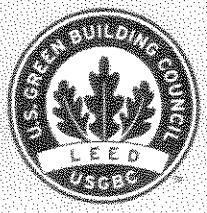

New Construction

Version 2.2

REFERENCE GUIDE

Third Edition October 2007

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LEED for New Construction Reference Guide

Version 2.2

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Trees*	Solid Waste	Liquid Waste	Electricity	Greenhouse Gases	Sulfur & Nitrogen Oxides
187,035 lbs. of virgin wood, equal to 325 trees	29,325 lbs.	275,036 gallons	42,085 kWh	62,030 lbs.	116 lbs.

*One tree = approx. 575 lbs.

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LEED for New Construction ratings:

- ❑ Certified 26-32 points
- ❑ Silver 33-38 points
- ❑ Gold 39-51 points
- ❑ Platinum 52-69 points

Foreword from the USGBC

The built environment has a profound impact on our natural environment, economy, health and productivity. Breakthroughs in building science, technology and operations are now available to designers, builders, operators and owners who want to build green and maximize both economic and environmental performance.

The U.S. Green Building Council (USGBC) is coordinating the establishment and evolution of a national consensus effort to provide the industry with tools necessary to design, build and operate buildings that deliver high performance inside and out. Council members work together to develop industry standards, design and construction practices and guidelines, operating practices and guidelines, policy positions and educational tools that support the adoption of sustainable design and building practices. Members also forge strategic alliances with key industry and research organizations, federal government agencies and state and local governments to transform the built environment. As the leading organization that represents the entire building industry on environmental building matters, the Council's unique perspective and collective power provides our members with enormous opportunity to effect change in the way buildings are designed, built, operated and maintained.

USGBC Membership

The Council's greatest strength is the diversity of our membership. The USGBC is a balanced, consensus nonprofit representing the entire building industry, consisting of over 11,000 companies and organizations. Since its inception in 1993, the USGBC has played a vital role in providing a leadership forum and a unique, integrating force for the building industry. Council programs are—

- Committee-Based
  The heart of this effective coalition is our committee structure in which volunteer members design strategies that are implemented by staff and expert consultants. Our committees provide a forum for members to resolve differences, build alliances and forge cooperative solutions for influencing change in all sectors of the building industry.
- Member-Driven
  The Council's membership is open and balanced and provides a comprehensive platform for carrying out important programs and activities. We target the issues identified by our members as the highest priority. We conduct an annual review of achievements that allows us to set policy, revise strategies and devise work plans based on member needs.
- Consensus-Focused
  We work together to promote green buildings and in doing so, we help foster greater economic vitality and environmental health at lower costs. The various industry segments bridge ideological gaps to develop balanced policies that benefit the entire industry.

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Introduction

I. Why Make Your Building Green?

The environmental impact of the building design, construction and operation industry is significant. Buildings annually consume more than 30% of the total energy and more than 60% of the electricity used in the U.S. Each day five billion gallons of potable water is used soley to flush toilets. A typical North American commercial construction project generates up to 2.5 pounds of solid waste per square foot of completed floor space. Development shifts land usage away from natural, biologically-diverse habitats to hardscape that is impervious and devoid of biodiversity. The far reaching influence of the built environment necessitates action to reduce its impact.

Green building practices can substantially reduce or eliminate negative environmental impacts and improve existing unsustainable design, construction and operational practices. As an added benefit, green design measures reduce operating costs, enhance building marketability, increase worker productivity, and reduce potential liability resulting from indoor air quality problems. For example, energy efficiency measures have reduced operating expenses of the Denver Dry Goods building by approximately $75,000 per year. Students in day-lit schools in North Carolina consistently score higher on tests than students in schools using conventional lighting fixtures. Studies of workers in green buildings reported productivity gains of up to 16%, including reductions in absenteeism and improved work quality, based on "people-friendly" green design. At a grocery store in Spokane, Washington, waste management costs were reduced by 56% and 48 tons of waste was recycled during construction. In other words, green design has environmental, economic and social elements that benefit all building stakeholders, including owners, occupants and the general public.

II. LEED® Green Building Rating System

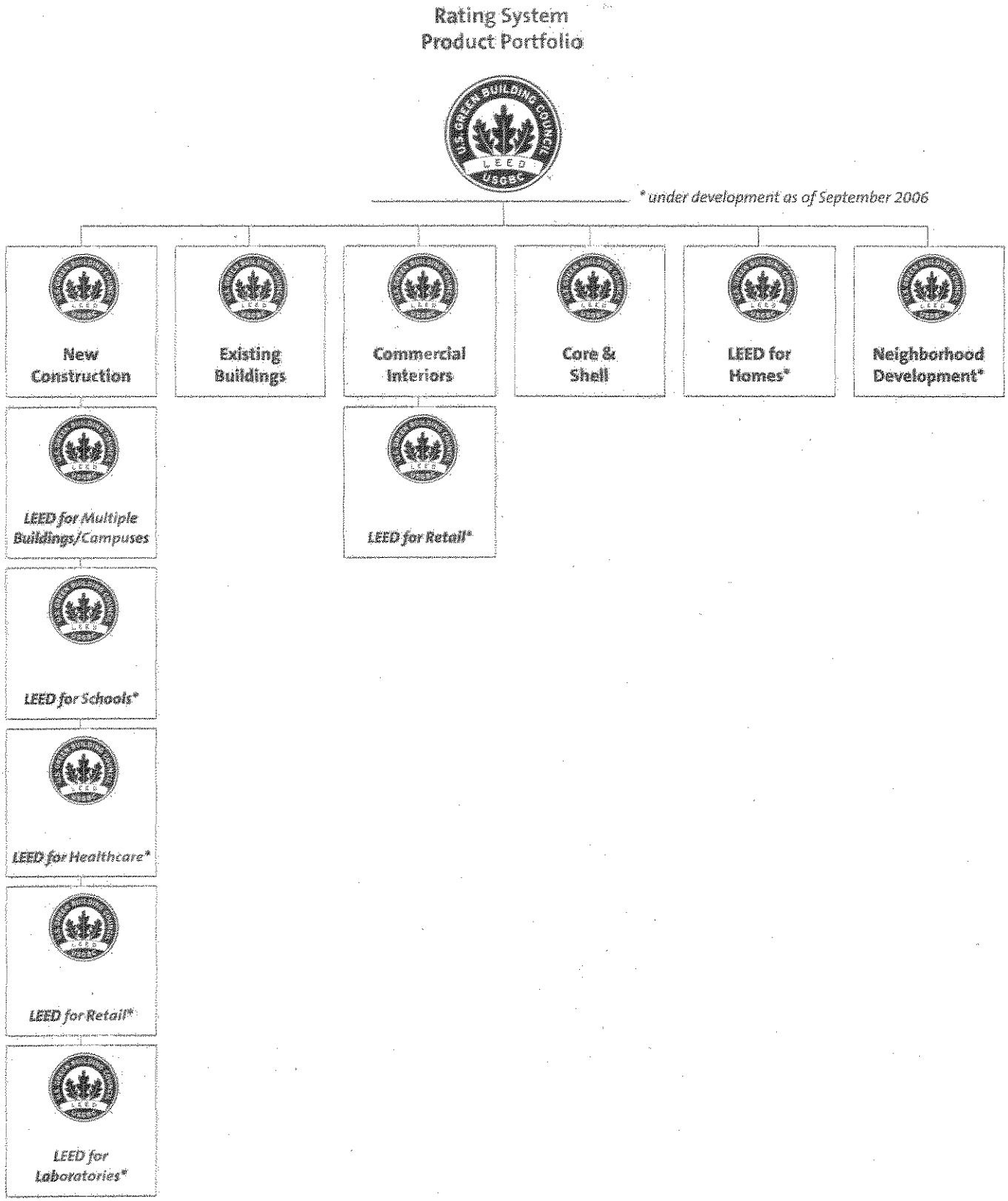
A. History of LEED®

The first LEED (Leadership in Energy and Environmental Design) Pilot Project Program following the formation of the U.S. Green Building Council (USGBC) in 1993, the membership quickly realized that a priority for the sustainable building industry was to have a system to define and measure "green buildings." The USGBC began to research existing green building metrics and rating systems. Less than a year after formation, the membership followed up on the initial findings with the establishment of a committee to focus solely on this topic. The diverse initial composition of the committee included architects, realtors, a building owner, a lawyer, an environmentalist and industry representatives. This cross section of people and professions added a richness and depth both to the process and to the ultimate product.

The first LEED Pilot Project Program, also referred to as LEED Version 1.0, was launched at the USGBC Membership Summit in August 1998. After extensive modifications, the LEED Green Building Rating System Version 2.0 was released in March 2000. This rating system is now called the LEED Green Building Rating System for New Commercial Construction and Major Renovations, or LEED for New Construction.

As LEED has evolved and matured, the program has undertaken new initiatives. In addition to a rating system specifically devoted to building operational and

maintenance issues, LEED addresses the different project development/delivery processes that exist in the U.S. building design and construction market. Currently, the LEED product portfolio is being expanded to the following areas:



LEED for New Construction is part of the growing portfolio of rating system products serving specific market sectors.

B. Features of LEED®

The LEED Green Building Rating System is a voluntary, consensus-based, market-driven building rating system based on existing proven technology. It evaluates environmental performance from a whole building perspective over a building's life cycle, providing a definitive standard for what constitutes a "green building." The development of the LEED Green Building Rating System was initiated by the USGBC Membership, representing all segments of the building industry and has been open to public scrutiny.

The rating system is organized into five environmental categories: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials & Resources, and Indoor Environmental Quality. An additional category, Innovation & Design Process, addresses sustainable building expertise as well as design measures not covered under the five environmental categories.

LEED is a measurement system designed for rating new and existing commercial, institutional and residential buildings. It is based on accepted energy and environmental principles and strikes a balance between known established practices and emerging concepts.

It is a performance-oriented system where credits are earned for satisfying criterion designed to address specific environmental impacts inherent in the design, construction and operations and maintenance of buildings. Different levels of green building certification are awarded based on the total credits earned. The system is designed to be comprehensive in scope, yet simple in operation.

C. The Future of LEED

The green design field is growing and changing daily. New technologies and products are coming into the marketplace and innovative designs are proving their effectiveness. Therefore, the Rating System and the Reference Guide will evolve as well. Teams wishing to certify with LEED should note that they will need to comply with the version of the rating system that is current at the time of their registration.

USGBC will highlight new developments on its Web site on a continuous basis at www.usgbc.org.

III. LEED for New Construction Overview and Process

The LEED Green Building Rating System for New Construction and Major Renovation (formerly referred to as LEED-NC) provides a set of performance standards for certifying the design and construction phases of commercial, institutional buildings, and high-rise residential buildings. The specific credits in the rating system provide guidelines for the design and construction of buildings of all sizes in both the public and private sectors. The intent of LEED for New Construction is to assist in the creation of high performance, healthful, durable, affordable and environmentally sound commercial and institutional buildings.

LEED for New Construction addresses:

- ❑ Sustainable Sites
- ❑ Water Efficiency
- ❑ Energy & Atmosphere
- ❑ Materials & Resources
- ❑ Indoor Environmental Quality
- ❑ Innovation in Design

A. When to Use LEED for New Construction

LEED for New Construction was designed primarily for new commercial office buildings, but it has been applied to many other building types by LEED

practitioners. All commercial buildings, as defined by standard building codes, are eligible for certification as a LEED for New Construction building. Commercial occupancies include (but are not limited to) offices, retail and service establishments, institutional buildings (libraries, schools, museums, churches, etc.), hotels and residential buildings of four or more habitable stories.

LEED for New Construction addresses design and construction activities for both new buildings and major renovations of existing buildings. The LEED Green Building Rating System for Existing Buildings is designed to address operational and maintenance issues of working buildings. Therefore, if you are performing a major renovation on an existing building, LEED for New Construction is the most appropriate rating system for your project. If however, your project scope does not involve significant design and construction activities and focuses more on O&M activities, LEED for Existing Buildings is the most appropriate tool for your project. As a general rule of thumb, a major renovation involves elements of major HVAC renovation, significant envelope modifications and major interior rehabilitation.

Many projects will cleanly and clearly fit the defined scope of only one LEED Rating System product. For other projects, two or more LEED Rating System products may be applicable. USGBC encourages the project team to tally a potential point total using the Rating System checklists for all possibilities. The project is a viable candidate for LEED certification if it can meet all prerequisites and achieve the minimum points required in a given Rating System. If more than one Rating System applies, then it is up to the project team to decide which one to pursue. For assistance in choosing the most appropriate LEED Rating System, please e-mail leedinfo@usgbc.org.

B. LEED for New Construction Registration

Project teams interested in obtaining LEED Certification for their project must first register this intent with USGBC. Projects can be registered on the USGBC Web site (www.usgbc.org) in the LEED section, under Register Your Project. The Web site includes information on registration costs for USGBC member companies as well as non-members. Registration is an important step that establishes contact with USGBC and provides access to LEED-Online software tool, errata, critical communications and other essential information.

About LEED-Online

As of January 2006, project teams pursuing LEED for New Construction certification under Version 2.2 are required to use LEED-Online, which enables teams to submit 100% of their documentation online in an easy-to-use format. LEED-Online stores all LEED information, resources, and support in one centralized location. LEED-Online enables team members to upload credit templates, track Credit Interpretation Requests (CIRs), manage key project details, contact customer service, and communicate with reviewers throughout the design and construction reviews.

C. Credit Interpretation Rulings

In some cases, the design team may encounter challenges in applying a LEED for New Construction prerequisite or credit to their particular project. These difficulties arise from instances where the Reference Guide does not sufficiently address a specific issue or there is a special conflict that requires resolution. To address such issues, the USGBC has established the LEED for New Construction Version 2.2 Credit Interpretation Ruling (CIR) process (separate from the CIR page for version 2.0 and 2.1 CIRs). See the LEED for New Construction section of the USGBC Web site for more information

at www.usgbc.org. Credit rulings posted after the registration date may be applied by the project team at their choosing (exception: the project's own CIRs must always be adhered to).

The Credit Interpretation process is summarized as follows:

1. Project teams should review the CIR webpage to read previously posted credit interpretation requests and USGBC responses. Many questions can be resolved by reviewing existing CIRs and the Reference Guide. Note that CIRs for other rating systems (LEED for Existing Buildings, LEED for Commercial Interiors and past versions of LEED for New Construction) are not necessarily applicable.
2. If no existing Credit Interpretation Rulings are relevant to the project, the LEED project team should submit an on-line credit interpretation request. The description of the challenge encountered by the project team should be brief but explicit; should be based on prerequisite or credit information found in the Rating System and Reference Guide; and should place a special emphasis on the Intent of the prerequisite or credit. If possible, the project team should offer potential solutions to the problem and solicit approval or rejection of their proposed interpretation. Follow the detailed instructions in the "CIR Guidelines" document available on the CIR Web page in the LEED section of the USGBC Web site.
3. USGBC will rule on your request electronically according to the posted schedule, either through a posting on the CIR Page or via e-mail correspondence.

