones and simple HVAC equipment.

The Energy-10TM software was developed by the National Renewable Energy Laboratory under funding from the Office of Building Technologies, Energy Efficiency and Renewable Energy, U.S. Department of Energy. It is distributed by the Sustainable Buildings Industry Council under license to the Midwest Research Institute.

New Buildings Institute (NBI)

www.newbuildings.org

The mission of NBI is to encourage the efficient use of energy in buildings and to mitigate the adverse environmental impacts resulting from energy use. The site includes helpful information to plan building upgrades, such as the Advanced Lighting Guidelines that describe energy-efficient lighting strategies.

Office of Energy Efficiency and Renewable Energy

U.S. Department of Energy

www.eere.energy.gov/EE/buildings.html

(877) 337-3463

This extensive website for energy efficiency is linked to a number of DOE-funded sites that address buildings and energy. Of particular interest is the tools directory that includes the Commercial Buildings Energy Consumption Tool for estimating end-use consumption in commercial buildings. The tool allows the user to define a set of buildings by principal activity, size, vintage, region, climate zone and fuels (main heat, secondary heat, cooling and water heating), and to view the resulting energy consumption and expenditure estimates in tabular format.

Print Media

ASHRAE Publication 90.1-2004 User's Manual

The 90.1–2004 User's Manual was developed as a companion document to the ANSI/ASHRAE/IESNA Standard 90.1–2004 (Energy Standard for

Buildings Except Low-Rise Residential Buildings). The User's Manual explains the new standard and includes sample calculations, useful reference material, and information on the intent and application of the standard.

ANSI/IESNA RP-1-04, American National Standard Practice for Office Lighting, ANSI

Daylight in Buildings: A Source Book on Daylighting Systems and Components, Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division, Download at: http://gaia.lbl.gov/iea21/ (See Chapter 5 – Daylight-Responsive Controls)

Design Brief – Lighting Controls Energy Design Resources

www.energydesignresources.com

Developed by Southern California Edison.

Electricity Used by Office Equipment and Network Equipment in the U.S.: Detailed Report and Appendices, Kawamoto, et al, February 2001, Ernest Orlando, Lawrence Berkeley National Laboratory, University of California, Berkeley, CA.; Download at http://enduse.lbl.gov/Projects/InfoTech.html

Energy Information Agency's (EIA) Commercial Building Energy Consumption

Survey (CBECS); www.eia.doe.gov

IESNA Lighting Handbook, Ninth Edition, IESNA, 2000.

This handbook for industry professionals includes comprehensive information about lighting concepts, techniques, application, procedures and systems.

International Energy Agency Solar Heating and Cooling Programme

www.iea-shc.org

A report of the International Energy Agency (IEA) Solar Heating and Cooling Programme, Energy Conservation in Buildings and Community Systems (IEA SHC Task 21/ECBCS Annex 29, July 2000). Published by the Lawrence Berkeley National Laboratory with support from the Energy Design Resources. LBNL Report Number: LBNL-47493. *Advanced Lighting Guidelines: 2001 Edition*, Chapter 8 – Lighting Controls

Mechanical and Electrical Equipment for Buildings, 9th Edition by Benjamin

Stein and John S. Reynolds, John Wiley and Sons, 2000. This reference resource details information on the relationship between mechanical and electrical systems in buildings.

New Buildings Institute, Inc, Published by New Buildings Inc. Available as a free download or purchased as a printed manual of 390 pages.www.newbuildings.org/lighting.htm

Sustainable Building Technical Manual, Public Technology Institute, 1996

www.pti.org

Definitions

Baseline Building Performance is the annual energy cost for a building design intended for use as a baseline for rating above standard design, as defined in ASHRAE 90.1-2004 Informative Appendix G.

Daylighting is the controlled admission of natural light into a space through glazing with the intent of reducing or eliminating electric lighting. By utilizing solar light, daylighting creates a stimulating and productive environment for building occupants.

An **ENERGY STAR®** rating is the rating a building earns using the ENERGY STAR Portfolio Manager to compare building energy performance to similar buildings in similar climates. A score of 50 represents average building performance.

Interior Lighting Power Allowance is the maximum light power in watts allowed for the interior of a building.

Lighting Power Density (LPD) is the installed lighting power, per unit area.

Percentage Improvement is the percent energy cost savings for the Proposed Building Performance versus the Baseline Building Performance.

Proposed Building Performance is the annual energy cost calculated for a proposed design, as defined in ASHRAE 90.1-2004 Informative Appendix G.

Rated Power is the nameplate power on a piece of equipment. It represents the capacity of the unit and is the maximum a unit will draw.

Receptacle Load refers to all equipment that is plugged into the electrical system, from office equipment to refrigerators.

Case Study

Alberici St. Louis Office Building

St. Louis, Missouri

Owner: Alberici Corporation

In the summer of 2005, after accumulating a total of 60 LEED-NC points, the headquarters building for the Alberici Corporation was awarded LEED® v2.0 Platinum. The building reduced its energy use so substantially that it managed to earn all of the possible 10 EA Credit 1 points. Through thermal envelope improvements, lower lighting power densities, daylighting, high efficiency HVAC, heat recovery and better pumps, the project demonstrated energy savings of 60%, relative to an ASHRAE 90.1-1999 building. Additionally, 18% of the building's regulated energy cost is provided by on-site renewable energy via a 65-kilowatt wind turbine.

On-Site Renewable Energy

SS | WE | EA | MR | EQ | ID

Credit 2

1–3 points

Intent

Encourage and recognize increasing levels of on-site renewable energy self-supply in order to reduce environmental and economic impacts associated with fossil fuel energy use.

Requirements

Use on-site renewable energy systems to offset building energy cost. Calculate project performance by expressing the energy produced by the renewable systems as a percentage of the building annual energy cost and using the table below to determine the number of points achieved.

Use the building annual energy cost calculated in EA Credit 1 or use the Department of Energy (DOE) Commercial Buildings Energy Consumption Survey (CBECS) database to determine the estimated electricity use. (Table of use for different building types is provided in this Reference Guide.)

% Renewable Energy	Points
2.5%	1
7.5%	2
12.5%	3

Potential Technologies & Strategies

Assess the project for non-polluting and renewable energy potential including solar, wind, geothermal, low-impact hydro, biomass and bio-gas strategies. When applying these strategies, take advantage of net metering with the local utility.

Summary of Referenced Standard

ASHRAE/IESNA 90.1-2004: Energy Standard For Buildings Except Low-Rise Residential

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

On-site renewable or site-recovered energy that might be used to capture EA Credit 2 is handled as a special case in the modeling process. If either renewable or recovered energy is produced at the site, the Performance Rating Method considers it free energy and it is not included in the Design Energy Cost. See the Calculation section for details.

Approach and Implementation

Renewable energy systems include technologies designed to capture solar, wind, geothermal, water, or bio-based energy to satisfy on-site electric power demand, or to directly offset space-heating, space-cooling, or water heating energy consumption. Renewable energy systems should be installed and commissioned to maximize useful contributions of renewable energy.

Eligible systems will produce either electric power and/or thermal energy for use on-site. Systems producing on-site renewable electrical power should be designed to facilitate net metering back to the grid for periods when renewable energy system output exceeds the site demand. Cost savings from renewable energy systems' shall be reported exclusive of energy costs associated with system operation (i.e., deduct energy costs of pumps, fans, and other auxiliary devices).

Renewable Energy Systems Eligible for EA Credit 2

- ❑ **Electrical Systems:** Photovoltaic (PV), wind, hydro, wave, tidal, and bio-fuel based electrical production systems deployed at the project site are renewable energy technologies and may be eligible for this credit.
- ❑ **Geothermal Energy Systems:** Geothermal energy systems using deep-earth water or steam sources (and not using vapor compression systems for heat transfer) may be eligible for this credit. These systems may either produce electric power or provide thermal energy for primary use at the building.
- ❑ **Solar Thermal Systems:** Active solar thermal energy systems that employ collection panels; heat transfer mechanical components, such as pumps or fans, and a defined heat storage system, such as a hot water tank are eligible for this credit. Thermo-siphon solar and storage tank "batch heaters" are also eligible.

Systems Not Eligible for EA Credit 2

- ❑ **Architectural Features:** Architectural passive solar and daylighting strategies provide significant energy savings that are chiefly efficiency related. Their contributions shall be documented in EA Prerequisite 2, and may be considered under EA Credit 1.
- ❑ **Geo-exchange Systems:** (a.k.a. geothermal or ground-source heat pumps) Earth-coupled HVAC applications which do not obtain significant quantities of deep-earth heat, and use vapor-compression systems for heat transfer are not eligible as renewable energy systems. These systems are adequately addressed in EA Prerequisite 2, and may be considered under EA Credit 1.

- ❑ **"Green Power":** Green power products (tradable renewable certificates, green TAGs, and renewable energy certificates [RECs]) that are purchased from qualified contractual sources and delivered to the site via electric transmission lines shall be accounted for in EA Credit 6.