D. LEED for New Construction Application

Once a project is registered, the project design team begins to collect information and perform calculations to satisfy the prerequisite and credit submittal requirements. Since submittal documentation should be gathered throughout design and construction, it is helpful to designate a LEED team leader who is responsible for managing the compilation of this information by the project team. Use the LEED-Online Submittal Templates that are provided through the LEED project resources Web page located in the LEED section of the USGBC Web site. These templates contain embedded calculators, and are instrumental in documenting fulfillment of credit requirements and prompting for correct and complete supporting information.

Two-Phase Application

A new feature of LEED for New Construction v2.2 is the option of splitting a certification application into two phases. Rather than submitting all documentation for a project at the end of the construction phase, project teams will be able to submit designated "design phase credits" at the end of the design phase for review by USGBC. Design phase credits are those credits that USGBC can reasonably adjudicate based on design phase documentation. For example, if a project site meets the LEED for New Construction Sustainable Sites Credit 3: Brownfield Redevelopment Requirements, USGBC can assess the likelihood of the project achieving this credit prior to the completion of construction. It is important to remember that LEED credit is not awarded at the design review stage. Project teams are notified of the likelihood that their project will achieve a LEED credit if construction is executed in accordance with design phase plans. Projects must submit verification that design elements were implemented as planned after completion of construction. A list of the potential design phase credits can be found in the LEED section of the USGBC Web site. Project teams are allotted one design phase review. At the completion of construction, the balance of attempted credits, verification of design

phase credits, and additional documentation for any design phase credits that has changed since the design phase review are documented and submitted for USGBC review. See below for more details regarding the two-phase review.

E. Review and Certification

To earn LEED for New Construction certification, the applicant project must satisfy all of the prerequisites and a minimum number of points to attain the established LEED for New Construction project ratings as listed below. Having satisfied the basic prerequisites of the program, applicant projects are then rated according to their degree of compliance within the rating system. All projects will need to comply with the version of LEED for New Construction that is current at the time of project registration.

Design Phase Review

Once USGBC has received your complete design phase application and the design phase fee (which is a portion of the total certification fee), the USGBC will formally rule on your application by designating each attempted credit as either Anticipated or Denied. No certification award will be given at this time, nor will any credits be awarded. This process serves to allow project teams the opportunity to assess the likelihood of credit achievement, and requires follow through to ensure the design is executed in the construction phase according to design specifications.

Construction Phase Review

At the completion of construction, the project team will submit all attempted credits for review. If the project team had elected to have a design phase review and any of the design phase Anticipated credits have changed, additional documentation must be submitted to substantiate continued compliance with credit requirements. For design phase Anticipated credits that have not substantively changed, the project team must submit a verification that the design has been executed per requirements in the construction phase. Once USGBC has received the complete application and fee (the remainder of the total certification fee, if a design review has been conducted), the USGBC will formally rule on your full application. All applicant-verified design phase credits that were designated as Anticipated and have not changed since the design phase review will be declared as Achieved. All other credits will be designated as either Achieved or Denied.

Appeals

Appeals may be filed either after the design phase review or the final review. Please see the LEED Certification Process section (http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1497) of the USGBC Web site for more information on appeals.

Fees

Certification fee information can be found at the LEED Register your project page of the web site: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=65&. USGBC will acknowledge receipt of your application and proceed with application review when all project documentation has been submitted.

The LEED for New Construction ratings are awarded according to the following scale—

- ❑ Certified 26-32 points
- ❑ Silver 33-38 points
- ❑ Gold 39-51 points
- ❑ Platinum 52-69 points

USGBC will recognize buildings that achieve one of these rating levels with a formal letter of certification and a mountable plaque.

F. Updates & Errata

This is the second edition of the LEED for New Construction Version 2.2 Reference Guide, dated September 2006. As LEED for New Construction continues

to improve and evolve, updates and errata will be made available to substitute and augment the current material. USGBC cannot be held liable for any criteria set forth herein, which may not be applicable to later versions of LEED for New Construction. Updates and addenda will be accumulated between revisions and will be formally incorporated in major revisions. In the interim between major revisions, USGBC may use its consensus process to clarify criteria.

When a project registers for certification, the prerequisites, credits, errata, and credit rulings current at the time of project registration will continue to guide the project throughout its certification process.

IV. LEED for New Construction Version 2.2 Reference Guide

The LEED for New Construction v2.2 Reference Guide is a supporting document to the LEED Green Building Rating System. The Guide is intended to assist project teams in understanding LEED for New Construction criteria and the benefits of complying with each criterion. The Guide includes examples of strategies that can be used in each category, case studies of buildings that have implemented these strategies successfully, and additional resources that will provide more information. The guide does not provide an exhaustive list of strategies for meeting the criteria as subsequent strategies will be developed and employed by designers that satisfy the Intent of each credit. Nor does it provide all of the information that design teams need to determine the applicability of a credit to their project.

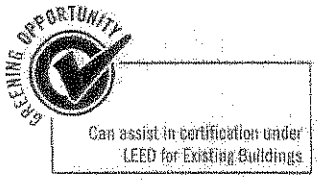
Prerequisite and Credit Format

Each prerequisite and credit is organized in a standardized format for simplicity and quick reference. The first section summarizes the key points regarding the measure and includes the Intent, Requirements, and some Potential Technologies & Strategies for achieving the credit. The subsequent sections provide supportive information to help interpret the measure, examples, and links to various resources.

If your project team encounters an out-of-date web link in the Reference Guide, please go to the root Web site, which should take the form of www.organization.com with no additional text following. Then you may be able to navigate through the Web site to find the referenced document. Please contact the USGBC at (202) 828-7422 if you are unable to locate a resource.

Greening Opportunity Icon

Throughout this Reference Guide, you will see this icon:



This icon will assist projects that are proceeding with the intention of certifying with LEED for Existing Buildings, following their LEED for New Construction certification. It identifies credits that involve measures that are significantly more cost-effective and convenient to implement during design and construction than they are during the operation of the building. These credits are—

SSc 2:	Development Density & Community Connectivity
SSc 4.1:	Alternative Transportation: Public Transportation Access
EAc 1:	Optimize Energy Performance
EAc 3:	Enhanced Commissioning
EAc 5:	Measurement & Verification
MRc 4:	Recycled Content
MRc 5:	Regional Materials
MRc 6:	Rapidly Renewable Materials

MRc 7: Certified Wood

EQc 1: Outdoor Air Delivery Monitoring

EQc 6.2: Controllability of Systems: Thermal Comfort

EQc 7: Thermal Comfort

EQc 8: Daylight and Views

Sustainable Sites

Buildings affect ecosystems in a variety of ways. Development of greenfield or previously undeveloped sites consumes land. Development projects must also be sensitive to encroaching on agricultural lands, compromising existing wildlife habitat, and exacerbating local and regional erosion. The impacts of increased impervious surfaces to stormwater runoff should be controlled to mimic natural conditions and protect water quality in receiving waters. Sedimentation caused by erosion may hinder regional waterway navigation, disrupt aquatic life and reduce the quality of local/regional recreation areas. Heat from the sun is absorbed by buildings and paved surfaces and is radiated back, increasing temperatures in surrounding urban areas. External lighting systems may cause light pollution to the night sky and interfere with nocturnal ecology.

A building's location also affects ecosystems based on the occupants' options for travel to and from the site. According to the Federal Bureau of Transportation Statistics, vehicle use in America has nearly tripled, from 1 to 2.85 trillion miles per year, between 1970 and 2002. Vehicles are responsible for approximately 20% of U.S. greenhouse gas emissions annually (NRDC). Vehicle fuel consumption and emissions contribute to climate change, smog, and particulate pollution, all of which have negative impacts on human health. The infrastructure required to support vehicle travel (parking and roadway surfaces, service stations, fuel distribution networks, etc.) increase the consumption of land and nonrenewable resources, alter stormwater flow and absorb heat energy, exacerbating heat island effect.

Project teams undertaking building projects should be cognizant of the inherent impacts of development on land consumption, ecosystems, natural resources and energy use. Preference should be given to buildings with high performance attributes in locations that enhance existing neighborhoods, transportation networks, and urban infrastructures. During initial project scoping, preference should be given to sites and land use plans that preserve natural ecosystem functions and enhance the health of the surrounding community.

Establishing sustainable design objectives and integrating building location and sustainable features as a metric for decision making encourages development and preservation or restoration practices that limit the environmental impact of buildings on local ecosystems.

Sustainable Sites Credit Characteristics

Table 1 shows which credits were substantially revised for LEED for New Construction 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

SS Prerequisite 1
Construction Activity Pollution Prevention

SS Credit 1
Site Selection

SS Credit 2
Development Density & Community Connectivity

SS Credit 3
Brownfield Redevelopment

SS Credit 4.1
Alternative Transportation—Public Transportation Access

SS Credit 4.2
Alternative Transportation—Bicycle Storage & Changing Rooms

SS Credit 4.3
Alternative Transportation—Low-Emitting & Fuel-Efficient Vehicles

SS Credit 4.4
Alternative Transportation—Parking Capacity

SS Credit 5.1
Site Development—Protect or Restore Habitat

SS Credit 5.2
Site Development—Maximize Open Space

SS Credit 6.1
Stormwater Management—Quantity Control

SS Credit 6.2
Stormwater Management—Quality Control

SS Credit 7.1
Heat Island Effect—Non-Roof

SS Credit 7.1
Heat Island Effect—Roof

SS Credit 8
Light Pollution Reduction

Table 1: SS Credit Characteristics

Credit	Significant Change from Version 2.1	Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
SSp1: Construction Activity Pollution Prevention	*		*		*	*
SSc1: Site Selection		*		*		
SSc2: Development Density & Community Connectivity	*	*		*	*	
SSc3: Brownfield Redevelopment		*		*		
SSc4.1: Alternative Transportation, Public Transportation Access		*		*		
SSc4.2: Alternative Transportation, Bicycle Storage & Changing Rooms		*			*	
SSc4.3: Alternative Transportation, Low-Emitting & Fuel-Efficient Vehicles	*	*		*	*	
SSc4.4: Alternative Transportation, Parking Capacity		*		*	*	
SSc5.1: Site Development, Protect or Restore Habitat			*	*	*	*
SSc5.2: Site Development, Maximize Open Space		*		*	*	
SSc6.1: Stormwater Management, Quantity Control	*	*			*	
SSc6.1: Stormwater Management, Quality Control	*	*			*	
SSc7.1: Heat Island Effect, Non-Roof	*		*		*	*
SSc7.2: Heat Island Effect, Roof	*	*			*	*
SSc8: Light Pollution Reduction	*	*			*	

Construction Activity Pollution Prevention

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Required

Intent

Reduce pollution from construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation.

Requirements

Create and implement an Erosion and Sedimentation Control (ESC) Plan for all construction activities associated with the project. The ESC Plan shall conform to the erosion and sedimentation requirements of the 2003 EPA Construction General Permit OR local erosion and sedimentation control standards and codes, whichever is more stringent. The Plan shall describe the measures implemented to accomplish the following objectives:

- ❑ Prevent loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.
- ❑ Prevent sedimentation of storm sewer or receiving streams.
- ❑ Prevent polluting the air with dust and particulate matter.

The Construction General Permit (CGP) outlines the provisions necessary to comply with Phase I and Phase II of the National Pollutant Discharge Elimination System (NPDES) program. While the CGP only applies to construction sites greater than 1 acre, the requirements are applied to all projects for the purposes of this prerequisite. Information on the EPA CGP is available at: http://cfpub.epa.gov/npdes/stormwater/cgp.cfm.

Potential Technologies & Strategies

Create an Erosion and Sedimentation Control Plan during the design phase of the project. Consider employing strategies such as temporary and permanent seeding, mulching, earth dikes, silt fencing, sediment traps and sediment basins.

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Summary of Referenced Standard

Storm Water Management for Construction Activities (USEPA Document No. EPA 832R92005), **Chapter 3**

U.S. Environmental Protection Agency Office of Water,

www.epa.gov/OW

Internet download link for Chapter 3 (72 pages): www.epa.gov/npdes/pubs/chap03_conguide.pdf

Download site for all sections: http://yosemite.epa.gov/water/owrccatalog.nsf, search by title index. Hardcopy or microfiche (entire document, 292 pages): National Technical Information Service (order # PB92-235951),

www.ntis.gov

(800) 553-6847

This standard describes two types of measures that can be used to control sedimentation and erosion. Stabilization measures include temporary seeding, permanent seeding and mulching. All of these measures are intended to stabilize the soil to prevent erosion. Structural control measures are implemented to retain sediment after erosion has occurred. Structural control measures include earth dikes, silt fencing, sediment traps and sediment basins. The application of these measures depends on the conditions at the specific site.

Approach and Implementation

Erosion on existing sites typically results from foot traffic killing the vegetation, steep slopes where stormwater sheet flow exceeds vegetation holding power, runoff that exceeds vegetation holding power, or vehicle traffic on unpaved areas. Identifying and eliminating these and other causes will minimize soil loss and preserve receiving water quality.

This prerequisite effectively extends NPDES requirements for construction activities, which currently only apply to projects 1 acre and larger, to all projects pursuing LEED certification.

Typically, the civil engineer identifies erosion-prone areas and soil stabilization measures. The contractor then adopts a plan to implement the measures presented by the civil engineer and responds to rain events and other activities accordingly. It is recommended that the Erosion and Sedimentation Control (ESC) Plan be incorporated into the construction drawings and specifications, with clear

Table 1: Technologies for Controlling Erosion & Sedimentation

Control Technology	Description
Stabilization	
Temporary Seeding	Plant fast-growing grasses to temporarily stabilize soils
Permanent Seeding	Plant grass, trees, and shrubs to permanently stabilize soil
Mulching	Place hay, grass, woodchips, straw, or gravel on the soil surface to cover and hold soils
Structural Control	
Earth Dike	Construct a mound of stabilized soil to divert surface runoff volumes from distributed areas or into sediment basins or sediment traps
Silt Fence	Construct posts with a filter fabric media to remove sediment from stormwater volumes flowing through the fence
Sediment Trap	Excavate a pond area or construct earthen embankments to allow for settling of sediment from stormwater volumes
Sediment Basin	Construct a pond with a controlled water release structure to allow for settling of sediment from stormwater volumes

instructions regarding responsibilities, scheduling, and inspections.

If a Storm Water Pollution Prevention Plan (SWPPP) is required for the project via the National Pollutant Discharge Elimination System (NPDES) or local regulations, an ESC Plan may already be required. In that case, the only action required is to confirm that the plan meets the Requirements of this prerequisite and is implemented. If an ESC Plan is not required for purposes other than LEED, use the Referenced Standard listed above as a guideline on how to compose the plan.

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 credit compliance using the v2.2 Submittal Templates:

- ❑ Provide copies of the project drawings to document the erosion and sedimentation control measures implemented on the site.
- ❑ Provide confirmation regarding the compliance path taken by the project (NPDES Compliance or Local Erosion Control Standards).
- ❑ Provide a narrative to describe the Erosion and Sedimentation control measures implemented on the project. If a local standard has been followed, please provide specific information to demonstrate that the local standard is equal to or more stringent than the referenced NPDES program.