Table 1: EA Credit 2 Eligible On-Site Renewable Energy Systems

• Photovoltaic systems • Solar thermal systems • Bio-fuel based electrical systems (subject to **Table 3**) • Geothermal heating systems • Geothermal electric systems • Low-impact hydro electric power systems • Wave and tidal power systems

Table 2: EA Credit 2 Ineligible On-Site Renewable Energy Systems

• Architectural features • Passive solar strategies • Daylighting strategies • Geo-exchange systems (Ground Source Heat Pumps) • Renewable or Green-power from off-site sources

Strategies

Design and specify the use of on-site non-polluting renewable technologies to contribute to the total energy requirements of the project. Consider and employ photovoltaic, solar thermal, geothermal, wind, biomass and bio-gas energy technologies. Make use of net metering arrangements with local utilities or electric service providers.

Calculations

The fraction of energy cost supplied by the renewable energy systems is calculated against the Proposed Building Performance determined in EA Credit 1.

If no energy simulation was performed for EA Credit 1, then the fraction of

Table 3: EA Credit 2 Eligible & Ineligible Bio-Fuels

For the purposes of EA Credit 2, electrical production using the following bio-fuels shall be considered renewable energy:
• Untreated wood waste including mill residues • Agricultural crops or waste • Animal waste and other organic waste • Landfill gas
Electrical production based on the following bio-fuels are excluded from eligibility for this credit:
• Combustion of municipal solid waste • Forestry biomass waste, other than mill residue • Wood that has been coated with paints, plastics, or formica • Wood that has been treated for preservation with materials containing halogens, chlorine compounds, halide compounds, chromated copper arsenate (CCA), or arsenic. If more than 1% of the wood fuel has been treated with these compounds, the energy system shall be considered ineligible for EA Credit 2.

energy cost shall be calculated based on the U.S. Department of Energy (DOE) Energy Information Administration (EIA) 2003 Commercial Sector Average Energy Costs by State (**Table 5**), in conjunction with the Commercial Buildings Energy Consumption Survey (CBECS) database of annual electricity and natural gas usage per square foot (see **Table 4**). This database provides electricity and fuel consumption factors in kWh/ft2 and kBtu/ft2 for various building types in the United States. Costs per square foot can be determined by multiplying the average electricity and natural gas costs by the electricity and fuel consumption factors respectively.

The quantity of energy generated by on-site renewable systems should be estimated (either using the same simulation tool employed for EA Credit 1 calculations or a separate calculation methodology). Performance of the renewable system may be predicted using a bin type calculation. This requires the applicant to account for the contribution of variables associated

Table 4: Default Energy Consumption Intensity for Different Building Types (from EIA 1999 Commercial Building Energy Consumption Survey

Building Type	Median Electrical Intensity (kWh/sf-yr)	Median Non-Electrical Fuel Intensity (kBtu/sf-yr)
Education	6.6	52.5
Food Sales	58.9	143.3
Food Service	28.7	137.8
Health Care Inpatient	21.5	50.2
Health Care Outpatient	9.7	56.5
Lodging	12.6	39.2
Retail (Other than Mall)	8.0	18.0
Enclosed and Strip Malls	14.5	50.6
Office	11.7	58.5
Public Assembly	6.8	72.9
Public Order and Safety	4.1	23.7
Religious Worship	2.5	103.6
Service	6.1	33.8
Warehouse and Storage	3.0	96.9
Other	13.8	52.5

Table 5: Default Energy Costs by State (from EIA 2003 Commercial Sector Average Energy Costs by State)

State	Electricity ($/kWh)	Natural Gas ($/kBtu)	State	Electricity ($/kWh)	Natural Gas ($/kBtu)
Alabama	$0.0682	$0.00938	Missouri	$0.0505	$0.00796
Alaska	$0.1646	$0.00355	Montana	$0.0601	$0.00623
Arizona	$0.0670	$0.00758	Nebraska	$0.0500	$0.00698
Arkansas	$0.0526	$0.00668	Nevada	$0.0955	$0.00723
California	$0.1171	$0.00843	New Hampshire	$0.0973	$0.00917
Colorado	$0.0597	$0.00476	New Jersey	$0.0835	$0.00835
Connecticut	$0.0900	$0.01101	New Mexico	$0.0737	$0.00659
Delaware	$0.0693	$0.00840	New York	$0.1113	$0.00895
District of Columbia	$0.0645	$0.01266	North Carolina	$0.0641	$0.00863
			North Dakota	$0.0547	$0.00682
Florida	$0.0678	$0.001083	Ohio	$0.0723	$0.00789
Georgia	$0.0669	$0.00957	Oklahoma	$0.0571	$0.00755
Hawaii	$0.1502	$0.001926	Oregon	$0.0657	$0.00775
Idaho	$0.0601	$0.00612	Pennsylvania	$0.0819	$0.00898
Illinois	$0.0758	$0.00794	Rhode Island	$0.0834	$0.00964
Indiana	$0.0585	$0.00844	South Carolina	$0.0652	$0.00992
Iowa	$0.0602	$0.00750	South Dakota	$0.0605	$0.00693
Kansas	$0.0611	$0.00753	Tennessee	$0.0631	$0.00832
Kentucky	$0.0520	$0.00760	Texas	$0.0695	$0.00757
Louisiana	$0.0664	$0.00861	Utah	$0.0538	$0.00539
Maine	$0.1019	$0.01086	Vermont	$0.1087	$0.00778
Maryland	$0.0659	$0.00807	Virginia	$0.0572	$0.00920
Massachusetts	$0.0848	$0.01071	Washington	$0.0624	$0.00669
Michigan	$0.0701	$0.00631	West Virginia	$0.0545	$0.00734
Minnesota	$0.0546	$0.00778	Wisconsin	$0.0645	$0.00822
Mississippi	$0.0721	NA	Wyoming	$0.0548	$0.00469

with the renewable source. For example, a BIPV design would include the effects of sunny, cloudy and overcast conditions, the orientation and attitude of the array, and system losses. The method used to predict the quantity of energy generated by on-site renewable systems should be clearly stated in the LEED submittal narrative.

The following example illustrates how to calculate the renewable energy cost contribution for EA Credit 2.

Calculation based on EA Credit 1 Simulation

Once the amount of energy generated by the renewable system is calculated, an energy cost must be computed to establish the EA Credit 2 level of achievement. To assign a dollar value to the on-site energy, either use local utility rates or determine the "virtual" energy rate by dividing the annual energy cost for the specified fuel type by the annual energy consumption for that fuel type. Multiply the predicted on-site energy produced by the applicable energy rate for this fuel type.

When calculating the total energy cost of the Proposed Design using the Performance Rating Method, the contribution of any on-site renewable or recovered energy is accounted for by deducting the associated utility costs. In other words, the Renewable Energy Cost is excluded from the Proposed Building Performance.

In the example project described in EA Credit 1, 20 kW of photovoltaics contribute 28,245 kWh (or 96.4 MBtu) of energy to meet building electric power requirements. The virtual electric rate for the project is used for this example and is calculated by dividing the annual electric energy cost simulated for the Proposed Design ($81,485) by the annual electric energy consumption simulated for the Proposed Design (2975.0 MBtu), resulting in a virtual electric rate of $0.094/kWh (or $27.39/MBtu). This virtual electric rate is then multiplied by the PV contribution of 28,245 kWh to calculate the Renewable Energy Cost (REC) contribution from the PV of $2,639.

The predicted Proposed Design building annual energy cost, prior to the energy cost offset by the PV, is $85,669. Dividing the REC by the building annual energy cost yields the Percent Renewable Energy (3.1%), which qualifies the project for one point under EA Credit 2.

Calculation based on CBECS Data

If no energy performance calculation has been performed for the project, CBECS data can be used to determine the annual energy consumption intensities (kWh/ft2 and therms/ft2) based on building type. The total estimated energy consumption for the project is then calculated by multiplying the energy consumption intensities by the total building area. Building Annual Energy Cost is then calculated by summing the product of the energy consumption and average cost for electricity and natural gas, where the average electricity and natural gas costs are determined based on EIA 2003 commercial sector rates for the state the building is located in (see **Table 5**). The Renewable Energy Cost (REC) is calculated by multiplying the renewable energy contribution by either the local utility rate or the EIA 2003 average energy cost for the renewable fuel type. Dividing the REC by the Building Annual energy cost yields the Percent Renewable Energy.

Example EA Credit 2 Calculation based on CBECS Data

For example, if a project is a 1,000,000 sq.ft. office building in New York, determine how much renewable energy is required to meet the requirements of EA Credit 2 by using Tables 4 and 5 above to find the default energy consumption intensity for office buildings and energy costs for New York State.

Default Annual Electrical Costs

1,000,000 sf x 11.7 kWh/sf-yr x $0.1113/kWh = $1,302,210/yr

Default Annual Fuel Costs

1,000,000 sf x 58.3kBtu/sf-yr x $0.00895/kWh = $521,785/yr

Default Total Annual Energy Costs

$1,302,210/yr + $521,785/yr = $1,823,995/yr

This project would need to meet 2.5% of its annual energy costs ($45,600) with renewable energy systems to earn one point under EA Credit 2. The project plans to install a 300-kW PV system that is predicted to produce 450,000 kWh/yr. Using the default cost of electricity for New York State in **Table 5** ($0.1113/kWh) this system will provide $50,085/yr of electricity or 2.7%—enough for one point under EA Credit 2.

Exemplary Performance

There is no exemplary performance point available for this credit.

Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

The EA Credit 2 Submittal Template provides calculations to assist with the completion of this credit. The following project data and calculation information is required to document prerequisite compliance using the v2.2 Submittal Templates:

- ❑ Provide the On-Site Renewable Energy Source(s) used, the annual energy generated from each source, and the backup fuel for each source (i.e., the fuel that is used when the renewable energy source is unavailable).
- ❑ Describe the source of the annual energy cost information (energy model or industry database), and provide the appropriate energy values and costs.

Considerations

Renewable energy can be generated on a building site by using technologies that convert energy from the sun, wind and biomass into usable energy. On-site renewable energy is superior to conventional energy sources such as coal, nuclear, oil, natural gas and hydropower generation, because of its negligible transportation costs and impacts. In addition to preventing environmental degradation, on-site use of renewable power can improve power reliability and reduce reliance on the local power distribution grid.

Environmental Issues

Use of renewable energy reduces environmental impacts associated with utility energy production and use. These impacts include natural resource destruction, air pollution and water pollution. Utilization of biomass can divert an estimated 350 million tons of woody construction, demolition, and land-clearing waste from landfills each year. Conversely, air pollution will occur due to incomplete combustion if these wastes are not processed properly.

Economic Issues

Use of on-site renewable energy technologies can result in energy cost savings, particularly if peak hour demand charges are high. Utility rebates are often available to reduce first costs of renewable energy equipment. In some states, first costs can be offset by net metering, where excess electricity is sold back to the utility. The reliability and lifetime of PV systems are also improving. Manufacturers typically guarantee their PV systems for up to 20 years.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

American Wind Energy Association (AWEA)

www.awea.org

(202) 383-2500

AWEA is a national trade association representing wind power plant developers, wind turbine manufacturers, utilities, consultants, insurers, financiers, researchers and others involved in the wind industry.

Database of State Incentives for Renewable Energy (DSIRE)

www.dsireusa.org

The North Carolina Solar Center developed this database to contain all available information on state financial and regulatory incentives (e.g., tax credits, grants and special utility rates) that are designed to promote the application of renewable energy technologies. DSIRE also offers additional features such as preparing and printing reports that detail the incentives on a state-by-state basis.

ENERGY Guide

www.energyguide.com

This website provides information on different power types, including green power, as well as general information on energy efficiency and tools for selecting power providers based on various economic, environmental and other criteria.

Green Power Network

U.S. Department of Energy

www.eere.energy.gov/greenpower

The Green Power Network provides news and information on green power markets and related activities and is maintained by the National Renewable Energy Laboratory for the U.S. Department of Energy.

National Center for Photovoltaics (NCPV)

www.nrel.gov/ncpv/

NCPV provides clearinghouse information on all aspects of PV systems.

National Renewable Energy Laboratory

www.nrel.gov

The National Renewable Energy Laboratory (NREL) is a leader in the U.S. Department of Energy's effort to secure an energy future for the nation that is environmentally and economically sustainable.

Office of Energy Efficiency and Renewable Energy (EERE)

U.S. Department of Energy

www.eere.energy.gov

This website includes information on all types of renewable energy technologies and energy efficiency.

U.S. EPA Green Power Partnership

www.epa.gov/greenpower/index.htm

EPA's Green Power Partnership provides assistance and recognition to organizations that demonstrate environmental leadership by choosing green power. It includes a buyer's guide with listings of providers of green power in each state.

Print Media

Wind and Solar Power Systems by Mukund Patel, CRC Press, 1999. This text offers information about the fundamental elements of wind and solar power generation, conversion and storage, and detailed information about the design, operation, and control methods of both stand-alone and grid-connected systems.

Wind Energy Comes of Age by Paul Gipe, John Wiley & Sons, 1995. This book provides extensive information on the wind power industry, and is one of several books by the author covering general and technical information about wind power.

Definitions

Biomass is plant material such as trees, grasses and crops that can be converted to heat energy to produce electricity.

The **Environmental Attributes of Green Power** include emission reduction benefits that result from green power being used instead of conventional power sources.

Net Metering is a metering and billing arrangement that allows on-site generators to send excess electricity flows to the regional power grid. These electricity flows offset a portion of the electricity flows drawn from the grid. For more information on net metering in individual states, visit the DOE's Green Power Network website at www.eere.energy.gov/greenpower/netmetering.

Renewable Energy Certificates (RECs) are a representation of the environmental attributes of green power, and are sold separately from the electrons that make up the electricity. RECs allow the purchase of green power even when the electrons are not purchased.

SS	WE	EA	MR	EQ	ID
Credit 3					

1 point

EB

Enhanced Commissioning

Intent

Begin the commissioning process early during the design process and execute additional activities after systems performance verification is completed.

Requirements

Implement, or have a contract in place to implement, the following additional commissioning process activities in addition to the requirements of EA Prerequisite 1 and in accordance with this LEED-NC 2.2 Reference Guide:

1. Prior to the start of the construction documents phase, designate an independent Commissioning Authority (CxA) to lead, review, and oversee the completion of all commissioning process activities. The CxA shall, at a minimum, perform Tasks 2, 3 and 6. Other team members may perform Tasks 4 and 5.
   a. The CxA shall have documented commissioning authority experience in at least two building projects.
   b. The individual serving as the CxA shall be—
      i. independent of the work of design and construction;
      ii. not an employee of the design firm, though they may be contracted through them;
      iii. not an employee of, or contracted through, a contractor or construction manager holding construction contracts; and
      iv. (can be) a qualified employee or consultant of the Owner.
   c. The CxA shall report results, findings and recommendations directly to the Owner.
   d. This requirement has no deviation for project size.
2. The CxA shall conduct, at a minimum, one commissioning design review of the Owner's Project Requirements (OPR), Basis of Design (BOD), and design documents prior to mid-construction documents phase and back-check the review comments in the subsequent design submission.
3. The CxA shall review contractor submittals applicable to systems being commissioned for compliance with the OPR and BOD. This review shall be concurrent with A/E reviews and submitted to the design team and the Owner.
4. Develop a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems.
5. Verify that the requirements for training operating personnel and building occupants are completed.
6. Assure the involvement by the CxA in reviewing building operation within 10 months after substantial completion with O&M staff and occupants. Include a plan for resolution of outstanding commissioning-related issues.

Potential Technologies & Strategies

Although it is preferable that the CxA be contracted by the Owner, for the enhanced commissioning credit, the CxA may also be contracted through the design firms or construction management firms not holding construction contracts.

This LEED-NC 2.2 Reference Guide provides detailed guidance on the rigor expected for following process activities:

- ❑ Commissioning design review
- ❑ Commissioning submittal review
- ❑ Systems manual

Summary of Referenced Standards

There is no standard referenced for this credit.

Approach and Implementation

Relationship Between Fundamental and Enhanced Commissioning

LEED-NC addresses building commissioning in two places, EA Prerequisite 1 and EA Credit 3. The exact scope of services for commissioning a LEED-NC project should be based on the Owner's Project Requirements. Other systems, including the building envelope, stormwater management systems, water treatment systems, information technology systems, etc., may be included in the commissioning process based on the Owner's Project Requirements.

Table 1 outlines the team members primarily responsible to perform each project requirement; and also which requirements are common to EA Prerequisite 1 and EA Credit 3. All individuals on the project team are encouraged to participate in the commissioning activities as part of a larger commissioning team.

Strategies

Commissioning is a planned, systematic quality-control process that involves the owner, users, occupants, operations and maintenance staff, design professionals and contractors. Commissioning often begins at project inception; provides ongoing verification of achievement of the owner's project requirements; requires integration of contractor-completed commissioning process activities into the construction documents; aids in the coordination of static and dynamic

Table 1: Primary Responsibilities Chart for EA Prerequisite 1 and EA Credit 3

Tasks	Responsibilities	
	If you are only meeting EA Prerequisite 1...	**If you are meeting the EAp1 AND EA credit 3...**
Designate Commissioning Authority (CxA)	Owner or Project Team	Owner or Project Team
Document Owner's Project Requirements (OPR)	Owner	Owner
Develop Basis of Design	Design Team	Design Team
Incorporate commissioning requirements into the construction documents	Project Team or CxA	Project Team or CxA
Conduct commissioning design review prior to mid-construction documents	N/A	CxA
Develop and implement a commissioning plan	Project Team or CxA	Project Team or CxA
Review contractor submittals applicable to systems being commissioned	N/A	CxA
Verify the installation and performance of commissioned systems	CxA	CxA
Develop a systems manual for the commissioned systems	N/A	Project Team and CxA
Verify that the requirements for training are completed	N/A	Project Team and CxA
Complete a summary commissioning report	CxA	CxA
Review building operation within 10 months after substantial completion	N/A	CxA

system testing; verifies staff training; and concludes with warranty verification and commissioning documentation.

The specific tasks satisfying this LEED-NC credit include:

1. **Prior to the start of the construction document phase, designate an independent Commissioning Authority (CxA) to lead, review, and oversee the completion of all commissioning process activities. The CxA shall, at a minimum, perform Tasks 2, 3 and 6 of the EA Credit 3 requirements. Other team members may perform Tasks 4 and 5.**

   The minimum defined experience for the designated CxA for EA Credit 3 is the same as described for EA Prerequisite 1. The design and submittal review activities called for in EA Credit 3 must be conducted by a third party CxA, independent of the firms responsible for design and construction, or a qualified member of the Owner's staff.