Considerations

Environmental Issues

The loss of topsoil is the most significant on-site consequence of erosion. Topsoil is the soil layer that contains organic matter,

Photo Credit: CTG Energetics, Inc.

Example of Structural Control. Silt fence: fabric filter media removes sediment from stormwater volumes flowing through the fence.

SS | WE | EA | MR | EQ | ID

Prerequisite 1

plant nutrients and biological activity. Loss of topsoil greatly reduces the soil's ability to support plant life, regulate water flow, and maintain the biodiversity of soil microbes and insects that controls disease and pest outbreaks. Loss of nutrients, soil compaction, and decreased biodiversity of soil inhabitants can severely limit the vitality of landscaping. This can lead to additional site management and environmental concerns, such as increased use of fertilizers, irrigation and pesticides; and increased stormwater runoff that heightens the pollution of nearby lakes and streams.

The off-site consequences of erosion from developed sites include a variety of water quality issues. Runoff from developed sites carries pollutants, sediments and excess nutrients that disrupt aquatic habitats in the receiving waters. Nitrogen and phosphorous from runoff hasten eutrophication by causing unwanted plant growth in aquatic systems, including algal blooms that alter water quality and habitat conditions. Algal blooms can also result in decreased recreation potential and diminished diversity of indigenous fish, plant and animal populations.

Sedimentation also contributes to the degradation of water bodies. The build-up of sedimentation in stream channels can lessen flow capacity, potentially leading to increased flooding. Sedimentation also affects aquatic habitat by increasing turbidity levels. Turbidity reduces sunlight penetration into the water and leads to reduced photosynthesis in aquatic vegetation, causing lower oxygen levels that cannot support diverse communities of aquatic life.

Economic Issues

Erosion and sedimentation control measures are required in most areas in order to minimize difficult and expensive mitigation measures in receiving waters. The cost of erosion and sedimentation control on construction sites will include some minimal expense associated with installing and inspecting measures, particularly before and after storm events. The cost will vary depending on the type, location, topography and soil conditions of the project.

Resources

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

In addition to the resources below, check with state and local organizations for information on erosion and sedimentation control specific to your region.

Web Sites

CPESC Inc.

www.cpesc.net

(828) 655-1600

Search the directory on this Web site to find certified erosion and sedimentation control professionals in your state.

Environment Canada's Freshwater Web – Sediment Page

www.ec.gc.ca/water/en/nature/sedim/e_sedim.htm

(819) 953-6161

This site includes information on the environmental effects of sedimentation.

EPA Erosion and Sediment Control Model Ordinances

www.epa.gov/owow/nps/ordinance/erosion.htm

(202) 566-1155

This resource, developed by the EPA, is geared towards helping municipalities draft ordinances for erosion and sedimentation control and might serve as a helpful tool in developing company policies for meeting this LEED for New Construction Prerequisite.

Erosion Control Technology Council

www.ectc.org

(651) 554-1895

This nonprofit organization develops performance standards, testing procedures, and guidance on the application and installation of rolled erosion control products.

International Erosion Control Association (IECA)

www.ieca.org

(970) 879-3010

This organization's mission is to connect, educate and develop the worldwide erosion and sediment control community.

Soil Erosion and Sedimentation in the Great Lakes Region

www.great-lakes.net/envt/pollution/erosion.html

(734) 971-9135

This resource from the Great Lakes Information Network provides links to general resources, education and training opportunities, materials, manuals, maps and other resources related to soil erosion, sedimentation and watershed management.

Definitions

Erosion is a combination of processes in which materials of the earth's surface are loosened, dissolved or worn away, and transported from one place to another by natural agents (such as water, wind or gravity).

Sedimentation is the addition of soils to water bodies by natural and human-related activities. Sedimentation decreases water quality and accelerates the aging process of lakes, rivers and streams.

SS	WE	EA	MR	EQ	ID
Prerequisite 1					

Site Selection

SS | WE | EA | MR | EQ | ID

Credit 1

1 Point

Intent

Avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

Requirements

Do not develop buildings, hardscape, roads or parking areas on portions of sites that meet any one of the following criteria:

- ❑ Prime farmland as defined by the United States Department of Agriculture in the United States Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5)
- ❑ Previously undeveloped land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by FEMA (Federal Emergency Management Agency)
- ❑ Land that is specifically identified as habitat for any species on Federal or State threatened or endangered lists
- ❑ Within 100 feet of any wetlands as defined by United States Code of Federal Regulations 40 CFR, Parts 230-233 and Part 22, and isolated wetlands or areas of special concern identified by state or local rule, OR within setback distances from wetlands prescribed in state or local regulations, as defined by local or state rule or law, whichever is more stringent
- ❑ Previously undeveloped land that is within 50 feet of a water body, defined as seas, lakes, rivers, streams and tributaries which support or could support fish, recreation or industrial use, consistent with the terminology of the Clean Water Act
- ❑ Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt)

Potential Technologies & Strategies

During the site selection process, give preference to those sites that do not include sensitive site elements and restrictive land types. Select a suitable building location and design the building with the minimal footprint to minimize site disruption of those environmentally sensitive areas identified above.

Summary of Referenced Standards

U.S. Department of Agriculture Definition of Prime Agricultural Land as stated in

United States Code of Federal Regulations Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5)

www.gpoaccess.gov/cfr/index.html (Go to "Browse and/or search the CFR.")

See also "Identification of Important Farmlands": http://a257.g.akamaitech.net/7/257/2422/11feb20051500/edocket.access.gpo.gov/cfr_2005/janqtr/pdf/7cfr657.5.pdf

This standard states: "Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and is also available for these uses (the land could be cropland, pastureland, rangeland, forest land, or other land, but not urban built-up land or water). It has the soil quality, growing season, and moisture supply needed to economically produce sustained high yields of crops when treated and managed, including water management, according to acceptable farming methods. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding. Examples of soils that qualify as prime farmland are Palouse silt loam, 0 to 7 percent slopes; Brookston silty clay loam, drained; and Tama silty clay loam, 0 to 5 percent slopes."

Federal Emergency Management Agency (FEMA) 100-Year Flood Definition

Federal Emergency Management Agency

www.fema.gov

(202) 646-4600

This referenced standard addresses flood elevations. FEMA defines a 100-Year Flood as the flood elevation that has a 1% chance of being reached or exceeded each year. It is not the most significant flood in a 100-year period. Instead, 100-year floods can occur many times within a 100-year period. See the FEMA Web site for comprehensive information on floods and other natural disasters such as wildfires and hurricanes.

Endangered Species Lists

U.S. Fish and Wildlife Service's List of Threatened and Endangered Species,

www.fws.gov/endangered/

This referenced standard addresses threatened and endangered wildlife and plants. The Service also maintains a list of plants and animals native to the United States that are candidates for possible addition to the federal list.

National Marine Fisheries Service's List of Endangered Marine Species,

www.nmfs.noaa.gov/pr/species/esa_species.htm

Consult state agencies for state-specific lists of endangered or threatened wildlife and plant species.

Definition of Wetlands in the United States Code of Federal Regulations, 40 CFR,

Parts 230-233, and Part 22

www.gpoaccess.gov/cfr/index.html

(888) 293-6498

This referenced standard addresses wetlands and discharges of dredged or filled material into waters regulated by states. The definition of wetland areas pertaining to this credit, found in Part 230, is as follows:

"Wetlands consist of areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

Approach and Implementation

One of the most important factors in creating sustainable buildings is locating them on an appropriate site. Developing a building on an inappropriate site can result in the loss of prime farmland or key habitat. Before a project site is selected, evaluate the potential environmental disturbance that will occur as a result. Channel development into previously developed areas to prevent sprawl and habitat loss.

Avoid developing sites that exhibit any of the characteristics listed in the restricted criteria. Consider the proposed use of the building, and set a preference for previously developed sites that complement the use, thereby reducing associated parking needs and vehicular miles traveled. The site selection process might include landscape architects, ecologists, environmental engineers and civil engineers, as well as local professionals who can provide site-specific expertise. Have a government official, ecologist or other qualified professional perform a site survey to inventory the important environmental characteristics, including wetlands, sloped areas, unique habitat areas and forested areas. Zoning requirements of the local municipality and the community master plan should be integrated to the greatest extent possible. Community coordination and consideration of public comments can help preempt negative community reaction.

Regarding the fifth bullet point of the Requirements, the Clean Water Act is vague in defining "water body" and thus requires interpretation. Small man-made ponds, such as those used in stormwater retention, fire suppression and recreation are not to be included in this definition for LEED purposes. Man-made wetlands and other water bodies created to restore natural habitat and ecological systems are not exempt. Wetlands are addressed specifically by the fourth bullet point of the Requirements.

Where feasible, integrate neighboring activities to create a development with shared amenities and spaces. When designing the building, consider a smaller footprint, and set aside large contiguous areas for natural space on the project site to minimize disruption of the environmentally sensitive areas identified above. Build in dense blocks to limit the development footprint and site disturbance to the smallest area possible. Incorporate site features into the design such as natural features that already exist on the site, natural shelter from trees or terrain, natural areas for outdoor activities, and water features for thermal, acoustic and aesthetic benefit.

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 **Design Submittal**.

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

- ❑ Provide confirmation that the project site does not meet any of the prohibited criteria. Special circumstances for

SS | WE | EA | MR | EQ | ID

Credit 1

individual projects and site compliance should be noted.

AND (For Projects with Special Circumstances)

❑ Provide a narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

As non-urban development increases, the importance of prudent site selection increases as well. Prevention of habitat encroachment is an essential element of sustainable site selection. The best strategy for selecting a building site is to choose a previously developed site. Since these sites have already been disturbed, damage to the environment is limited and sensitive land areas can be preserved. The site surrounding a building defines the character of the building and provides the first impression for occupants and visitors to the building. Creative and careful site designs can integrate the natural surroundings with the building(s), providing a strong connection between the built and natural environments and minimizing adverse impacts on the non-built portions of the site.

Habitat preservation is the most effective means to meet the requirements of the Endangered Species Act and to minimize developmental impacts on indigenous wildlife. Not building on inappropriate sites preserves these areas for wildlife, recreation and ecological balance. Building on inappropriate sites such as floodplains can be detrimental to ecosystems.

Economic Issues

Site selection can play an important role in the way that the public responds to, and is involved with, the proposed development. Channeling development away from sensitive ecological areas in favor of previously disturbed sites can encourage public support for a project and speed public review periods, thus minimizing or preventing obstacles traditionally encountered during project scoping. Economically, this can also save on mitigation costs that a developer would incur if the proposed development were approved within a sensitive area.

Appropriate site selection can reduce the risk of property damage due to natural events such as landslides, floods, sinkholes and soil erosion. Higher first costs may be encountered due to site survey and selection activities. Increased property values can offset these costs in the future. Proper site selection can also avoid potential loss of property due to potential litigation resulting from harm to endangered species.

Resources

Web Sites

ESRI

www.esri.com/hazards

This software company creates tools for GIS mapping. Its Web site includes an option to make a map of all of the flood areas within a user-defined location.

Natural Resources Defense Council

www.nrdc.org

(212) 727-2700

NRDC uses law, science, and a large membership base for protection of wildlife and wild places to ensure a safe and healthy environment.

Print Media

Constructed Wetlands in the Sustainable Landscape by Craig Campbell and Michael Ogden, John Wiley & Sons, 1999.

Holding Our Ground: Protecting America's Farms and Farmland by Tom Daniels and Deborah Bowers, Island Press, 1997.

Saved By Development: Preserving Environmental Areas, Farmland by Rick Pruetz, Arje Press, 1997.

Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping by Ralph W. Tiner, Lewis Publishers, 1999.

Definitions

A **Community** is an interacting population of individuals living in a specific area.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

An **Ecosystem** is a basic unit of nature that includes a community of organisms and their nonliving environment linked by biological, chemical, and physical process.

An **Endangered Species** is an animal or plant species that is in danger of becoming extinct throughout all or a significant portion of its range due to harmful human activities or environmental factors.

Previously Developed Sites are those that previously contained buildings, roadways, parking lots, or were graded or altered by direct human activities.

A **Threatened Species** is an animal or plant species that is likely to become endangered within the foreseeable future.

Wetland Vegetation consists of plants that require saturated soils to survive, as well as certain tree and other plant species that can tolerate prolonged wet soil conditions.

SS	WE	EA	MR	EQ	ID
Credit 1					

Development Density & Community Connectivity

SS | WE | EA | MR | EQ | ID

Credit 2

1 Point

Can assist in certification under LEED for Existing Buildings

Intent

Channel development to urban areas with existing infrastructure, protect greenfields and preserve habitat and natural resources.

Requirements

OPTION 1 — DEVELOPMENT DENSITY

Construct or renovate building on a previously developed site AND in a community with a minimum density of 60,000 sq.ft. per acre net. (Note: density calculation must include the area of the project being built and is based on a typical two-story downtown development.)

OR

OPTION 2 — COMMUNITY CONNECTIVITY

Construct or renovate building on a previously developed site AND within 1/2 mile of a residential zone or neighborhood with an average density of 10 units per acre net AND within 1/2 mile of at least 10 Basic Services AND with pedestrian access between the building and the services.

Basic Services include, but are not limited to:

1) Bank; 2) Place of Worship; 3) Convenience Grocery; 4) Day Care; 5) Cleaners; 6) Fire Station; 7) Beauty; 8) Hardware; 9) Laundry; 10) Library; 11) Medical/Dental; 12) Senior Care Facility; 13) Park; 14) Pharmacy; 15) Post Office; 16) Restaurant; 17) School; 18) Supermarket; 19) Theater; 20) Community Center; 21) Fitness Center; 22) Museum.

Proximity is determined by drawing a 1/2 mile radius around the main building entrance on a site map and counting the services within that radius.

Potential Technologies & Strategies

During the site selection process, give preference to urban sites with pedestrian access to a variety of services.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

The general approach for achieving this credit is to give preference to sites within an existing urban fabric. Work with local jurisdictions and follow the urban development plan to meet or exceed density goals. Consider synergies with neighbors and choose sites based on infrastructure, transportation and quality-of-life considerations. Sites with redevelopment plans that will achieve the required development density by the completion of the project should not be excluded from consideration. This credit can be achieved by choosing to develop a site where community revitalization is occurring provided the required development density or basic services adjacency is in place or in construction by the project's completion.

Calculations

Option 1 — Development Density

To determine the development density of a project, both the project density and the densities of surrounding developments must be considered. The calculations detailed below refer to the building(s) that comprise the project pursuing certification, the project site area, and the area and density of the surrounding buildings.

Note: The LEED for New Construction Submittal Template can be used to perform these calculations.

1. Determine the total area of the project site and the total square footage of the building. For projects that are part of a larger property (such as a campus), define the project area that is defined in the LEED project's scope. The project area must be defined consistently throughout LEED documentation.
2. Calculate the development density for the project by dividing the total square footage of the building by the total site area in acres. This development density must be equal to or greater than 60,000 sq.ft. per acre (see **Equation 1**).