2. **The CxA shall conduct, at a minimum, one commissioning design review of the Owner's Project Requirements (OPR), Basis of Design (BOD), and design documents prior to mid-construction documents phase and back-check the review comments in the subsequent design submission.**

   The CxA shall review the OPR, BOD and design documents to provide the owner and design team with an independent assessment of the state of the design for the commissioned systems. Typically the design review(s) performed by the CxA will focus on the following issues:

   - ❑ Clarity, completeness and adequacy of OPR
   - ❑ Verifying all issues discussed in OPR are addressed adequately in BOD
   - ❑ Reviewing design documents for achieving the OPR and BOD and coordination of commissioned systems

   Additional reviews by the CxA, throughout the design and construction process may be advisable and appropriate depending on the project duration, phasing, complexity and the owner's requirements.

3. **The CxA shall review contactor submittals applicable to systems being commissioned for compliance with the OPR and BOD. This review shall be concurrent with A/E reviews and submitted to the design team and the Owner.**

   The CxA shall provide a review of the contractor submittals to help identify any issues that might otherwise result in re-work and/or change orders. The CxA should specifically evaluate the submittals for:

   - ❑ Meeting the OPR and BOD
   - ❑ Operation and maintenance requirements
   - ❑ Facilitating performance testing

   The CxA review of contractor submittals does not, typically, substitute or alter the scope or responsibility of the design team's obligations to approve or reject submittals.

4. **Develop a systems manual that provides future operating staff the information needed to understand and optimally operate the commissioned systems.**

   Provide a Systems Manual in addition to the O&M Manuals submitted by the Contractor. The Systems Manual generally focuses on operating, rather than maintaining the equipment, particularly the interactions between equipment.

   The Systems Manual shall include the following for each commissioned system:

- ❑ Final version of the BOD
- ❑ System single line diagrams
- ❑ As-built sequences of operations, control drawings and original set-points
- ❑ Operating instructions for integrated building systems
- ❑ Recommended schedule of maintenance requirements and frequency, if not already included in the project O&M manuals
- ❑ Recommended schedule for retesting of commissioned systems with blank test forms from the original Commissioning Plan
- ❑ Recommend schedule for calibrating sensors and actuators

5. **Verify that the requirements for training operating personnel and building occupants are completed.**

   Based on the particular project, establish and document training expectations and needs with the Owner. Ensure that operations staff and occupants receive this training and orientation. Pay particular attention to new or uncommon sustainable design features that may have a potential to be over-ridden or removed because of a lack of understanding. Document that the training was completed according to the contract documents.

6. **Assure the involvement by the CxA in reviewing building operation within 10 months after substantial completion with O&M staff and occupants. Include a plan for resolution of outstanding commissioning-related issues.**

   The CxA should coordinate with the Owner and the O&M staff to review the facility and its performance 8 to 10 months after handover of the facility. Any outstanding construction deficiencies or deficiencies identified in this post-occupancy review should be documented and corrected under manufacturer or contractor warranties.

   The CxA review of the building operation with operations staff and occupants should identify any problems in operating the building as originally intended. Any significant issues identified by the CxA that will not be corrected should be recorded in the systems manual.

Calculations

There are no calculations associated with this credit

Exemplary Performance

There is no exemplary performance point available for this credit.

Submittal Documentation

This credit is submitted as part of the **Construction Submittal**.

The following project data and calculation information is required to document credit compliance using the v2.2 Submittal Templates:

- ❑ Provide the name, firm and experience information for the CxA
- ❑ Confirm that the 6 required tasks have been completed
- ❑ Provide a narrative description of the results of the commissioning design review, implementation of the systems manual and training, and the plan for the review of building operation at 8 to 10 months.

Considerations

Cost Issues

An effective commissioning process will typically result in increased project soft costs and may require additional scheduling for commissioning activities.

SS	WE	EA	MR	EQ	ID
Credit 3					

This investment is generally recouped in improved design and construction coordination, reduced change-orders, and reduced operating costs.

Facilities that do not perform as intended may consume significantly more resources over the useful life of the building. Commissioning can minimize the negative environmental impacts buildings have on our environment by helping verify that buildings are designed, constructed, and operated as intended and in accordance with the owner's project requirements.

Building occupant comfort and indoor air quality may have tremendous impact on occupant productivity, health and well-being, as well as the cost of ownership. Commissioning can significantly reduce repairs, construction change orders, energy costs, and maintenance and operation costs.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

See the Resources section of EA Prerequisite 1 for a list of specific commissioning resources.

Definitions

Basis of Design includes all information necessary to accomplish the owner's project requirements, including weather data, interior environmental criteria, other pertinent design assumptions, cost goals, and references to applicable codes, standards, regulations and guidelines.

Commissioning is the process of verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements.

Commissioning Plan is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process.

Commissioning Report is the document that records the results of the commissioning process, including the as-built performance of the HVAC system and unresolved issues.

Commissioning Specification is the contract document that details the commissioning requirements of the construction contractors.

Installation Inspection is the process of inspecting components of the commissioned systems to determine if they are installed properly and ready for systems performance testing.

Owner's Project Requirements is a written document that details the functional requirements of a project and the expectations of how it will be used and operated.

System Performance Testing is the process of determining the ability of the commissioned systems to perform in accordance with the owner's project requirements, basis of design, and construction documents.

SS	WE	EA	MR	EQ	ID
Credit 4					

1 point

Enhanced Refrigerant Management

Intent

Reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to global warming.

Requirements

OPTION 1

Do not use refrigerants.

OR

OPTION 2

Select refrigerants and HVAC&R that minimize or eliminate the emission of compounds that contribute to ozone depletion and global warming. The base building HVAC&R equipment shall comply with the following formula, which sets a maximum threshold for the combined contributions to ozone depletion and global warming potential:

$LCGWP + LCODP \times 10^5 \leq 100$

Where:

$LCODP = [ODP_r \times (Lr \times Life + Mr) \times Rc]/Life$

$LCGWP = [GWPr \times (Lr \times Life + Mr) \times Rc]/Life$

LCODP: Lifecycle Ozone Depletion Potential (lbCFC11/Ton-Year)

LCGWP: Lifecycle Direct Global Warming Potential ($lbCO_2$/Ton-Year)

GWPr: Global Warming Potential of Refrigerant (0 to 12,000 $lbCO_2$/lbr)

ODPr: Ozone Depletion Potential of Refrigerant (0 to 0.2 lbCFC11/lbr)

Lr: Refrigerant Leakage Rate (0.5% to 2.0%; default of 2% unless otherwise demonstrated)

Mr: End-of-life Refrigerant Loss (2% to 10%; default of 10% unless otherwise demonstrated)

Rc: Refrigerant Charge (0.5 to 5.0 lbs of refrigerant per ton of cooling capacity)

Life: Equipment Life (10 years; default based on equipment type, unless otherwise demonstrated)

For multiple types of equipment, a weighted average of all base building level HVAC&R equipment shall be applied using the following formula:

$[\sum (LCGWP + LCODP \times 10^5) \times Qunit] / Qtotal \leq 100$

Where:

Qunit = Cooling capacity of an individual HVAC or refrigeration unit (Tons)

Qtotal = Total cooling capacity of all HVAC or refrigeration

Small HVAC units (defined as containing less than 0.5 lbs of refrigerant), and other equipment such as standard refrigerators, small water coolers, and any other cooling equipment that contains less than 0.5 lbs of refrigerant, are not considered part of the "base building" system and are not subject to the requirements of this credit.

AND

Do not install fire suppression systems that contain ozone-depleting substances (CFCs, HCFCs or Halons).

Potential Technologies & Strategies

Design and operate the facility without mechanical cooling and refrigeration equipment. Where mechanical cooling is used, utilize base building HVAC and refrigeration systems for the refrigeration cycle that minimize direct impact on ozone depletion and global warming. Select HVAC&R equipment with reduced refrigerant charge and increased equipment life. Maintain equipment to prevent leakage of refrigerant to the atmosphere. Utilize fire suppression systems that do not contain HCFCs or Halons.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Most commonly used refrigerants contained in building HVAC and refrigeration equipment are stable chemical compounds that, when released to the environment, result in damage to the atmosphere by the following:

- ❑ Contributing to deterioration of the Earth's protective ozone layer (Ozone Depletion)
- ❑ Contributing greenhouse gases to the atmosphere (Global Warming)

Building HVAC&R systems also contribute to global warming through their associated energy consumption and power plant emissions of greenhouse gases. Over the life of the equipment, the "indirect" global warming impact of HVAC&R equipment may be much greater than the direct impact of releasing the refrigerant to the atmosphere. The indirect global warming impact of refrigerants in HVAC&R equipment is addressed by EA Credit 1, which credits the energy savings associated with more energy efficient equipment. EA Credit 4 addresses only the direct atmospheric impact of refrigerant selection and management decisions.

If the building(s) is (are) connected to an existing chilled water system, have the chilled water supplier perform the required calculations and submit a letter showing compliance with the requirements.

There are several strategies associated with reducing or eliminating the potential negative impact of refrigerant use on the environment.

Do Not Use Refrigerants

Green building designs that avoid the use of refrigerants by eliminating the use of vapor-compression HVAC&R equipment have no potential for atmospheric damage associated with refrigerant release. LEED projects that do not use refrigerants are awarded this LEED-NC credit with no calculations or analysis required. For example, a naturally ventilated building with no active cooling systems (and therefore no refrigerants) is awarded this credit.

"Natural refrigerants" including water, carbon dioxide, and ammonia are used in some HVAC&R systems. These naturally occurring compounds generally have much lower potential for atmospheric damage than more common manufactured chemical refrigerants. Projects that employ natural refrigerants are eligible for this credit.

Select Refrigerants with Low ODP and GWP

Table 1 shows the Ozone Depleting Potential (ODP) and direct Global Warming Potential (GWP) of many common refrigerants.

The LEED Technical and Scientific Committee (TSAC) report that provides the basis of this LEED-NC credit notes the following:

"The ozone-depletion potential (ODP) of the HCFCs (e.g., HCFC-123, HCFC-22) is much smaller than the ODP of the CFCs, but is not negligible. In contrast, the HFCs (e.g., HFC-134a, HFC-410a) have an ODP that is essentially zero, but their global warming potential (GWP) is substantially greater than some of the HCFCs, leading to a direct global warming mechanism when the compound leaks into the atmosphere. Moreover, thermodynamic properties make the HFCs slightly less efficient refrigerants than the HCFCs given idealized equipment design, so the same amount of cooling may require more electricity and thereby

Table 1: Ozone-depletion and global-warming potentials of refrigerants (100-yr values)

Refrigerant	ODP	GWP	Common Building Applications
Chlorofluorocarbons			
CFC-11	1.0	4,680	Centrifugal chillers
CFC-12	1.0	10,720	Refrigerators, chillers
CFC-114	0.94	9,800	Centrifugal chillers
CFC-500	0.605	7,900	Centrifugal chillers, humidifiers
CFC-502	0.221	4,600	Low-temperature refrigeration
Hydrochlorofluorocarbons			
HCFC-22	0.04	1,780	Air conditioning, chillers,
HCFC-123	0.02	76	CFC-11 replacement
Hydrofluorocarbons			
HFC-23	~ 0	12,240	Ultra-low-temperature refrigeration
HFC-134a	~ 0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	~ 0	1,020	Insulation agent, centrifugal chillers
HFC-404A	~ 0	3,900	Low-temperature refrigeration
HFC-407C	~ 0	1,700	HCFC-22 replacement
HFC-410A	~ 0	1,890	Air conditioning
HFC-507A	~ 0	3,900	Low-temperature refrigeration
Natural Refrigerants			
Carbon Dioxide (CO2)	0	1.0	
Ammonia (NH3)	0	0	
Propane	0	3	

causes the indirect release of more CO_2 in generating that electricity. The dilemma, therefore, is that some refrigerants cause more ozone depletion than others, but the most ozone-friendly refrigerants cause more global warming."

Refrigerants with non-zero ODP are being phased out according to an international agreement—the Montreal Protocol. In accordance with the Montreal Protocol, all chlorinated refrigerants including CFCs and HCFCs will be phased out by the year 2030.

In the meantime, selecting the appropriate refrigerant for any given project and HVAC system may be impacted by available equipment, energy efficiency, budget, and other factors. Where viable options are available, projects should select refrigerants with no or very little ODP and minimal GWP.

Minimize Refrigerant Leakage

Refrigerants cannot damage the atmosphere if they are contained and are never released to the environment. Unfortunately, in real world applications, some or all refrigerant provided for HVAC&R equipment is leaked to the environment during installation, operation, servicing, and/or decommissioning of the equipment.

Under Section 608 of the Clean Air Act of 1990, the EPA has established regulations that—

- ❑ Require service practices that maximize recycling of ozone-depleting compounds (both CFCs and HCFCs) during the servicing and disposal of air-conditioning and refrigeration equipment.
- ❑ Set certification requirements for recycling and recovery equipment, technicians, and reclaimers and restrict the sale of refrigerant to uncertified technicians.

- ❑ Require persons servicing or disposing of air-conditioning and refrigeration equipment to certify to EPA that they have acquired recycling or recovery equipment and are complying with the requirements of the rule.
- ❑ Require the repair of substantial leaks in air-conditioning and refrigeration equipment with a charge of greater than 50 pounds.
- ❑ Establish safe disposal requirements to ensure removal of refrigerants from goods that enter the waste stream with the charge intact (e.g., motor vehicle air conditioners, home refrigerators, and room air conditioners).
- ❑ Prohibits individuals from knowingly venting ozone-depleting compounds (generally CFCs and HCFCs) used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (appliances).

Federal regulation and best practices for refrigerant management and equipment maintenance can minimize the loss of refrigerant to the atmosphere. Manufacturers may offer leakage rate guarantees for certain types of major HVAC&R equipment (such as chillers) as part of a long-term service contract.

Most refrigerant loss to the environment occurs due to undetected leaks in outdoor equipment and/or refrigerant loss during the installation, charging, servicing, or decommissioning of equipment.

Select Equipment with Efficient Refrigerant Charge

Refrigerant charge is the ratio of refrigerant required (lbs) to cooling capacity provided (tons) for a given piece of HVAC&R equipment. Equipment that uses refrigerant efficiently and therefore has low refrigerant charge has less potential to contribute to atmospheric damage.

Table 2, below, shows the maximum refrigerant charge for any single unit of equipment that would comply with this credit for various common refrigerants and types of equipment. Most projects have multiple units of base building HVAC&R equipment, but if each unit is compliant with the table below, the project as a whole will comply with this credit. In the table below the calculations assume that refrigerant leakage default factors are used.

Select Equipment with Long Service Life

HVAC&R service equipment with long service life will generally reduce the potential amount of refrigerant leaked to the environment since a significant portion of refrigerant loss occurs during installation and decommissioning of equipment. The 2003 ASHRAE Applications Handbook provides general data on the

Table 2: Default Maximum Allowable Equipment Refrigerant Charge (lb/ton) for Compliance with EA Credit 4

Refrigerant	10 Year Life	15 Year Life	20 Year Life	23 Year Life
	(Room or Window AC & Heat Pumps)	(Unitary, split and packaged AC and heat pumps)	(Reciprocating compressors & chillers)	(Centrifugal, Screw & Absorption Chillers)
R-22	0.57	0.64	0.69	0.71
R-123	1.60	1.80	1.92	1.97
R-134a	2.52	2.80	3.03	3.10
R-245fa	3.26	3.60	3.92	4.02
R-407c	1.95	2.20	2.35	2.41
R-410a	1.76	1.98	2.11	2.17

typical service life of different types of HVAC equipment:

- ❑ Window air-conditioning units and heat pumps – 10 years
- ❑ Unitary, split and packaged air-conditioning units and heat pumps – 15 years
- ❑ Reciprocating compressors and reciprocating chillers – 20 years
- ❑ Centrifugal and absorption chillers – 23 years

Base Building HVAC&R Equipment

Base building HVAC&R equipment includes any equipment permanently installed in the building that contains more than 0.5 lbs of refrigerant. This includes chillers, unitary (split and packaged) HVAC equipment, room or window air-conditioners, computer room air conditioning (CRAC) units, data and telecommunications room cooling units, and commercial refrigeration equipment. Portable cooling equipment (such as standard refrigerators), temporary cooling equipment, and equipment with less than 0.5 lbs of refrigerant (such as small water coolers) may be excluded from the calculations for this credit.

Calculations

To complete the calculations to demonstrate compliance with this credit, the following information will be required for each unit of base building HVAC&R equipment:

- ❑ Refrigerant charge, (Rc) in lbs of refrigerant per ton of cooling capacity
- ❑ Refrigerant type (used to determine ODPr and GWPr)
- ❑ Equipment type (used to determine Life)

Table 1 includes ODPr and GWPr values for many common refrigerants. These values should be used in the calculations associated with this credit.

Equipment Life shall be assumed (as excerpted from 2003 ASHRAE Applications Handbook) to be the following:

- ❑ Window air-conditioning units and heat pumps – 10 years
- ❑ Unitary, split and packaged air-conditioning units and heat pumps – 15 years
- ❑ Reciprocating compressors and reciprocating chillers – 20 years
- ❑ Centrifugal and absorption chillers – 23 years

All other HVAC&R equipment will be assumed to have a life of 15 years. Applicants may use an alternate value for Equipment Life if they demonstrate and document information in support of their claim. For example if there is a manufacturer's guarantee and long-term service contract assuring a 30-year life for a chiller installation, this alternate value of equipment life could be used in the calculations for that unit of equipment.

Refrigerant Leakage Rate (Lr) is assumed to be 2%/yr for all equipment types. End-of-life Refrigerant Loss (Mr) is assumed to be 10% for all equipment types. Applicants may use alternate values for Lr and Mr if they demonstrate and document information in support of their claim, such as—

- ❑ Manufacturers' test data for refrigerant leakage rates (%/yr);
- ❑ Refrigerant leak detection equipment in the room where the equipment is located;
- ❑ A preventative maintenance program for minimizing equipment refrigerant leakage; and
- ❑ A program for recovering and recycling refrigerant at the end of the equipment lifecycle.