Project Site Area (acres)

3. Convert the total site area from acres to sq.ft. and calculate the square root of this number. Then multiply the square root by three to determine the appropriate density radius. (Note: the square root function is used to normalize the calculation by removing effects of site shape.) (See **Equation 2**).
4. Overlay the density radius on a map (see **Figure 1**) that includes the project site and surrounding areas, originating from the center of the site. This is the density boundary.
5. For each property within the density boundary and for those properties that intersect the density boundary, create a table with the building square footage and site area of each property. Include all properties in the density calculations except for undeveloped public areas such as parks and water bodies. Do not include public roads and right-of-way areas. Information on neighboring properties can be obtained from your city or county zoning department.

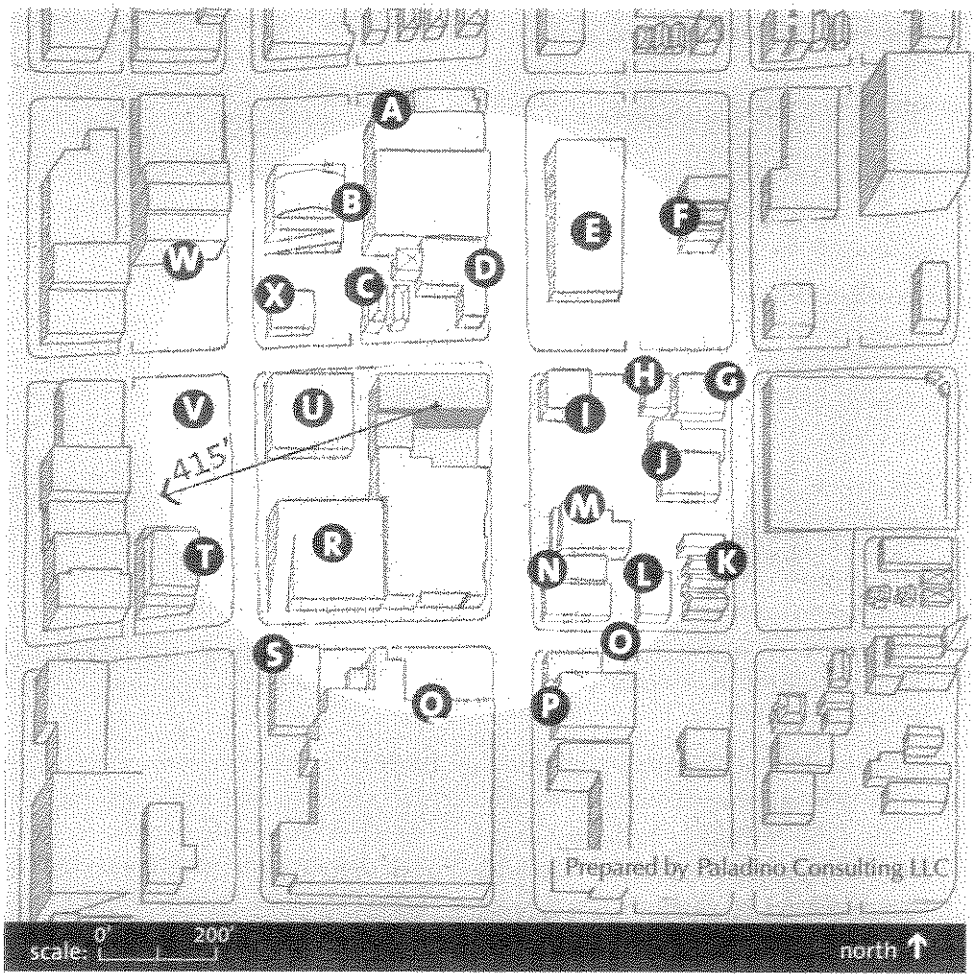
Equation 1

$$\text{Development Density (sq.ft./acre)} = \frac{\text{Gross Building Square Footage (sq.ft.)}}{\text{Project Site Area (acres)}}$$

Equation 2

$$\text{Density Radius (LF)} = 3 \times \sqrt{(\text{Property Area [acres]} \times 43{,}560 \text{ [sq.ft./acre]})}$$

Figure 1: An Illustration of a Sample Area Plan



6. Add all the square footage values and site areas. Divide the total square footage by the total site area to obtain the average property density within the density boundary. The average property density of the properties within the density boundary must be equal to or greater than 60,000 sq.ft. per acre.

Example

The following example illustrates the property density calculations: A 30,000-sq.ft. building is located on a 0.44-acre urban site and the calculations are used to determine the building density. The property density is above the minimum density of 60,000 sq.ft. per acre required by the credit (see **Table 1**).

Table 1: Property Density Calculation

Project Buildings	Building Space [SF]	Site Area [acres]
Project	30,000	0.44
Density [SF/acre]		**68,182**

Next, the density radius is determined. A density radius of 415 feet is calculated (see **Table 2**). The density radius is applied to an area plan of the project site and surrounding area. The plan identifies all properties that are within or are intersected by the density radius. The plan includes a scale and a north indicator.

Table 3 summarizes the information about the properties identified on the map (see **Figure 1**). The building space and site area are listed for each property.

Table 2: Density Radius Calculation

Density Radius Calculation	
Site Area [acres]	0.44
Density Radius [LF]	415

These values are summed and the average density is calculated by dividing the total building space by the total site area.

For this example, the average building density of the surrounding area is greater than 60,000 sq.ft. per acre, thus, the example qualifies for one point under this credit.

OR

Option 2—Community Connectivity

To determine the connectivity of a project, both residential and commercial adjacencies must be considered. The calculation process is described in the following steps:

Prepare a site map (**Figure 2**) and draw a 1/2-mile radius around the main building entrance. Radiuses may be drawn around multiple entrances for projects with multiple buildings or more than one main entrance. The combination of the area in these radiuses would then be considered the project radius. Mark all residential developments within the radius. At least one area zoned for residential development of 10 units per acre or greater must be present within the radius for the project to earn this credit.

Mark all commercial buildings within the radius. At least 10 community services must be present within the radius for the project to earn this credit.

Services may include: Bank, Place of Worship, Convenience Grocery, Day Care, Cleaners, Fire Station, Beauty, Hardware, Laundry, Library, Medical/Dental, Senior Care Facility, Park, Pharmacy, Post Office, Restaurant, School, Supermarket, Commercial Office, and Community Center. Other services will be considered on a project-by-project basis.

With the exception of restaurants, no service may be counted more than once in the calculation. Up to 2 restaurants may be counted towards achievement of this credit. Only count those services for which there is pedestrian access between the service and the project. Pedestrian access is assessed by confirming that pedestrians can walk to the services without being blocked by walls, highways, or other barriers.

Table 3: Sample Area Properties

Buildings within Density Radius	Building Space [SF]	Site Area [acres]	Buildings within Density Radius	Building Space [SF]	Site Area [acres]
A	33,425	0.39	N	28,740	0.30
B	87,500	1.58	O	6,690	0.15
C	6,350	0.26	P	39,000	0.39
D	27,560	0.32	Q	348,820	2.54
E	66,440	1.17	R	91,250	1.85
F	14,420	1.36	S	22,425	0.27
G	12,560	0.20	T	33,650	0.51
H	6,240	0.14	U	42,400	0.52
I	14,330	0.22	V	-	0.76
J	29,570	0.41	W	19,200	0.64
K	17,890	0.31	X	6,125	0.26
L	9,700	0.31	Y	5,000	0.30
M	24,080	0.64	Z	4,300	0.24
			Total Building Space [SF]	997,665	
			Total Site Area [acres]		16.04
			Average Density [SF/acres]		**62,199**

Figure 2: Example Map for Community Connectivity (Source: Google Maps)

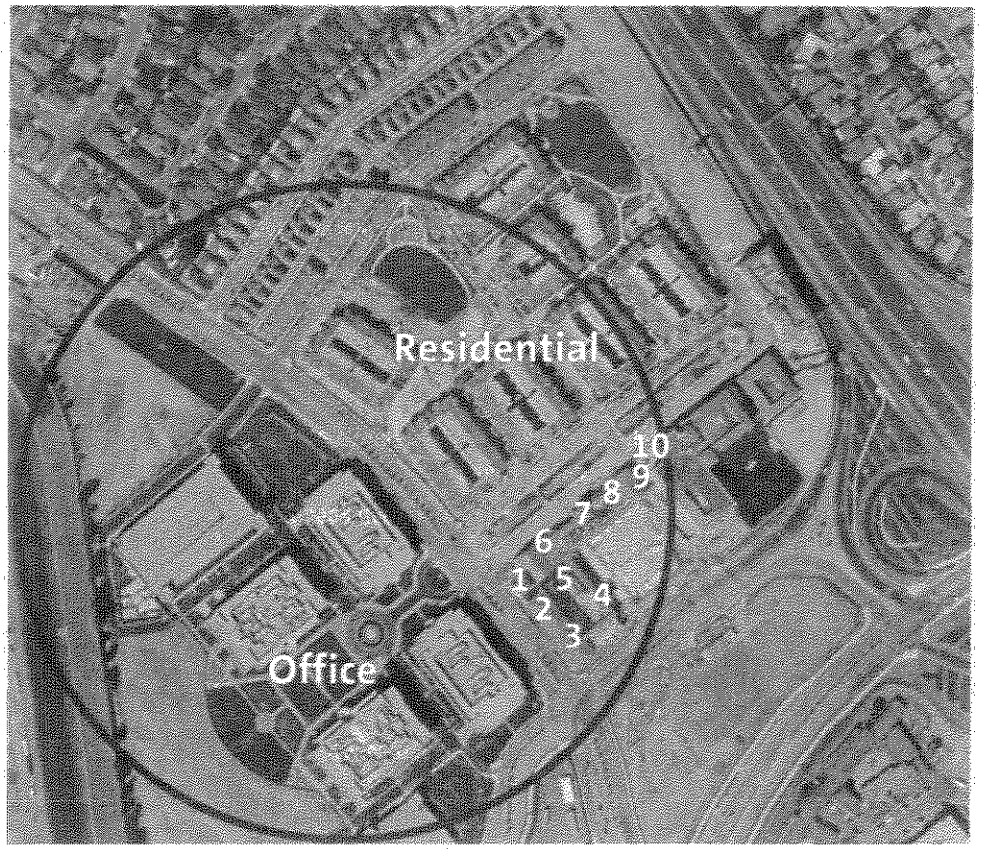


Table 4: Example Community Connectivity Tabulation

Service Identification (Corresponds to Uploaded Vicinity Plan)	Business Name	Service Type
1	Restaurant 1	Restaurant
2	Grocery 1	Convenience Grocery
3	Urgent Care 1	Medical
4	Pharmacy 1	Pharmacy
5	Gym 1	Fitness
6	Hair Care 1	Beauty
7	Bank 1	Bank
8	Restaurant 2	Restaurant
9	Cleaners 1	Cleaners
10	Post Office 1	Post Office

Prepare a table (see Table 4) listing each of the identified services, the business name, and the service type to confirm compliance.

Exemplary Performance

Based on evidence that higher density locations can achieve substantially and quantifiably higher environmental benefits, the following threshold requirements can be used to qualify a project for an exemplary performance Innovation Credit:

A LEED for New Construction project must first meet the requirements of Option 1 of SSc2 (density path) in LEED for

SS | WE | EA | MR | EQ | ID

Credit 2

New Construction v2.2. Additionally, the project must meet one of the two following requirements:

- ❑ The project itself must have a density of at least double that of the average density within the calculated area (see equation 2).

OR

- ❑ The average density within an area twice as large as that for the base credit achievement must be at least 120,000 square feet per acre. To double the area, use equation 2 but double the property area first.

These requirements are based on the decision that a project achieving exemplary performance for this credit should:

- ❑ Not lower the existing average density of the area,
- ❑ Achieve a density of at least twice the threshold of the base credit,

AND/OR

- ❑ Locate within an area of established density that is larger than that required for the base credit, which is why the radius used in the base credit has been doubled.

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:

Option 1 – Development Density

- ❑ Provide a site vicinity plan showing the project site and the surrounding sites and buildings. Sketches, block diagrams, maps, and aerial photos are all acceptable for this purpose. Draw the density boundary on the drawing or note the drawing scale.
- ❑ Project site and building area (sq.ft.)
- ❑ Submit a listing of site and building areas for all surrounding sites within the density radius.

OR

Option 2 – Community Connectivity

- ❑ Provide a site vicinity drawing showing the project site, the 1/2 mile community radius, and the locations of the community services surrounding the project site. Sketches, block diagrams, maps, and aerial photos are all acceptable for this purpose. Either draw the 1/2 mile radius on the drawing or note the drawing scale.
- ❑ Project site and building area (sq.ft.)
- ❑ Submit a listing (including business name and type) of all community services within the 1/2 mile radius.

AND (For Projects With Special Circumstances – Either Compliance Path)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

Consider the functional adjacencies of the site with respect to transportation and productivity. Community developments with at least 10 of the basic services listed in this credit within a 1/2-mile radius reduce transportation impacts. Making access to basic services walkable may improve productivity by reducing the time spent driving between services and accessing parking. In addition, occupant health can be improved by increased levels of physical activity.

Urban redevelopment affects all areas of site design including site selection, transportation planning, building density and stormwater management. Urban sites often involve the rehabilitation of an existing building, with a reduction

of construction waste and new material use. The potential trade-offs of sites in dense areas are limited open space and possible negative IEQ aspects such as contaminated soils, undesirable air quality or limited daylighting applications.

Economic Issues

A significant economic benefit of infill development is the reduction or elimination of new infrastructure, including roads, utility services and other amenities already in place. If mass transit serves the urban site, significant cost reductions are possible by downsizing the project parking capacity. Urban infill development sometimes requires significant additional costs when compared with suburban development due to site constraints, contaminated soils and other issues. Municipal and county incentives for urban infill projects may also be available.

Community Issues

Urban sprawl affects quality of life because commuters must spend increasing amounts of time in their automobiles. In addition, families often need more vehicles to accommodate family needs, resulting in a higher cost of living and less free time. The redevelopment of urban areas helps restore, invigorate and sustain established urban living patterns, creating a more stable and interactive community.

Resources

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

Web Sites

Congress for New Urbanism

www.cnu.org

Urban Land Institute

ULI Washington

www.washington.uli.org

(703) 390-9217

The Urban Land Institute is a nonprofit organization based in Washington D.C. that promotes the responsible use of land in order to enhance the total environment.

The International Union for the Scientific Study of Population

www.iussp.org

33 1 56 06 21 73

The IUSSP promotes scientific studies of demography and population-related issues.

Print Media

Changing Places: Rebuilding Community in the Age of Sprawl by Richard Moe and Carter Wilkie, Henry Holt & Company, 1999.

Density by Design: New Directions in Residential Development by Steven Fader, Urban Land Institute, 2000.

Green Development: Integrating Ecology and Real Estate by Alex Wilson, et al., John Wiley & Sons, 1998.

Once There Were Greenfields: How Urban Sprawl Is Undermining America's Environment, Economy, and Social Fabric by F. Kaid Benfield, et al., Natural Resources Defense Council, 1999.

Suburban Nation: The Rise of Sprawl and the Decline of the American Dream by Andres Duany, et al., North Point Press, 2000.