Projects may not claim zero leakage over the lifecycle of the HVAC&R equipment installed in the project.

For each piece of HVAC&R equipment, the project should calculate the following values:

- ❑ Lifecycle Ozone Depletion Potential (LCODP) = [ODP_r x (Lr x Life +Mr) x Rc]/Life
- ❑ Lifecycle Direct Global Warming Potential (LCGWP) = [GWPr x (Lr x Life +Mr) x Rc]/Life

If there is only one piece of base building HVAC&R equipment, the following equation shall be used to demonstrate compliance with this LEED credit:

Refrigerant Atmospheric Impact = LCGWP + LCODP x $10^5 \leq 100$

If there are multiple pieces of base building HVAC&R equipment, the project should use a weighted average of all equipment, based on cooling capacity:

- ❑ Average Refrigerant Atmospheric Impact = [∑ (LCGWP + LCODP x 10^5) x Qunit] / Qtotal ≤ 100

Where

- ❑ Qunit = Cooling capacity of an individual HVAC or refrigeration unit (tons)
- ❑ Qtotal = Total cooling capacity of all HVAC or refrigeration

Three examples of projects are shown below. In two of these examples (the office building and the hotel) the overall project complies with EA Credit 4, although individual units of HVAC&R equipment have refrigerant atmospheric impact > 100. The school classroom building, overall, does not comply with EA Credit 4.

Example Calculation 1—School Classroom Building

- ❑ (12) 5-ton packaged HVAC units with HFC-410A for classrooms
- ❑ (1) 2-ton split system HVAC units with HCFC-22 for a data room
- ❑ (1) 1-ton window HVAC unit with HCFC-22 for an office

Example Calculation 2—Office Building

- ❑ (1) 500-ton centrifugal chiller with HFC-134a—provided with manufacturers data and service contract guaranteeing less than 1% per year leakage
- ❑ (1) 50-ton reciprocating "pony" chiller with HCFC-22
- ❑ (5) 10-ton computer room air conditioning units with HCFC-22

Example Calculation 3—Hotel

- ❑ (3) 400-ton centrifugal chillers with HCFC-123
- ❑ (1) 40-ton commercial refrigeration compressor rack with HCFC-22
- ❑ (12) 2-ton telephone/data room split system cooling units with HCFC-22

Example Calculation 1: School Classroom Building

Inputs									Calculations				
N (Number of Units)	**Qunit** (Tons)	**Refrigerant**	**GWPr**	**ODPr**	**Rc** (lb/ton)	**Life** (yrs)	**Lr** (%)	**Mr** (%)	**Tr** Total Leakage (Lr x Life + Mr)	**LCGWP** (GWPr x Tr x Rc)/Life	**LCODP x 10^5** 100,000 x (ODPr x Tr x Rc)/Life	**Refrigerant Atmospheric Impact = LCGWP + LCODP x 10^5**	**(LCGWP + LCODP x 10^5) x N x Qunit**
12	5	R410a	1,890	0	1.8	15	2%	10%	40%	90.72	0	**90.7**	5443
1	2	R22	1,780	0.04	3.3	15	2%	10%	40%	156.6	35.2	**191.8**	384
1	1	R22	1,780	0.04	2.1	10	2%	10%	30%	112.1	25.2	**137.3**	137
Qtotal:	**63 tons**											**Subtotal:**	**5964**
Average Refrigerant Atmospheric Impact = [∑ (LCGWP + LCODP x 105) x Qunit] / Qtotal :													**94.7**

Exemplary Performance

There is no exemplary performance point available for this credit.

Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

The following project data and calculation information is required to document credit compliance using the v2.2 Submittal Templates:

❑ Enter into the template the HVAC&R equipment types, including number, size (tons), refrigerant, and refrigerant charge.

❑ Provide a narrative describing any special circumstances or calculation explanations.

Considerations

LEED TSAC makes the following observation:

"An objective scientific analysis of tradeoffs between global warming and ozone depletion is extremely complex, and will only come from a full understanding of all interacting pathways and the effects on economic activities, human health, and terrestrial and oceanic ecosystems. Any quantitative credit scheme addressing both must involve some subjectivity in the relative weight given to each issue."

Refrigerant management to minimize the negative impacts of refrigerant use on ozone depletion and global warming is dependant on several factors that include—

Example Calculation 2: Office Building

Inputs										Calculations			
N (Number of Units)	**Qunit** (Tons)	**Refrigerant**	**GWPr**	**ODPr**	**Rc** (lb/ton)	**Life** (yrs)	**Lr** (%)	**Mr** (%)	**Tr** Total Leakage (Lr x Life + Mr)	**LCGWP** (GWPr x Tr x Rc)/ Life	**LCODP x 10^5** 100,000 x (ODPr x Tr x Rc)/ Life	**Refrigerant Atmospheric Impact = LCGWP + LCODP x 10^5**	**(LCGWP + LCODP x 10^5) x N x Qunit**
1	500	R134a	1,320	0	2	23	1%	10%	33%	37.9	0	**37.9**	18939
1	50	R22	1,780	0.04	2.1	20	2%	10%	50%	93.5	21	**114.5**	5723
5	10	R22	1,780	0.04	2.4	15	2%	10%	40%	113.9	25.6	**139.5**	6976
Qtotal:	**600 tons**											**Subtotal:**	**31637**
Average Refrigerant Atmospheric Impact = [∑ (LCGWP + LCODP x 105) x Qunit] / Qtotal :													**52.7**

Example Calculation 3: Hotel

Inputs										Calculations			
N (Number of Units)	**Qunit** (Tons)	**Refrigerant**	**GWPr**	**ODPr**	**Rc** (lb/ton)	**Life** (yrs)	**Lr** (%)	**Mr** (%)	**Tr** Total Leakage (Lr x Life + Mr)	**LCGWP** (GWPr x Tr x Rc)/ Life	**LCODP x 10^5** 100,000 x (ODPr x Tr x Rc)/ Life	**Refrigerant Atmospheric Impact = LCGWP + LCODP x 10^5**	**(LCGWP + LCODP x 10^5) x N x Qunit**
3	400	R123	76	0.02	1.63	23	2%	10%	56%	3.016209	79.37391	**82.4**	98868.1
1	40	R22	1,780	0.04	2.1	20	2%	10%	50%	93.45	210	**303.5**	12138.0
12	2	R22	1,780	0.04	3.1	15	2%	10%	40%	147.1467	330.6667	**477.8**	11467.5
Qtotal:	**1264 tons**											**Subtotal:**	**122473.666**
Average Refrigerant Atmospheric Impact = [∑ (LCGWP + LCODP x 105) x Qunit] / Qtotal :													**96.9**

- Designing buildings that do not rely on chemical refrigerants;
- Designing HVAC&R equipment that uses energy efficiently;
- Selecting refrigerants with zero or low ODP and minimal direct GWP; and
- Maintaining HVAC&R equipment to reduce refrigerant leakage to the environment.

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

EPA's Significant New Alternatives Policy (SNAP)

www.epa.gov/ozone/snap/index.html

SNAP is an EPA program to identify alternatives to ozone-depleting substances. The program maintains up-to-date lists of environmentally friendly substitutes for refrigeration and air conditioning equipment, solvents, fire suppression systems, adhesives, coatings and other substances.

Stratospheric Ozone Protection: Moving to Alternative Refrigerants

http://es.epa.gov/program/epaorgs/oar/altrefrg.html

This EPA document includes 10 case histories on buildings that have been converted to accommodate non-CFC refrigerants.

Print Media

The Treatment by LEED of the Environmental Impact of HVAC Refrigerants

U.S. Green Building Council

www.usgbc.org/DisplayPage.aspx?CMSPageID=154

(202) 82-USGBC

This report was prepared under the auspices of the U.S. Green Building Council's LEED Technical and Scientific Advisory Committee (TSAC), in response to a charge given TSAC by the LEED Steering Committee to review the atmospheric environmental impacts arising from the use of halocarbons as refrigerants in building heating, ventilating, and air conditioning (HVAC) equipment.

Building Systems Analysis & Retrofit Manual, SMACNA, 1995.

This manual provides an overview of a number of topics relating to HVAC retrofits, including energy management retrofits and CFC/HCFC retrofits.

CFCs, HCFC and Halons: Professional and Practical Guidance on Substances that Deplete the Ozone Layer, CIBSE, 2000.

This booklet provides background information on the environmental issues associated with CFCs, HCFCs, and halons, design guidance, and strategies for refrigerant containment and leak detection.

The Refrigerant Manual: Managing the Phase-Out of CFCs, BOMA International, 1993.

This manual gives an overview of the phase-out of CFCs, including information on retaining existing equipment, retrofitting existing equipment, or replacing equipment.

Definitions

Chlorofluorocarbons (CFCs) are hydrocarbons that deplete the stratospheric ozone layer.

Halons are substances used in fire suppression systems and fire extinguishers in buildings. These substances deplete the stratospheric ozone layer.

Hydrochlorofluorocarbons (HCFCs) are refrigerants used in building equipment that deplete the stratospheric ozone layer, but to a lesser extent than CFCs.

Hydrofluorocarbons (HFCs) are refrigerants that do not deplete the stratospheric ozone layer. However, some HFCs have high global warming potential and, thus, are not environmentally benign.