Definitions

Building Density is the floor area of the building divided by the total area of the site (square feet per acre).

SS | WE | EA | MR | EQ | ID

Credit 2

Greenfields are sites that have not been previously developed or built on, and which could support open space, habitat or agriculture.

Property Area is the total area within the legal property boundaries of a site and encompasses all areas of the site including constructed areas and non-constructed areas.

Site Area is defined the same as property area.

The **Square Footage** of a building is the total area in square feet of all rooms including corridors, elevators, stairwells and shaft spaces. Only 2 stories of a parking structure may be counted as part of building square footage. Surface parking (only 1 story of parking) cannot count as part of building square footage; this is to ensure efficient use of land adjacent to the building footprint. Both structured and stacked parking are allowable in square footage calculations.

Pedestrian Access implies that pedestrians can walk to the services without being blocked by walls, freeways or other barriers.

Case Study

Capital Area East End Complex (Building 225)

Sacramento, CA

Owner: State of California Department of General Services

Photo courtesy of: Fentress Bradburn Architects

Building 225 in the Capital Area East End Complex achieved LEED® v2.0 Gold in 2003. Built on land that had been identified by an Urban Land Institute panel as an area at high risk for blight, this design-build project was part of a larger effort to revitalize downtown Sacramento. Building 225 is an integral part of a series of state office buildings that incorporate offices, parking, public space, and joint-use facilities in a mixed-use neighborhood. The building is close to public transit, allowing employees to commute downtown to work.

Brownfield Redevelopment

SS | WE | EA | MR | EQ | ID

Credit 3

1 Point

Intent

Rehabilitate damaged sites where development is complicated by environmental contamination, reducing pressure on undeveloped land.

Requirements

Develop on a site documented as contaminated (by means of an ASTM E1903-97 Phase II Environmental Site Assessment or a local Voluntary Cleanup Program) OR on a site defined as a brownfield by a local, state or federal government agency.

Potential Technologies & Strategies

During the site selection process, give preference to brownfield sites. Identify tax incentives and property cost savings. Coordinate site development plans with remediation activity, as appropriate.

SS | WE | EA | MR | EQ | ID

Credit 3

Summary of Referenced Standards

ASTM E1903-97 Phase II Environmental Site Assessment

ASTM International

www.astm.org

This guide covers a framework for employing good commercial and customary practices in conducting a Phase II environmental site assessment of a parcel of commercial property. It covers the potential presence of a range of contaminants that are within the scope of CERCLA, as well as petroleum products.

EPA Brownfields Definition

EPA Sustainable Redevelopment of Brownfields Program

www.epa.gov/brownfields

With certain legal exclusions and additions, the term "brownfield site" means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant (source: Public Law 107-118, H.R. 2869 – "Small Business Liability Relief and Brownfields Revitalization Act"). See the Web site for additional information and resources.

Approach and Implementation

Gain community support by highlighting the environmental, economic and community-related benefits of brownfield redevelopment. Negotiate with local municipalities and landowners for below-market purchase prices for brownfield real estate. Also, obtain tax incentives by meeting the locally applicable requirements of EPA brownfield tax credits. The advantages and disadvantages of brownfield redevelopment should be carefully considered during the site selection process.

Utilize remediation experts to develop a master plan for site remediation. Prioritize site remediation activities based on available funds and specific site considerations, and establish time frames for completing remediation activities. Test for toxicity and hazardous levels of pollution on the proposed site. To earn this credit, a site with existing hazardous substances present or potentially present must be selected, and remediation efforts must be performed to identify, contain and mitigate the hazard.

Clean the site using established technologies that have minimal disruption on the natural site features, both above ground and underground. Consider in-situ remediation schemes that treat contaminants in place instead of off-site. Once remediation is complete, continue to monitor the site for the identified contaminants to ensure that contamination problems do not return.

Remediation efforts on brownfield sites are sometimes costly and time-intensive due to the potentially extensive effort required to characterize the contamination, evaluate cleanup options and perform cleanup activities. However, substantially lower property costs can offset remediation costs and time delays. The cost of remediation strategies varies by site and region. Several remediation strategies should be considered in order to identify the strategy with the greatest benefit and lowest cost to the property owner. The appropriate technology for a specific site depends on the contaminants present, hydrogeologic conditions and other factors. Traditional remediation efforts for contaminated groundwater are termed "pump-and-treat." Pump-and-treat technologies involve pumping contaminated groundwater to the surface and treating the water using physical or chemical processes. Contaminated soils can be remediated in a variety of ways. Advanced technologies such as bioreactors and in-

situ applications are sometimes more cost-effective than hauling large quantities of contaminated soil to an approved disposal facility. Innovative remediation efforts such as solar detoxification technologies are currently being developed and are expected to reduce remediation costs in the future. It is important to consider the environmental implications of all remediation strategies being investigated for your project to ensure the solution does not cause problems elsewhere.

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 **Design Submittal**.

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

- ❑ Provide confirmation whether the project site was determined contaminated by means of an ASTM E1903-97 Phase II Environmental Site Assessment or the site was defined as a brownfield by a local, state or federal government agency.
- ❑ Provide a detailed narrative describing the site contamination and remediation efforts undertaken by the project.

Considerations

Environmental Issues

Many potential building sites in urban locations have been abandoned due to real or potential contamination from previous industrial or municipal activities. These sites can be remediated and redeveloped for reuse. Environmental and economic concerns are key issues when evaluating brownfield redevelopment. Costs incurred to remediate site contamination and land prices can be additive or can offset each other. Perception of the building site by the building owner and future building occupants must also be weighed. Building owners may be wary of cleanup requirements and the potential for liability associated with contaminants migrating off-site and impacting downstream neighbors. Building occupants may worry about health risks from breathing contaminated air or coming into contact with contaminated soil. These concerns must be investigated and resolved before making the final decision to redevelop a brownfield site.

Remediation efforts remove hazardous materials from brownfield sites' soil and groundwater. This reduces the exposure of humans and wildlife to health risks as a result of environmental pollution. Redevelopment of brownfield sites provides an alternate option to developing on greenfield sites. Preservation of greenfield sites for future generations decreases the overall environmental impact of development. Brownfields often have existing infrastructure improvements in place including utilities and roads, reducing the need for further environmental impacts due to construction of new infrastructure. In some instances, rather than remediate the contamination, it may be more sensible to leave contaminants in place, choosing instead to stabilize and isolate the contaminants from human exposure.

Brownfields can offer an attractive location and are often inexpensive when compared to comparable uncontaminated properties. It is essential to weigh the value of the remediated property against cleanup costs to determine if the site is economically viable for redevelopment.

SS | WE | EA | MR | EQ | ID

Credit 3

Developers have been reluctant to redevelop brownfield sites in the past due to potential liability associated with taking responsibility for the cleanup of others' contamination. In recent years, the EPA and many state and local government agencies have begun to provide incentives for brownfield redevelopment by enacting laws that reduce the liability of developers who choose to remediate contaminated sites. Before embarking on a brownfield development effort, it is important to contact state and local regulators to determine the rules governing these sites and available financial assistance programs. It may also be helpful to contact the regional EPA's Office of Solid Waste and Emergency Response (OSWER), which may provide site characterization and remediation support.

Economic Issues

Remediation and reclamation of contaminated sites can contribute to social and economic revitalization of depressed or disadvantaged neighborhoods. Local liabilities can be turned into valuable community assets and catalyze increased community investment. Clean up of contaminated properties can renew and augment a sense of community pride in local residents.

Resources

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

Web Sites

Brownfields Technology Support Center

www.brownfieldstsc.org

A public cooperative effort that provides technical support to federal, state and local officials on items related to site investigation and cleanup.

EPA Sustainable Redevelopment of Brownfields Program

www.epa.gov/brownfields

A comprehensive site on brownfields that includes projects, initiatives, tools, tax incentives and other resources to address brownfield remediation and redevelopment. For information by phone, contact your regional EPA office.

Print Media

ASTM Standard Practice E1739-95: Risk-Based Corrective Action Applied at Petroleum Release Sites, American Society for Testing & Materials

www.astm.org

(610) 832-9585

This document is a guide for risk-based corrective action (RBCA), a decision making process that is specific to cleaning up petroleum releases at contaminated sites. It presents a tiered approach to site assessment and remedial actions. It also includes a comprehensive appendix with risk calculations and sample applications.

EPA OSWER Directive 9610.17: Use of Risk-Based Decision-Making in UST Correction Action Programs, U.S. Environmental Protection Agency, Office of Underground Storage Tanks,

www.epa.gov/swerust1/directiv/od961017.htm

(703) 603-7149

This document addresses the application of risk-based decision-making techniques to properties where leaking underground storage tanks (USTs) have created risks to human health and the environment. Guidelines are included to assist in making decisions in a manner consistent with federal law, specifically CERCLA and RCRA programs. Risk-based decision-making is a method that utilizes risk and exposure assessment methodology to determine the extent and urgency of cleanup actions. The goal is to protect

human health and the environment. This standard includes several examples of state programs that use risk-based decision-making in leaking UST legislation.

Definitions

Bioremediation involves the use of microorganisms and vegetation to remove contaminants from water and soils. Bioremediation is generally a form of in-situ remediation, and can be a viable alternative to landfilling or incineration.

CERCLA refers to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund. CERCLA addresses abandoned or historical waste sites and contamination. It was enacted in 1980 to create a tax on the chemical and petroleum industries and provided federal authority to respond to releases of hazardous substances.

Ex-Situ Remediation involves the removal of contaminated soil and groundwater. Treatment of the contaminated media occurs in another location, typically a treatment facility. A traditional method of ex-situ remediation is pump-and-treat technology that uses carbon filters and incineration. More advanced methods of ex-situ remediation include chemical treatment or biological reactors.

In-Situ Remediation involves treatment of contaminants in place using technologies such as injection wells or reactive trenches. These methods utilize the natural hydraulic gradient of groundwater and usually require only minimal disturbance of the site.

RCRA refers to the Resource Conservation and Recovery Act. RCRA focuses on active and future facilities. It was enacted in 1976 to give the EPA authority to control hazardous wastes from cradle to grave, including generation, transportation, treatment, storage and disposal. Some non-hazardous wastes are also covered under RCRA.

Remediation is the process of cleaning up a contaminated site by physical, chemical or biological means. Remediation processes are typically applied to contaminated soil and groundwater.

Risk Assessment is a methodology used to analyze for potential health effects caused by contaminants in the environment. Information from the risk assessment is used to determine cleanup levels.

A **Site Assessment** is an evaluation of above-ground (including facilities) and subsurface characteristics, including the geology and hydrology of the site, to determine if a release has occurred, as well as the extent and concentration of the release. Information generated during a site assessment is used to support remedial action decisions.

SS | WE | EA | MR | EQ | ID

Credit 3

Alternative Transportation

Public Transportation Access

SS | WE | EA | MR | EQ | ID

Credit 4.1

1 Point

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

Locate project within 1/2 mile of an existing—or planned and funded—commuter rail, light rail or subway station.

OR

Locate project within 1/4 mile of one or more stops for two or more public or campus bus lines usable by building occupants.

Potential Technologies & Strategies

Perform a transportation survey of future building occupants to identify transportation needs. Site the building near mass transit.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

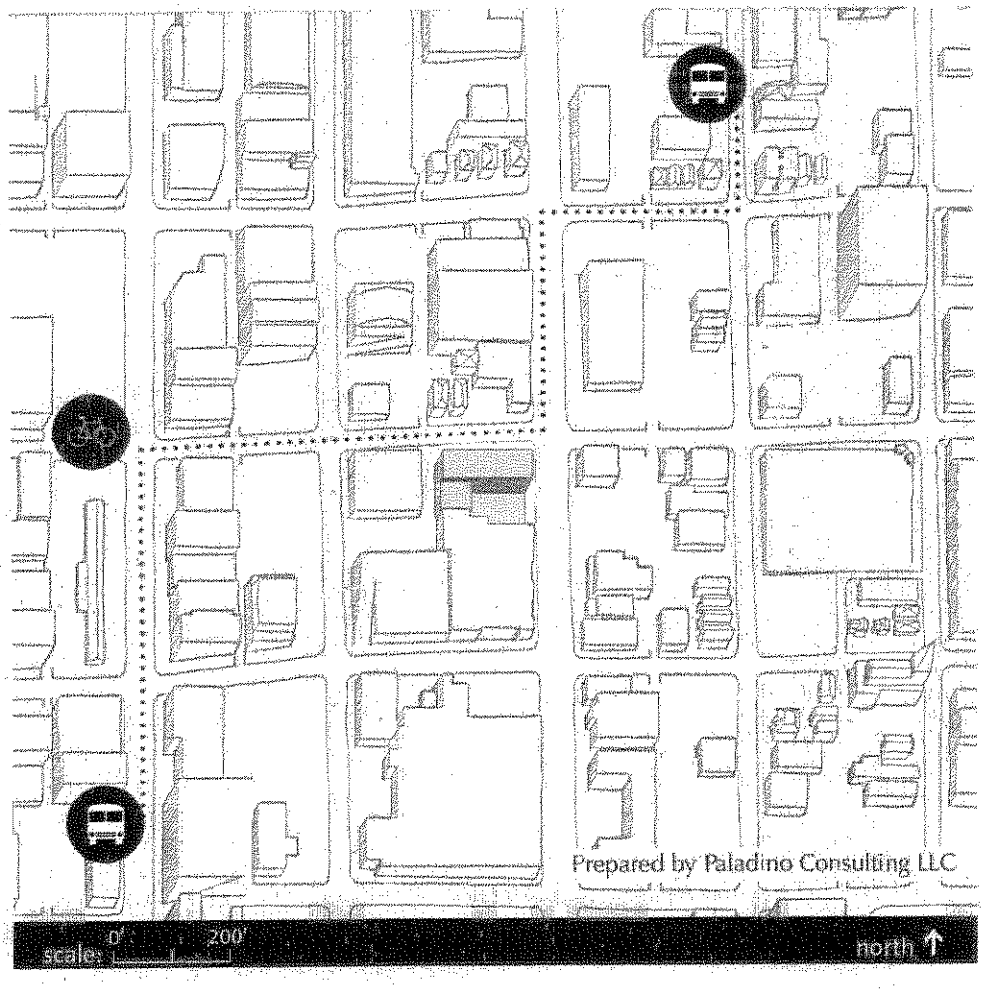
Select a site that has convenient access to existing transportation networks to minimize the need for new transportation lines. Local telephone books and community Web sites provide maps and directories that will be helpful in determining the transportation options available. Look for functional and direct sidewalks, paths and walkways to existing mass transit stops. Provide incentives such as transit passes to encourage occupants to use mass transit.

If a light rail or subway station is sited, planned and funded at the time the project is completed, it satisfies the intent of the credit.

Calculations

Use an area drawing to indicate mass transit stops within 1/2 mile of the project. Remember that the project is required to be within a 1/2 mile pedestrian route to a commuter rail, light rail or subway station or within 1/4 mile of two or more bus lines. **Figure 1** shows two bus lines within 1/4 mile of the project location. The map includes a scale bar and a north indicator.