Refrigerants are the working fluids of refrigeration cycles that absorb heat from a reservoir at low temperatures and reject heat at higher temperatures.

SS | WE | EA | MR | EQ | ID

Credit 5

1 point

EB

Measurement & Verification

Intent

Provide for the ongoing accountability of building energy consumption over time.

Requirements

- ❑ Develop and implement a Measurement & Verification (M&V) Plan consistent with Option D: Calibrated Simulation (Savings Estimation Method 2), or Option B: Energy Conservation Measure Isolation, as specified in the *International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April, 2003*.
- ❑ The M&V period shall cover a period of no less than one year of post-construction occupancy.

Potential Technologies & Strategies

Develop an M&V Plan to evaluate building and/or energy system performance. Characterize the building and/or energy systems through energy simulation or engineering analysis. Install the necessary metering equipment to measure energy use. Track performance by comparing predicted performance to actual performance, broken down by component or system as appropriate. Evaluate energy efficiency by comparing actual performance to baseline performance.

While the IPMVP describes specific actions for verifying savings associated with energy conservation measures (ECMs) and strategies, this LEED credit expands upon typical IPMVP M&V objectives. M&V activities should not necessarily be confined to energy systems where ECMs or energy conservation strategies have been implemented. The IPMVP provides guidance on M&V strategies and their appropriate applications for various situations. These strategies should be used in conjunction with monitoring and trend logging of significant energy systems to provide for the ongoing accountability of building energy performance.

Summary of Referenced Standard

International Performance Measurement & Verification Protocol (IPMVP) Volume III: Concepts and Options for Determining Energy Savings in New Construction, April, 2003.

www.ipmvp.org

IPMVP Inc. is a nonprofit organization whose vision is a global marketplace that properly values energy and water efficiency.

IPMVP Volume III provides a concise description of best-practice techniques for verifying the energy performance of new construction projects. Chapter 2 describes the process for developing the theoretical Baseline for new construction projects and provides examples of relevant applications. Chapter 3 describes the basic concepts and structure of the M&V Plan. Chapter 4 describes specific M&V Methods for Energy Conservation Measure Isolation (Option B) and Whole Building Calibrated Simulation (Option D).

Approach and Implementation

The IPMVP Volume III presents four options for new construction M&V. Of these, Options B and D are deemed to be suitable for the purposes of LEED M&V (see **Table 1**).

Option B (ECM Isolation) addresses M&V at the system or ECM level. This approach is suitable for smaller and/or simpler buildings that may be appropriately monitored by isolating the main energy systems and applying Option B to each on an individual basis. Projects following Option B may also need to implement whole-building metering and tracking to satisfy the intent of this credit.

Option D (Whole Building Calibrated Simulation, Savings Estimation) addresses M&V at the whole-building level. This approach is most suitable for buildings with a large number of ECMs or systems that are interactive, or where the building design is integrated and holistic, rendering isolation and M&V of individual ECMs impractical or inappropriate. It essentially requires comparing the actual energy use of the building and its systems with the performance predicted by a calibrated computer model (presumably created from the computer models used for EA Credit 1 Option 1). Calibration is achieved by adjusting the as-built simulation to reflect actual operating conditions and parameters. To

Table 1: Office Building

M&V Option	How Baseline is Determined	Typical Applications
B. ECM Isolation		
Savings are determined by full measurement of the energy use and operating parameters of the system(s) to which an ECM was applied, separate from the rest of the facility.	Projected baseline energy use is determined by calculating the hypothetical energy performance of the baseline system under measured post-construction operating conditions.	Variable speed control of a fan motor. Electricity use is measured on a continuous basis throughout the M&V period.
Savings are determined at the whole-building or system level by measuring energy use at main meters or sub-meters.	Projected baseline energy use is determined by energy simulation of the baseline under the post-construction operating conditions.	Savings determination for the purposes of a new building Performance Contract, with the local energy code defining the baseline.

determine energy savings, similar calibrations or adjustments should be applied to the Baseline Building simulation.

Option D serves two purposes:

- ❑ Calibration of the as-built simulation model to actual energy use reveals ECM/design or operational underperformance.
- ❑ Adjusting the Baseline simulation allows meaningful performance comparisons and the determination of verified savings.

The IPMVP is not prescriptive regarding the application of M&V options, but instead defers to the professional judgment of the implementer(s) to apply the options in a manner that is appropriate to the project scale while still meeting the M&V objective (see Economic Issues below).

IPMVP Vol. III provides specific requirements for the M&V Plan. In general the plan identifies the M&V option(s) to be applied, defines the Baseline or how it will be determined, identifies metering requirements, and outlines specific methodologies associated with implementing the M&V Plan. Responsibility for the design, coordination, and implementation of the M&V Plan should reside with one entity of the design team. The person(s) responsible for energy engineering and analysis is usually best-suited for this role, although third-party verification may be appropriate in some cases. Since the pursuit of this credit is largely affected by the option selected to achieve EA Credit 1, the Baseline definition will vary. For EA Credit 1 Option 1 the baseline is defined by ASHRAE 90.1 Appendix G. The Baselines for EA Credit 1 Options 2 and 3 are defined by the respective prescriptive standards, which in some cases may be effectively the same as the Design. In that case the M&V Plan is reduced to addressing Design performance only. However, it is necessary in all cases to project the energy performance of the Design and/or its systems. For Option B this can be accomplished through computer modeling or engineering analysis for simple buildings or systems.

The start of the M&V period should occur after the building has achieved a reasonable degree of occupancy and operational stability.

After the M&V period has been completed (after at least one year of stable and optimized operation) long term M&V can be economically implemented. Essentially, the one year of stable post-construction operation becomes the Base Year against which subsequent energy performance is compared by applying operational adjustments and regression analysis. Refer to IPMVP Volume I, which focuses on the pertinent methods of M&V, for further information.

Calculations

IPMVP Volume III provides fundamental calculation formulae as well as quantitative guidelines for error estimation and tolerance for various M&V options.

Exemplary Performance

There is no exemplary performance point available for this credit.

Submittal Documentation

This credit is submitted as part of the **Design Submittal**.

The following project data and calculation information is required to document credit compliance using the v2.2 Submittal Templates:

- ❑ Confirm the IPMVP Option pursued by the project.
- ❑ Upload a copy of the M&V Plan.
- ❑ Provide a narrative describing any special circumstances or calculation explanations.

Section 3.2 of IPMVP Volume III provides specific content requirements for the M&V Plan.

Considerations

The benefits of optimal building operation, especially in terms of energy performance, are substantial. The lifetime of many buildings is greater than 50 years. Even minor energy savings are significant when considered in aggregate. These long-term benefits often go unrealized due to maintenance personnel changes, aging of building equipment, and changing utility rate structures. Therefore, it is important to institute M&V procedures to achieve and maintain optimal performance over the lifetime of the building through continuous monitoring. The goal of M&V activities is to provide building owners with the tools and data necessary to identify systems that are not functioning as expected, and to optimize building system performance.

Environmental Issues

Measurement & Verification of a building's ongoing energy use allows for optimization of related systems over the lifetime of the building. As a result, the cost and environmental impacts associated with energy can be minimized.

Economic Issues

The added cost to institute an M&V program in a new construction project is strongly tied to the complexity of the building systems. Costs can come from additional instrumentation and metering equipment, additional controls programming, and/or labor for the monitoring and processing of the data collected. The extent to which these costs are considered extraneous will depend on the level of instrumentation and controls in the Baseline Design. Often times, projects with sophisticated digital controls can support an effective M&V program without incurring significant additional costs. In other instances, projects with a series of chillers and air handlers and simple controls may need to install a significant amount of equipment to generate the necessary data for an effective M&V program. Smaller buildings with packaged HVAC equipment and fewer pieces of equipment may have lower costs because there are fewer systems to measure and verify. The cost of an M&V program must be balanced against the potential performance risk. A simple method of estimating performance risk can be based on the project value and technical uncertainty. An illustration is provided below in **Table 2**.

A capital and operational budget for M&V may be established as a percentage of the project's performance risk over a suitable period of years. As illustrated, the smaller project consisting of predictable technologies has less performance risk (and thus a lower M&V budget) than the large project that includes less predictable technologies.

In general, higher M&V intensity and rigor means higher cost, both upfront and over time. The factors that typically affect M&V accuracy and costs are as follows (note that many are interrelated):

- ❑ Level of detail and effort associated with verifying post-construction conditions

Table 2

Sample Project	Anticipated Annual Energy Costs	Estimated Savings	Estimated Uncertainty	Performance Risk
Small	$250,000	$50,000	20%	$10,000
Large	$2,000,000	$500,000	30%	$150,000

- ❑ Number and types of metering points
- ❑ Duration and accuracy of metering activities
- ❑ Number and complexity of dependent and independent variables that must be measured or determined on an ongoing basis
- ❑ Availability of existing data collecting systems (e.g., energy management systems)
- ❑ Confidence and precision levels specified for the analyses

Resources

Please see the USGBC website at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Websites

International Performance Measurement and Verification Protocol (IPMVP)

www.ipmvp.org

IPMVP Inc. is a nonprofit organization whose vision is a global marketplace that properly values energy and water efficiency.