Figure 1. Sample Area Drawing



Exemplary Performance

Projects may be awarded one innovation point for Exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

Based on evidence that locations with higher transit density can achieve substantially and a quantifiably higher environmental benefit, meeting the following threshold qualifies a project for exemplary performance Innovation Credit. This follows the Center for Clean Air Policy's finding that average transit ridership increases by 0.5% for every 1.0% increase in growth of transit service levels, which leads to the conclusion that quadrupling transit service generally doubles transit ridership.

To accomplish this quadrupling of service and doubling of ridership, at a minimum:

❑ Locate the project within ½ mile of at least two existing commuter rail, light rail, or subway lines, OR locate project within ¼ mile of at least two or more stops for four or more public or campus bus lines usable by building occupants;

AND

❑ Frequency of service must be such that at least 200 transit rides per day are available in total at these stops. A combination of rail and bus is allowable. This strategy is based on the assumption that the threshold of the base credit would provide, in most cases, at least 50 transit rides per day (half-hourly service 24 hours per day or more frequent service for less than 24 hours per day). If, on average, transit ridership increases by 0.5% for every 1.0% increase in transit service, then quadrupling the number of rides available would, on average, double the transit ridership. (4 x 50 rides = 200 rides). Include a transit schedule and map within your LEED certification submittal.

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:

Commuter Rail Service

❑ Provide a site vicinity drawing showing the project site and the location of all (existing/proposed) fixed rail stations within 1/2 mile of the site.

❑ A listing of each fixed rail station and the distance from the station to the project site (miles).

OR

Bus Service

❑ Provide a site vicinity drawing showing the project site and the location of all existing bus stops within 1/4 mile of the site.

❑ A listing of each bus line that serves the site vicinity and the distance from the bus stop to the project site (miles).

AND (For Projects With Special Circumstances—Either Compliance Path)

❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

The environmental effects of automobile use include vehicle emissions that contribute to smog and air pollution as well as environmental impacts from

oil extraction and petroleum refining. Increased use of public transportation can improve air quality. A surprisingly large number of people are willing to use alternative means of transportation such as mass transit if it is convenient and facilities are provided to encourage their use. Encouraging the use of mass transit reduces the energy demand for transportation needs and affects building sites by reducing the space needed for parking lots, which encroach on green space on the building site. Minimizing parking lots reduces the building footprint and sets aside more space for natural areas or greater development densities

Reduction in private vehicle use reduces fuel consumption and air and water pollutants in vehicle exhaust. On the basis of passenger miles traveled, public transportation is approximately twice as fuel efficient as private vehicles. Another benefit of public transportation is the associated reduction in the need for infrastructure used by vehicles. Parking facilities and roadways for automobiles have negative impacts on the environment because impervious surfaces like asphalt increase stormwater runoff while contributing to urban heat island effects.

Economic Issues

Many occupants view proximity to mass transit as a benefit and this can influence the value and marketability of the building. For building occupants, costs associated with traveling to and from the workplace can be significantly reduced if access to public transportation is available. For this reason, providing access to public transportation may provide an economic benefit associated with attracting and retaining employees. Existing building project teams have little to no control over their building's proximity to mass transit. If a building is not near mass transit, a shuttle can be provided to earn this credit, but this would be an added operating cost for the building.

Reducing the size of parking areas based on anticipated use of public transit by building occupants may alter operating costs associated with parking lot maintenance. If local utilities charge for stormwater based on impervious surface area, minimization of these areas can result in lower stormwater charges.

Resources

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

Web Sites

Office of Transportation and Air Quality

U.S. Environmental Protection Agency

www.epa.gov/otaq/

US EPA Web site provides information on the types and effects of air pollution associated with automobile use, information for consumers, and links to resources for organizations interested in promoting commuter choice programs.

Best Workplaces for Commuters

www.bestworkplacesforcommuters.gov/index.htm

(888) 856-3131

This program, established by the US EPA and DOT, publicly recognizes employers for their exemplary commuter benefits programs. It provides tools, guidance and promotions to help employers incorporate commuter benefits into their employee benefits plan, reap financial benefits and gain national recognition.

Advanced Transportation Technology Institute

www.atti-info.org

A nonprofit organization that advances clean transportation technologies through research, education and technology transfer in order to promote a healthy environment and energy independence.

Definitions

Mass Transit is a publicly or privately operated transportation service that provides transportation, for the general public, to multiple fixed stops on a scheduled basis. Mass transit vehicles are typically capable of serving 10 or more occupants, such as buses, trolleys, light rail, etc.

Public Transportation is bus, rail or other transportation service for the general public operating on a regular, continual basis that is publicly or privately owned.

Case Study

Johnson & Johnson Pharmaceutical Research and Development

Pfizer Global Research & Development, La Jolla Campus

TKG Consulting Engineers Corporate Offices

La Jolla, CA

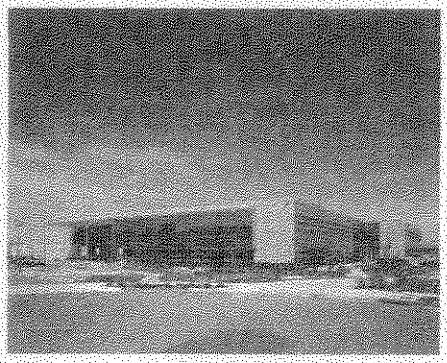


Photo © Johnson & Johnson

Owner: Johnson & Johnson, Pfizer, and TKG Consulting

Photo © Pfizer

Three separate projects attained LEED® Certification in part by connecting their building occupants to public transportation via a common shuttle bus program. The Johnson & Johnson Pharmaceutical Research & Development project (v2.0 2005 Certified), the Pfizer Global Research & Development, La Jolla Campus project (v2.0 2004 Certified), and TKG Consulting Engineers Corporate Offices (v2.0 2004 Gold), all utilize The Sorrento Valley Coaster Connection, a shuttle service provided by the North San Diego County Transit District, to offer an alternative means of transportation for their employees. This shuttle transports its riders from various locations in the area to the Sorrento Valley Station, which offers connections to regional light rail and multiple bus lines.

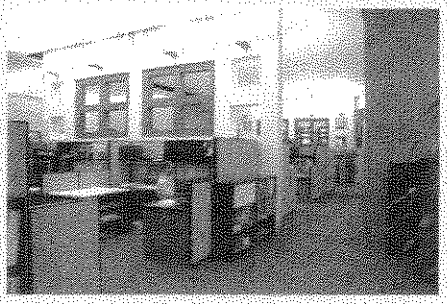


Photo © Ted Walton

SS	WE	EA	MR	EQ	ID
Credit 4.1					

SS | WE | EA | MR | EQ | ID

Credit 4.2

1 Point

Alternative Transportation

Bicycle Storage & Changing Rooms

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

For commercial or institutional buildings, provide secure bicycle racks and/or storage (within 200 yards of a building entrance) for 5% or more of all building users (measured at peak periods), AND, provide shower and changing facilities in the building, or within 200 yards of a building entrance, for 0.5% of Full-Time Equivalent (FTE) occupants.

OR

For residential buildings, provide covered storage facilities for securing bicycles for 15% or more of building occupants in lieu of changing/shower facilities.

Potential Technologies & Strategies

Design the building with transportation amenities such as bicycle racks and showering/changing facilities.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Select a site that provides convenient access to safe bicycle pathways and secure bicycle storage areas for cyclists. Provide shower and changing areas for cyclists that are easily accessible from bicycle storage areas.

During the site selection process, survey potential building occupants and determine if the available bike routes and their compatibility with mass transit options meet their needs. Look for functional and direct paths that can be used by bicycle commuters. This information will help inform the size, type, and location of bike racks and showering facilities for the project.

There are a number of different types of secure bike storage systems, and design and costs will vary. Secure bicycle storage means that bikes can be individually locked and stored, for example to a rack. For residential projects, bike storage must be covered to protect bicycles from weather as well as theft.

For projects that are located on a campus or similar setting, showering facilities can be shared between buildings as long as the facilities are within 200 yards of the entrance to the building pursuing LEED certification.

Calculations

To determine the number of secure bicycle spaces and changing/showering facilities required for the building, follow the calculation methodology as follows:

1. Identify the total number of full-time and part-time building occupants.
2. Calculate the Full-Time Equivalent (FTE) building occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0 while a part-time occupant has a FTE value based on their hours per day divided by 8 (see **Equation 1**). Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits. In buildings with multiple shifts, use only the highest volume shift in the FTE calculation but consider shift overlap when determining peak building users.
3. Estimate the Transient occupants, such as students, visitors and customers, for the peak period for the facility.
4. Calculate peak building users by combining FTE occupants and Transient occupants.
5. The minimum number of **secure bicycle spaces** required is equal to 5% of the peak building users (see **Equation 2**) or 15% of the building occupants for residential projects. Secure bicycle spaces include bicycle racks, lockers and storage rooms. These spaces should be easily accessible by building occupants during all periods of the year, and free of charge.

Equation 1

$$\text{FTE Occupants} = \frac{\text{Occupant Hours}}{8}$$

Equation 2

Secure Bicycle Spaces (non-residential) = Peak Building Users x 0.05

Secure Bicycle Spaces (residential) = Occupants x 0.15

6. The required number of **changing** and **showering facilities** for non-residential buildings is equal to 0.5% of the FTE occupants. Showering facilities can be unit showers or group showering facilities. (See **Equation 3.**)

Example—College Classroom Building

Many college buildings house faculty, staff and students, making the calculation of FTEs complicated. In the example in **Table 1** below, the building occupants are separated into full-time and part-time users to simplify the calculation. The number of persons is multiplied by the number of hours they spend in the building each day and then divided by 8 to calculate the FTE value.

Exemplary Performance

Projects may be awarded one innovation point for exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

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:

- ❑ Provide the FTE occupancy and Transient occupancy for the project.
- ❑ Provide project drawings to show the location(s) of the secure bicycle storage areas and shower/changing facilities.

In addition, please provide the following project data and calculation information based on project type:

Non-Residential Buildings

- ❑ Confirm the quantity of shower/changing facilities provided and their distance from the building entry.

Equation 3

Showering Facilities (non-residential buildings) = FTE Occupants x 0.005

Table 1: Sample Occupancy Calculation for College Building

FTE Occupant Calculation			
Occupant Type	**Number**	**Total Person-Hours Per Day**	**Sub Total FTEs**
FULL-TIME (assume 8 hr/day)			
Staff	8	64	8
Faculty	6	48	6
PART-TIME (assume 2 hr/day)			
Faculty	24	48	6
Student Researchers	20	40	5
		TOTAL FTEs	**25**

Transient Occupant Calculation		
Occupant Type	**Number at Peak Period**	**Occupant Value for LEED Calculations**
Students	310	310
	Peak Building Users	**335**

Residential Buildings

❑ No additional documentation is required.

Mixed Non-Residential and Residential Buildings

- Confirm the number of residential units and residential FTE occupants for the project.
- Confirm the quantity of shower/changing facilities provided for the non-residential portion of the project and their distance from the building entry.

AND (For Projects With Special Circumstances— Any Compliance Path)

- Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

The environmental effects of automobile use include vehicle emissions that contribute to smog and air pollution as well as environmental impacts from oil extraction and petroleum refining. Bicycling as an alternative to personal vehicle operation offers a number of environmental benefits. Bicycle commuting produces no emissions and has zero demand for petroleum-based fuels. Bicycle commuting also relieves traffic congestion, reduces noise pollution, and requires far less infrastructure for roadways and parking lots. Roadways and parking lots produce stormwater runoff, contribute to the urban heat island effect, and encroach on green space.

Bicycles are more likely to be used for relatively short commuting trips. Displacing vehicle miles with bicycling even for short trips carries a large environmental benefit, since a large portion of vehicle emissions occur in the first few minutes of driving following a cold start, as emissions control equipment is less effective at cool operating temperatures.

Economic Issues

The initial project cost increase for bike storage areas and changing facilities or showers is typically low relative to the overall project cost. Building occupants can realize health benefits through bicycle and walking commuting strategies. Bicycling and walking also expose people to the community, encouraging interaction among neighbors and allowing for enjoyment of the area in ways unavailable to automobile passengers.

Resources

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

Web Sites

Advanced Transportation Technology Institute

www.atti-info.org

(423) 622-3884

A nonprofit organization that advances clean transportation technologies through research, education and technology transfer in order to promote a healthy environment and energy independence.

Definitions

A **Carpool** is an arrangement in which two or more people share a vehicle for transportation.

Mass Transit includes transportation facilities designed to transport large groups of persons in a single vehicle such as buses or trains.

Public Transportation is bus, rail or other transportation service for the general public operated on a regular, continual basis that is publicly or privately owned.

Credit 4.3

1 Point

Alternative Transportation

Low-Emission & Fuel-Efficient Vehicles

Intent

Reduce pollution and land development impacts from automobile use.

Requirements

OPTION 1

Provide low-emitting and fuel-efficient vehicles for 3% of Full-Time Equivalent (FTE) occupants AND provide preferred parking for these vehicles.

OR

OPTION 2

Provide preferred parking for low-emitting and fuel-efficient vehicles for 5% of the total vehicle parking capacity of the site.

OR

OPTION 3

Install alternative-fuel refueling stations for 3% of the total vehicle parking capacity of the site (liquid or gaseous fueling facilities must be separately ventilated or located outdoors).

For the purposes of this credit, low-emitting and fuel-efficient vehicles are defined as vehicles that are either classified as Zero Emission Vehicles (ZEV) by the California Air Resources Board or have achieved a minimum green score of 40 on the American Council for an Energy Efficient Economy (ACEEE) annual vehicle rating guide.

"Preferred parking" refers to the parking spots that are closest to the main entrance of the project (exclusive of spaces designated for handicapped) or parking passes provided at a discounted price.

Potential Technologies & Strategies

Provide transportation amenities such as alternative fuel refueling stations. Consider sharing the costs and benefits of refueling stations with neighbors.

SS | WE | EA | MR | EQ | ID

Credit 4.3

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Establishing alternative fuel refueling stations requires the consideration of a number of legal, technical and safety issues, which vary by fuel type. Consider the following while developing alternative fuel station infrastructure:

- ❑ Poll building occupants to determine which alternative fuel type is in highest demand.
- ❑ Compare the environmental and economic costs/benefits of different alternative fuel types to determine which alternative fuel type would provide the highest benefit.
- ❑ Investigate local codes and standards for refueling stations in the area.
- ❑ Compare different fuel station equipment options and fuel availability. Depending on the type of alternative fuel provided, equipment requirements will differ in terms of expense and complexity of installation. Lack of availability may limit the feasibility of providing refueling stations for some types of fuels.
- ❑ Learn about the safety issues associated with alternative fuel types. Ensure that appropriate building personnel are trained to operate and maintain refueling stations.