Definitions

Energy Conservation Measures (ECMs) are installations of equipment or systems, or modifications of equipment or systems, for the purpose of reducing energy use and/or costs.

Case Study

Frito-Lay Jim Rich Service Center

Rochester, NY

Owner: Frito Lay, Inc.

The Frito-Lay Jim Rich Service Center is a LEED-NC version 2 Gold Certified building serving as Frito-Lay's product storage and distribution center. The building houses offices and a warehouse facility, and was designed to utilize existing site resources and provide a positive work environment for its occupants. Frito-Lay has incorporated photo-voltaics, daylighting, occupancy sensors, heat recovery cycles, natural ventilation, and high efficiency furnaces and compressors into its energy management system. A Building Energy Management System (EMS) provides ongoing monitoring of operation and equipment utilization, and control of systems. Electricity, natural gas, and water are all monitored by central meters in the building as well.

SS	WE	EA	MR	EQ	ID

Credit 6

1 point

Green Power

Intent

Encourage the development and use of grid-source, renewable energy technologies on a net zero pollution basis.

Requirements

Provide at least 35% of the building's electricity from renewable sources by engaging in at least a two-year renewable energy contract. Renewable sources are as defined by the Center for Resource Solutions (CRS) Green-e products certification requirements.

DETERMINE THE BASELINE ELECTRICITY USE

Use the annual electricity consumption from the results of EA Credit 1.

OR

Use the Department of Energy (DOE) Commercial Buildings Energy Consumption Survey (CBECS) database to determine the estimated electricity use.

Potential Technologies & Strategies

Determine the energy needs of the building and investigate opportunities to engage in a green power contract. Green power is derived from solar, wind, geothermal, biomass or low-impact hydro sources. Visit www.green-e.org for details about the Green-e program. The power product purchased to comply with credit requirements need not be Green-e certified. Other sources of green power are eligible if they satisfy the Green-e program's technical requirements. Renewable energy certificates (RECs), tradable renewable certificates (TRCs), green tags and other forms of green power that comply with Green-e's technical requirements can be used to document compliance with EA Credit 6 requirements.

Summary of Referenced Standard

Center for Resource Solutions' Green-e Product Certification Requirements

www.green-e.org

(888) 634-7336

The Green-e Program is a voluntary certification and verification program for green electricity products. Those products exhibiting the Green-e logo are greener and cleaner than the average retail electricity product sold in that particular region. To be eligible for the Green-e logo, companies must meet certain threshold criteria for their products. Criteria include qualified sources of renewable energy content such as solar electric, wind, geothermal, biomass and small or certified low-impact hydro facilities; "new" renewable energy content (to support new generation capacity); emissions criteria for the non-renewable portion of the energy product; absence of nuclear power; and other criteria regarding renewable portfolio standards and block products. Criteria are often specific per state or region of the United States. Refer to the standard for more details.

Approach and Implementation

There are three approaches for achieving this credit.

1. In a state with an open electrical market, building owners may have the ability to select a Green-e certified power provider for their electricity purchases. In this scenario, the owner secures a two-year contract for a minimum of 35% of their annual electrical power consumption from a Green-e certified provider.
2. In a state with a closed electrical market, the governing utility company may have a Green-e accredited utility program. In this case, the owner simply enrolls in the green power program for at least 35% of the provided electrical energy. In most cases, there is a premium added to the monthly utility billing.
3. If direct purchase of Green-e certified power is not available through the local utilities, the owner and project team have the option of purchasing Green-e accredited Tradable Renewable Certificates (RECs). In this case, the team purchases a quantity of RECs equal to 35% of the predicted annual electrical consumption over a two year period (which is equivalent to 70% of predicted annual electrical consumption if all of the RECs are purchased at one time). These RECs or "green-tags" compensate Green-e generators for the premium of production over the market rate they sell to the grid. Purchasing Green-e certified RECs will have no impact for the project on the cost or procurement of the electricity from the local electrical utility. See the Calculations section below for information on calculating electrical power consumption and determining the 35% threshold.

A separate campus facility that produces green power (to Green-e standards) may supply the building(s) on the same campus or be wheeled to a different campus through an internal campus agreement. Green power may be purchased or installed on a centralized basis and credit attributed to a specific project. This same green power may not be credited to another project.

Calculations

Applicants have two compliance paths to calculate the amount of electrical energy that must be obtained from Green-e certified providers in order to achieve compliance with EA Credit 6.

1. Design Energy Cost (DEC)

The first compliance path is based on the design case annual electrical consumption that the project team may have calculated as part of compliance with EA Credit 1. The project owner should contract with a Green-e certified power producer for that amount.

2. Default Electricity Consumption

If an energy model was not performed in EA Credit 1, use the Department of Energy (DOE) Commercial Buildings Energy Consumption Survey (CBECS) database to determine the estimated electricity use. This database provides electricity intensity factors (kWh/sf-yr) for various building types in the United States.

Table 1, below, presents a summary of median annual electrical intensities (kWh/sf-yr) for different building types, based on data from the latest CBECS. The energy intensity multiplied by the square footage of the project represents the total amount of green power (in kWh) that would need to be purchased over a two-year period to qualify for EA Credit 6 using this option.

Example EA Credit 6 Calculation based on CBECS Data

For example, a project is a 50,000 sq.ft. restaurant. In order to determine how much renewable energy is required to meet the requirements of EA Credit 6, use **Table 1** above and the median electrical consumption intensity for food service facilities.

Default Annual Electrical Consumption

50,000 sf x 28.7 kWh/sf-yr = 1,435,000 kWh/yr

Required Green Power for EA Credit 6

1,435,000 kWh/yr x 35% x 2 yrs = 1,004,500 kWh

This project would need to purchase Green-e certified green power or RECs equal to 1,004,500 kWh/yr. If, for example, the project obtained a quote from a RECs provider of $0.02/kWh, the total cost to the project to earn EA Credit 6 would be $20,090.

Exemplary Performance

There is no exemplary performance point available for this credit.

Table 1: Ozone-Depletion and Global-Warming Potentials of Refrigerants (100-yr values)

Building Type	Median Electrical Intensity (kWh/sf-yr)
Education	6.6
Food Sales	58.9
Food Service	28.7
Health Care Inpatient	21.5
Health Care Outpatient	9.7
Lodging	12.6
Retail (Other than Mall)	8.0
Enclosed and Strip Malls	14.5
Office	11.7
Public Assembly	6.8
Public Order and Safety	4.1
Religious Worship	2.5
Service	6.1
Warehouse and Storage	3.0
Other	13.8

Submittal Documentation

This credit is submitted as part of the **Construction Submittal**.

The following project data and calculation information is required to document credit compliance using the v2.2 Submittal Templates:

OPTION 1

- ❑ Provide the name of the green power provider and contract term
- ❑ Enter total annual electricity consumption (kWh) and total annual green power purchase (kWh)

OPTION 2

- ❑ Provide the name of the renewable energy certificate vendor
- ❑ Enter total annual electricity consumption (kWh)
- ❑ Enter the value of the green tags purchased (kWh)

Considerations

Environmental Issues

Energy production is a significant contributor to air pollution in the United States. Air pollutants released from energy production include sulfur dioxide, nitrogen oxide and carbon dioxide. These pollutants are primary contributors to acid rain, smog and global warming. With other associated pollutants, they have widespread and adverse effects on human health in general, especially on human respiratory systems. The Green-e Program was established by the Center for Resource Solutions to promote green electricity products and provide consumers with a rigorous and nationally recognized method to identify green electricity products. These products reduce the air pollution impacts of electricity generation by relying on renewable energy sources such as solar, water, wind, biomass and geothermal sources. In addition, the use of ecologically responsive energy sources avoids reliance on nuclear power and large-scale hydropower. Deregulated energy markets have enabled hydroelectric generation activities to market their electricity in regions unaffected by the regional impacts that dams can have on endangered aquatic species. While green electricity is not environmentally benign, it greatly lessens the negative environmental impacts of power generation.

Costs for green power products may be somewhat greater than conventional energy products. However, green power products are derived, in part, from renewable energy sources with stable energy costs. As the green power market matures and impacts on the environment and human health are factored into power costs, green power products are expected to be less expensive than conventional power products.

Resources

Websites

The Green Power Network

U.S. Department of Energy

www.eere.energy.gov/greenpower

Provides news on green power markets and utility pricing programs—both domestic and international. It contains up-to-date information on green power providers, product offerings, consumer issues and in-depth analyses of issues and policies affecting green power markets. The website is maintained by the National Renewable Energy Laboratory for the Department of Energy.

Green-e Program

www.green-e.org

(888) 634-7336

See the Summary of Referenced Standard for more information.

Clean Energy

Union of Concerned Scientists

www.ucsusa.org/clean_energy

(617) 547-5552

UCS is an independent nonprofit that analyzes and advocates energy solutions that are sustainable both environmentally and economically. The site provides news and information on research and public policy.

Green Power Partnership

U.S. Environmental Protection Agency (EPA)

www.epa.gov/greenpower

EPA's Green Power Partnership is a new voluntary program designed to reduce the environmental impact of electricity generation by promoting renewable energy. The Partnership will demonstrate the advantages of choosing renewable energy, provide objective and current information about the green power market, and reduce the transaction costs of acquiring green power.