Calculations

Option 1

Equation 1

$$\text{FTE Occupants} = \frac{\text{Occupant Hours}}{8}$$

To determine the number of alternative fuel vehicles required, follow the calculation methodology as follows:

1. Identify the total number of full-time and part-time building occupants.
2. Calculate the Full-Time Equivalent (FTE) building occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0 while a part-time occupant has a FTE value based on their hours per day divided by 8 (see **Equation 1**). Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits. In buildings with multiple shifts, use only the highest volume shift in the FTE calculation but consider shift overlap when determining peak building users.
3. Multiply the number of FTE occupants by 3% to determine the number of vehicles and preferred parking spaces to provide.

Option 2

To determine the number of alternative fuel vehicle parking spaces required, multiply the total number of parking spaces in the project by 5%.

Option 3

To determine the number of alternative fuel vehicle fueling stations required, multiply the total number of parking spaces in the project by 3%.

Exemplary Performance

Projects may be awarded one innovation point for exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

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:

- ❑ Provide the FTE occupancy for the project.
- ❑ Provide the total parking capacity of the site.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Option 1—Low-Emitting/Fuel Efficient Vehicles

- ❑ Provide project drawings to show the location(s) of the preferred parking spaces for low-emitting/fuel-efficient vehicles.
- ❑ Confirm the quantity of low-emitting/fuel-efficient vehicles provided and their make, model and manufacturer.
- ❑ Confirm whether each vehicle is a zero-emission vehicle or enter each vehicle's ACEEE vehicle score.

Option 2—Preferred Parking for Low-Emitting/Fuel Efficient Vehicles

- ❑ Provide project drawings to show the location(s) of the preferred parking spaces for low-emitting/fuel-efficient vehicles.
- ❑ Confirm the number of preferred parking spaces provided.

Option 3—Alternative Fuel Refueling Stations

- ❑ Provide project drawings to show the location(s) of the alternative fuel refueling stations.
- ❑ Confirm the fuel type, number of stations, and fueling capacity for each station for an 8-hour period.

AND (For Projects With Special Circumstances—Any Compliance Path)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

Operation of vehicles significantly contributes to global change and air quality problems through the emission of greenhouse gases (GHGs) and other pollutants generated from combustion engines and fuel evaporation. Motor gasoline is estimated to account for 60 percent of all carbon dioxide (a major GHG) emitted in the United States in the last 20 years. Personal vehicles also generate large portions of the air pollutants responsible for smog and ground-level ozone, both of which have negative effects on human health.

Alternative fuel and alternative technology vehicles offer the possibility of reducing air pollutants from vehicular travel as well as the environmental effects of producing gasoline. However, the extent to which alternative vehicles produce an environmental benefit depends on the complete lifecycle of their fuels and the vehicle technology. For example, electric vehicles generate zero green house gases (GHGs) during operation, but the amount of GHGs emitted during the production of the electricity that these vehicles run on varies greatly depending on the electricity source. Furthermore, alternative fuels may be superior to conventional gasoline on the basis of one pollutant, but carry a higher pollution load for another pollutant. Because the environmental benefit of alternative fuel and alternative technology vehicles depend on complete fuel-cycle energy-use and emissions, carefully consider available vehicle technologies and fuel sources before purchasing vehicles or installing fuel stations.

Economic Issues

Initial costs for alternative vehicles are higher than for conventional vehicles, and this may delay their purchase. Federal, state and local government may offer tax incentives for purchasing alternative vehicles, which can help offset their higher initial costs. Different alternative fuel vehicles need different refueling stations, and the costs vary. Hybrid vehicles are gaining traction in the marketplace, which should start to drive down their cost. For fuel-efficient vehicles, reduced operating costs on a per-mile basis can offset higher initial purchase prices or higher fuel costs.

Resources

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

Web Sites

Alternative Fuels Data Center

www.afdc.doe.gov

A section of the DOE Office of Transportation Technologies that has information on alternative fuels and alternative fueled vehicles, a locator for alternative refueling stations and other related information.

American Council for an Energy-Efficient Economy (ACEEE)

www.greenercars.com

Online searchable green car guide based on a combination of fuel efficiency and tailpipe emission levels. Also offers hard-copy Green Guide to Cars and Trucks, an annual publication of the American Council for an Energy-Efficient Economy.

CARB Cleaner Car Guide

www.driveclean.ca.gov/en/gv/home/index.asp

(916) 323-6169

The California Air Resources Board (CARB) has developed a comprehensive searchable buyer's guide to find the cleanest cars on the market, which lists advantages clean vehicles offer.

California Certified Vehicles List

www.arb.ca.gov/msprog/ccvl/ccvl.htm

This site provides a list of all vehicles certified by the California Air Resources Board.

Clean Cities Vehicle Buyer's Guide For Consumers

www.eere.energy.gov/cleancities/vbg/

The Vehicle Buyer's Guide for Consumers explains the alternative fuel and advanced technology vehicles, including hybrid and neighborhood electric vehicles available. You can use this site to learn more about the vehicle technologies; obtain pricing and technical specifications; locate the nearest alternative fuel station; contact a dealer, industry expert or manufacturer; research financial incentives and laws in your state; and more.

Clean Cities Vehicle Buyer's Guide For Fleets

www.eere.energy.gov/cleancities/vbg/fleets

The Vehicle Buyer's Guide for Fleets is designed to educate fleet managers and policy makers about alternative fuels and vehicles to help them determine whether the Energy Policy Act of 1992 (EPAct) affects them. Use the site to figure if your fleet is covered under EPAct; obtain pricing and technical specifications for light and heavy-duty AFVs; find an alternative fueling station in your area; or research information about state AFV purchasing incentives and laws.

CREST

www.crest.org/hydrogen/index.html

The Center for Renewable Energy and Sustainable Technology's fuel cell and hydrogen page.

Electric Auto Association

www.eaaev.org

This nonprofit education organization promotes the advancement and widespread adoption of electric vehicles.

Electric Drive Transportation Association

www.electricdrive.org

This industry association promotes electric vehicles through policy, information, and market development initiatives.

Fuel Economy Web Site

www.fueleconomy.gov/feg

This U.S. Department of Energy site allows comparisons of cars based on gas mileage (mpg), greenhouse gas emissions, air pollution ratings, and safety information for new and used cars and trucks.

Natural Gas Vehicle Coalition

www.ngvc.org

The Natural Gas Vehicle Coalition consists of natural gas companies, vehicle and equipment manufacturers, service providers, environmental groups and government organizations.

Rocky Mountain Institute Transportation Page

www.rmi.org/sitepages/pid18.php

This Web site offers information on the environmental impact of transportation, and extensive information about Hypercar vehicles.

Union of Concerned Scientists Clean Vehicle Program

www.ucsusa.org/clean_vehicles

This site provides information about the latest developments in alternative vehicles, the environmental impact of conventional vehicles, and information for consumers such as the guide Buying a Greener Vehicle: Electric, Hybrids, and Fuel Cells.

Definitions

Alternative Fuel Vehicles are vehicles that use low-polluting, non-gasoline fuels such as electricity, hydrogen, propane or compressed natural gas, liquid natural gas, methanol, and ethanol. Efficient gas-electric hybrid vehicles are included in this group for LEED purposes.

Hybrid Vehicles are vehicles that use a gasoline engine to drive an electric generator and use the electric generator and/or storage batteries to power electric motors that drive the vehicle's wheels.

Preferred Parking refers to parking spots that are closest to the main entrance of the project, exclusive of spaces designated for handicapped, or to parking passes provided at a discounted price.

Credit 4.3

Alternative Transportation

SS | WE | EA | MR | EQ | ID

Credit 4.4

1 Point

Parking Capacity

Intent

Reduce pollution and land development impacts from single occupancy vehicle use.

Requirements

OPTION 1 — NON-RESIDENTIAL

❑ Size parking capacity to not exceed minimum local zoning requirements, AND, provide preferred parking for carpools or vanpools for 5% of the total provided parking spaces.

OR

OPTION 2 — NON-RESIDENTIAL

For projects that provide parking for less than 5% of FTE building occupants:

❑ Provide preferred parking for carpools or vanpools, marked as such, for 5% of total provided parking spaces.

OR

OPTION 3 — RESIDENTIAL

❑ Size parking capacity to not exceed minimum local zoning requirements, AND, provide infrastructure and support programs to facilitate shared vehicle usage such as carpool drop-off areas, designated parking for vanpools, or car-share services, ride boards, and shuttle services to mass transit.

OR

OPTION 4 — ALL

Provide no new parking.

NOTES:

"Preferred parking" refers to the parking spots that are closest to the main entrance of the project (exclusive of spaces designated for handicapped) or parking passes provided at a discounted price.

When parking minimums are not defined by relevant local zoning requirements, or when there are no local zoning requirements, either:

A) Meet the requirements of Portland, Oregon, Zoning Code: Title 33, Chapter 33.266 (Parking and Loading)

OR, if this standard is not appropriate for the building type,

B) Install 25% less parking than the building type's average listed in the Institute of Transportation Engineers' Parking Generation study, 3rd Edition.

Potential Technologies & Strategies

Minimize parking lot/garage size. Consider sharing parking facilities with adjacent buildings. Consider alternatives that will limit the use of single occupancy vehicles.

SS | WE | EA | MR | EQ | ID

Credit 4.4

Summary of Referenced Standard

Portland, Oregon, Zoning Code: Title 33, Chapter 33.266 (Parking and Loading)

Available through http://www.portlandonline.com/planning/.

Institute of Transportation Engineers' *Parking Generation*, 3rd Edition

Contact LEED Customer Service for details.

Approach and Implementation

The intent of this credit is to limit availability of parking as a means of encouraging the use of alternative forms of transportation to and from the site. Select a project site that is easily accessible from residential areas by bicycle or public transportation. Once the site is selected, determine the expected number of cars likely to drive to the site and compare this number to local zoning requirements. If parking demand is expected to be less than that required by local codes, consider seeking a variance with the appropriate authorities to provide less parking. However, any on-site parking reductions should be carefully balanced with community needs to avoid needlessly burdening surrounding neighborhoods with excessive street parking.

Where possible, develop transportation demand management strategies in order to reduce the number of parking spaces required to meet the needs of occupants. Transportation demand strategies may include the publishing of an employee roster with addresses to assist people in finding carpool partners, creating incentive programs for carpooling, providing a ride share board, or setting parking fees at a level sufficient to encourage carpooling.

Calculations

Option 1—Non-Residential

Determine the minimum number of parking spaces required by local zoning requirements. Total the parking spaces provided for the project (excluding service lots) and verify that the project parking does not exceed the minimum required.

Determine the number of spaces 5% represents (rounding up to the next whole number) and designate the appropriate square foot area, closest to the building entrance and excluding handicapped spaces, as reserved carpool/vanpool spaces.

Option 2—Non-Residential

For projects that provide parking for less than 5% of FTE building occupants:

1. Identify the total number of full-time and part-time building occupants.
2. Calculate the Full-Time Equivalent (FTE) building occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0 while a part-time occupant has a FTE value based on their hours per day divided by 8 (see **Equation 1**). Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits. In buildings with multiple shifts, use only the highest volume shift in the FTE calculation but consider shift overlap when determining peak building users.
3. Determine if the total number of provided parking spaces is less than 5% of FTE occupants.

Equation 1

$$\text{FTE Occupants} = \frac{\text{Occupant Hours}}{8}$$

4. Designate project parking (closest to the building entrance and excluding handicapped spaces) equivalent to 5% of the total provided project parking as reserved carpool/vanpool spaces.

Option 3—Residential

No calculations are needed for residential projects beyond what is needed to comply with local zoning requirements.

Option 4—All

No calculations are required for this compliance path.

Exemplary Performance

Projects may be awarded one innovation point for Exemplary performance in alternative transportation, SS Credit 4, by instituting a comprehensive transportation management plan that demonstrates a quantifiable reduction in personal automobile use through the implementation of multiple alternative options.

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:

- ❑ Provide the FTE occupancy for the project.
- ❑ Provide the total parking capacity of the site.
- ❑ Confirm the appropriate project compliance path.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Option 1— Non-Residential

- ❑ Provide the number of parking spaces required for the project per local code or ordinance.
- ❑ Provide the number of carpool/vanpool spaces that are on-site.

Option 2— Non-Residential

- ❑ Provide the number of carpool/vanpool spaces that are on-site.

Option 3—Residential

- ❑ Provide a description of the infrastructure/programs that are in place to support and promote ridesharing.

Option 4— All

- ❑ There are no additional items required for this compliance path.

AND (For Projects With Special Circumstances—Any Compliance Path)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

Reducing the use of private automobiles saves energy and avoids environmental problems associated with automobile use, such as vehicle emissions that contribute to smog and other air pollutants and the environmental impacts associated with oil extraction and petroleum refining. The environmental benefits of carpooling are significant. For example, 100 people who carpooled (2 people per car) 10 miles to work and 10 miles home instead of driving separately would prevent emission of 7.7 pounds of hydrocarbons, 55 pounds of carbon monoxide, 3.3 pounds of nitrogen oxides, 990 pounds of carbon dioxide and 50 gallons of gasoline per day.

Parking facilities for automobiles also have negative impacts on the environment,

since asphalt surfaces increase stormwater runoff and contribute to urban heat island effects. By restricting the size of parking lots and promoting carpooling, buildings can reduce these effects while benefiting from reduced parking requirements and more and healthier green space.

Economic Issues

Carpooling reduces the size of the parking areas needed to support building occupants, allowing the building to accept more occupants without enlarging the parking area. It helps reduce the cost of land added for parking as well as infrastructure needed to support vehicles. Reduction in parking areas can decrease the amount of impervious surfaces on a site. This may result in reduced stormwater charges, as some local utilities charge for stormwater based on impervious surface area. Also, many municipalities and state governments offer tax incentives for carpooling programs, since fewer cars on the road reduces pollution, traffic congestion and wear and tear to roadways.

Resources

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

Web Sites

Advanced Transportation Technology Institute

www.atti-info.org

(423) 622-3884

A nonprofit organization that advances clean transportation technologies through research, education and technology transfer in order to promote a healthy environment and energy independence.

Definitions

A **Carpool** is an arrangement in which two or more people share a vehicle for transportation.

Preferred Parking refers to the parking spots that are closest to the main entrance of the project, exclusive of spaces designated for handicapped, or to parking passes provided at a discounted price.

Site Development

Protect or Restore Habitat

Credit 5.1

1 Point

Intent

Conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

Requirements

On greenfield sites, limit all site disturbance to 40 feet beyond the building perimeter; 10 feet beyond surface walkways, patios, surface parking and utilities less than 12 inches in diameter; 15 feet beyond primary roadway curbs and main utility branch trenches; and 25 feet beyond constructed areas with permeable surfaces (such as pervious paving areas, stormwater detention facilities and playing fields) that require additional staging areas in order to limit compaction in the constructed area.

Greenfield sites are those that are not previously developed or graded and remain in a natural state. Previously developed sites are those that previously contained buildings, roadways, parking lots, or were graded or altered by direct human activities.

OR

On previously developed or graded sites, restore or protect a minimum of 50% of the site area (excluding the building footprint) with native or adapted vegetation. Native/adapted plants are plants indigenous to a locality or cultivars of native plants that are adapted to the local climate and are not considered invasive species or noxious weeds.

Projects earning SS Credit 2 and using vegetated roof surfaces may apply the vegetated roof surface to this calculation (if the plants meet the definition of native/adapted), in which case the requirement is 20% of the total site area (including building footprint). This option is intended for urban sites with little or no building setback (i.e. zero-lot-line).

Potential Technologies & Strategies

On greenfield sites, perform a site survey to identify site elements and adopt a master plan for development of the project site. Carefully site the building to minimize disruption to existing ecosystems and design the building to minimize its footprint. Strategies include stacking the building program, tuck-under parking and sharing facilities with neighbors. Establish clearly marked construction boundaries to minimize disturbance of the existing site and restore previously degraded areas to their natural state. For previously developed sites, utilize local and regional governmental agencies, consultants, educational facilities, and native plant societies as resources for the selection of appropriate native or adapted plant materials. Prohibit plant materials listed as invasive or noxious weed species. Native/adapted plants require minimal or no irrigation following establishment, do not require active maintenance such as mowing or chemical inputs such as fertilizers, pesticides or herbicides, and provide habitat value and promote biodiversity through avoidance of monoculture plantings.

SS | WE | EA | MR | EQ | ID

Credit 5.1

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Preserve and enhance natural site elements including existing water bodies, soil conditions, ecosystems, trees and other vegetation. Identify opportunities for site improvements that increase the area of native/adapted vegetation or other ecologically appropriate features. Activities may include removing unnecessary paved areas and replacing them with landscaped areas, or replacing excessive turf-grass areas with native or adapted plantings to promote biodiversity and provide habitat.

During the construction process, establish clearly marked construction and disturbance boundaries and note these site protection requirements in construction documents. Delineate lay down, recycling and disposal areas, and use paved areas for staging activities. Erect construction fencing around the drip line of existing trees to protect them from damage and soil compaction by construction vehicles. Consider the costs/benefits of contractual penalties if destruction of protected areas outside of the construction boundaries occurs. Coordinate infrastructure construction to minimize the disruption of the site and work with existing topography to limit cut-and-fill efforts for the project.

For urban projects earning SS Credit 2, consider installing a vegetated roof. Select native or adapted, non-invasive species, and ensure that the roof structure is designed to support the added weight of the planting beds. Research the species that are likely to utilize this space (primarily birds and insects) and select plants that will help support these species by providing food, forage or nesting areas.

Calculations

There are no calculations associated with this credit.

Exemplary Performance

The project may be awarded one innovation point for exemplary performance in restoring or protecting a minimum of 75% of the site area (excluding the building footprint) with native or adapted vegetation on previous developed or graded sites.

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 project site area.
- ❑ Provide the project building footprint area.
- ❑ Provide a narrative describing the project's approach to this credit. Include information regarding any special circumstances or considerations regarding the project.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Greenfield Sites

- ❑ Provide a copy of the project's site/grading drawings highlighting the designated site disturbance boundaries.

Previously Developed/Graded Sites

- ❑ Provide the area (sq.ft.) of the site that has been restored using native and/or adaptive planting.
- ❑ Provide a copy of the project's site/landscape plan that provides information regarding the restored site area and the planting materials.

Considerations

Environmental Issues

Development on building sites often damages site ecology, indigenous plants and regional animal populations. Ecological site damage can be reduced by restoring native and adapted vegetation and other ecologically appropriate features on the site, which in turn provides habitat for fauna. Other ecologically appropriate features are natural site elements beyond vegetation that maintain or restore the ecological integrity of the site. They may include water bodies, exposed rock, bare ground, or other features that are part of the historic natural landscape within the region and provide habitat value. When construction occurs on the site, protection of open space and sensitive areas through the use of strict boundaries reduces damage to the site ecology, resulting in preservation of wildlife corridors and habitat.

Economic Issues

Native or adapted plantings typically reduce maintenance costs over their lifetime by minimizing inputs of fertilizers, pesticides and water. In many cases, trees and vegetation raised off site are costly to purchase and may not survive transplanting. Additional trees and other landscaping, as well as soil remediation and water elements, can incur first costs. It may be advantageous to implement site restoration in phases to spread costs out over time. Strategic plantings can shade the building and site impervious areas, which can decrease cooling loads during warm months and reduce energy expenditures.

Resources

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

Web Sites

American Society of Landscape Architects

www.asla.org

ASLA is the national professional association representing landscape architects. The Web site provides information about products, services, publications and events.

Ecological Restoration

http://ecologicalrestoration.info

This quarterly print and online publication from the University of Wisconsin-Madison Arboretum provides a forum for people interested in all aspects of ecological restoration.

Lady Bird Johnson Wildlife Center

www.wildflower.org

The center, located in Austin, Texas, has the mission of educating people about the environmental necessity, economic value and natural beauty of native plants. The Web site offers a number of resources, including a nationwide Native Plant Information Network and a National Suppliers Directory.

North American Native Plant Society

www.nanps.org

A nonprofit association dedicated to the study, conservation, cultivation and restoration of native plants. Its Web site contains links to state and provincial associations.

Plant Native

www.plantnative.org

This organization isdedicated to moving native plants and nature-scaping into mainstream landscaping practices.

Society for Ecological Restoration International

www.ser.org

Nonprofit consortium of scientists, planners, administrators, ecological consul-

tants, landscape architects, engineers, and others with the mission of promoting ecological restoration as a means of sustaining the diversity of life and reestablishing an ecologically healthy relationship between nature and culture.

Soil and Water Conservation Society

www.swcs.org

An organization focused on fostering the science and art of sustainable soil, water, and related natural resource management.

Print Media

Design for Human Ecosystems: Landscape, Land Use, and Natural Resources by John Tillman Lyle, Island Press, 1999.

This text explores methods of landscape design that function like natural ecosystems.

Landscape Restoration Handbook by Donald Harker, Marc Evans, Gary Libby, Kay Harker, and Sherrie Evans, Lewis Publishers, 1999.

This resource is a comprehensive guide to natural landscaping and ecological restoration, and provides information on 21 different ecological restoration types.

Definitions

The **Building Footprint** is the area on a project site that is used by the building structure and is defined by the perimeter of the building plan. Parking lots, landscapes and other non-building facilities are not included in the building footprint.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

Greenfield sites are those that are not previously developed or graded and remain in a natural state.

Local Zoning Requirements are local government regulations imposed to promote orderly development of private lands and to prevent land use conflicts.

Native (or Indigenous) Plants refers to plants adapted to a given area during a defined time period and are not invasive. In America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

Adapted (or introduced) Plants are those that reliably grow well in a given habitat with minimal attention from humans in the form of winter protection, pest protection, water irrigation, or fertilization once root systems are established in the soil. Adapted plants are considered to be low maintenance but not invasive.

Invasive Plants are both indigenous and non-indigenous species or strains that are characteristically adaptable, aggressive, have a high reproductive capacity and tend to overrun the ecosystems in which they inhabit. Collectively they are one of the great threats to biodiversity and ecosystem stability.

Open Space Area is as defined by local zoning requirements. If local zoning requirements do not clearly define open space, it is defined for the purposes of LEED calculations as the property area minus the development footprint; and it must be vegetated and pervious, with exceptions only as noted in the credit requirements section. For projects located in urban areas that earn SS Credit 2, open space also includes non-vehicular, pedestrian-oriented hardscape spaces.

Previously Developed sites are those that previously contained buildings, roadways, parking lots, or were graded or altered by direct human activities.

Site Development

Maximize Open Space

1 Point

Intent

Provide a high ratio of open space to development footprint to promote biodiversity.

Requirements

OPTION 1

Reduce the development footprint (defined as the total area of the building footprint, hardscape, access roads and parking) and/or provide vegetated open space within the project boundary to exceed the local zoning's open space requirement for the site by 25%.

OR

OPTION 2

For areas with no local zoning requirements (e.g., some university campuses, military bases), provide vegetated open space area adjacent to the building that is equal to the building footprint.

OR

OPTION 3

Where a zoning ordinance exists, but there is no requirement for open space (zero), provide vegetated open space equal to 20% of the project's site area.

ALL OPTIONS:

- ❑ For projects located in urban areas that earn SS Credit 2, vegetated roof areas can contribute to credit compliance.
- ❑ For projects located in urban areas that earn SS Credit 2, pedestrian oriented hardscape areas can contribute to credit compliance. For such projects, a minimum of 25% of the open space counted must be vegetated.
- ❑ Wetlands or naturally designed ponds may count as open space if the side slope gradients average 1:4 (vertical:horizontal) or less and are vegetated.

Potential Technologies & Strategies

Perform a site survey to identify site elements and adopt a master plan for development of the project site. Select a suitable building location and design the building with a minimal footprint to minimize site disruption. Strategies include stacking the building program, tuck-under parking and sharing facilities with neighbors to maximize open space on the site.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Choose a development footprint and location that minimizes disturbance to the existing ecosystem. Consider issues such as building orientation, daylighting, heat island effects, stormwater generation, significant vegetation, existing green corridors, and other sustainable building issues. Once the site and building location have been determined, design and construct a compact parking, road and building footprint layout in order to preserve open land and provide connections to adjacent ecosystems. Reduce footprints by tightening program needs and stacking floor plans.

In a campus setting with no zoning requirements, designated open space that is equal to the building footprint can be separate from the project site as long as the open space is preserved as such for the life of the building.

When designing green roofs, attention must be given to support, waterproofing and drainage. Green roofs typically include a waterproof and root repellant membrane, a drainage system, filter cloth, a lightweight growing medium and plants. Modular systems are available, with all layers pre-prepared into movable interlocking grids, or individual layers can be installed separately.

Open space in an urban context that includes hardscape surfaces should be pedestrian oriented and accessible, and provide for passive or active recreation opportunities. Examples of urban open space include pocket parks, accessible roof decks, plazas, and courtyards.

Calculations

Option 1

Determine the zoning requirement for open space. Set-back requirements and lot coverage requirements only qualify as open space requirements if the areas they set aside are required to be vegetated. Calculate the open space required for this credit as shown in **Equation 1**.

Option 2

In cases where there is no local zoning requirement, the open space requirement is equal to the building footprint.

Option 3

In cases where local codes require zero open space, determine the total project site area and multiply by 0.20 to determine the open space required for credit achievement, as shown in **Equation 2**.

This requirement can be met through open space provided at grade or on the roof.

Exemplary Performance

Projects may be awarded an innovation point for exemplary performance by demonstrating that they have doubled the amount of open space required for credit achievement. All designated open space shall be within the LEED project boundary. For example, projects with local zoning requirements must increase the amount of open space provided by 50%

Equation 1

Total Open Space Required = Open Space Required by Zoning x 1.25

Equation 2

Total Open Space Required = Total Project Site Area x 0.20

instead of by 25%; projects with no local zoning requirements must provide open space equal to two times the building footprint; and urban projects where zero open space is required must provide open space equal to 40% of the site area.

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:

- ❑ Provide the project site area.
- ❑ Provide the project building footprint area.
- ❑ Provide a copy of the project's site/landscape drawings highlighting the dedicated vegetated open space.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's credit approach.

In addition, please provide the following project data and calculation information based on the appropriate compliance path:

Option 1

- ❑ Provide the area (sq.ft.) of open space required by local zoning codes/ordinances.
- ❑ Provide the area (sq.ft.) of the vegetated dedicated open space provided by the project.

Option 2

- ❑ Provide the area (sq.ft.) of the vegetated dedicated open space provided by the project.

Option 3

- ❑ Provide the area (sq.ft.) of the vegetated dedicated open space provided by the project.

Considerations

Environmental Issues

Open space provides habitat for vegetation, which in turn provides habitat for local wildlife. Even small open spaces in urban areas can provide refuges for wildlife populations, which have become increasingly marginalized. Plants that specifically support local species such as insects and other pollinators can help sustain populations up the food chain. Open space also helps reduce urban heat island effect, increases stormwater infiltration, and provides the human population on the site with a connection to the outdoors

Economic Issues

Preserving topsoil, plants and trees on the site can reduce landscaping costs for the building. Even in cases where rent values are high and the incentive for building out to the property line is strong, well designed open space can significantly increase property values. Reducing the footprint of a structure on a given site can have varying economic impacts. Building a vertical structure with the same square footage as a horizontal structure may add a small percentage to first costs depending on building size and use. A structure with a smaller footprint is generally more resource-efficient, resulting in reduced material and energy costs. A more compact building with coordinated infrastructure can reduce initial project costs, as well as operations and maintenance costs. Reduced earthwork, shorter utility lines, and reduced surface parking and paved areas all can reduce initial project costs. Compact paving areas and buildings reduce operations and maintenance costs.

Resources

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

SS | WE | EA | MR | EQ | ID

Credit 5.2

Web Sites

North American Native Plant Society

www.nanps.org (416) 631-4438

A nonprofit association dedicated to the study, conservation, cultivation and restoration of native plants. Contains links to state/provincial associations.

Soil and Water Conservation Society

www.swcs.org (515) 289-2331

An organization focused on fostering the science and art of sustainable soil, water and related natural resource management.

Green Roofs for Healthy Cities

www.greenroofs.org

A nonprofit industry association consisting of public and private organizations and individuals committed to developing a market for green roof infrastructure products and services in cities across North America.

Print Media

Beyond Preservation: Restoring and Inventing Landscapes by A. Dwight Baldwin et al., University of Minnesota Press, 1994.

Design for Human Ecosystems: Landscape, Land Use, and Natural Resources by John Tillman Lyle and Joan Woodward, Milldale Press, 1999.

Landscape Restoration Handbook by Donald Harker, Lewis Publishers, 1999.

Definitions

The **Building Footprint** is the area on a project site that is used by the building structure and is defined by the perimeter of the building plan. Parking lots, landscapes and other non-building facilities are not included in the building footprint.

The **Development Footprint** is the area on the project site that has been impacted by any development activity. Hardscape, access roads, parking lots, non-building facilities and building structure are all included in the development footprint.

Greenfield Sites are those that are not previously developed or graded and remain in a natural state.

Local Zoning Requirements are local government regulations imposed to promote orderly development of private lands and to prevent land use conflicts.

Native (Indigenous) Plants refers to plants adapted to a given area during a defined time period and are not invasive. In America, the term often refers to plants growing in a region prior to the time of settlement by people of European descent.

Adapted (or introduced) Plants are those that reliably grow well in a given habitat with minimal attention from humans in the form of winter protection, pest protection, water irrigation, or fertilization once root systems are established in the soil. Adapted plants are considered to be low maintenance but not invasive.

Invasive Plants are both indigenous and non-indigenous species or strains that are characteristically adaptable, aggressive, have a high reproductive capacity and tend to overrun the ecosystems in which they inhabit. Collectively they are one of the great threats to biodiversity and ecosystem stability.

Open Space Area is as defined by local zoning requirements. If local zoning requirements do not clearly define open space, it is defined for the purposes of LEED calculations as the property area minus the development footprint; and it must be vegetated and pervious, with exceptions only as noted in the credit requirements section. For projects located in urban areas that earn SS Credit 2, open space also includes non-vehicular, pedestrian-oriented hardscape spaces.

SS | WE | EA | MR | EQ | ID

Credit 6.1

1 Point

Stormwater Design

Quantity Control

Intent

Limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, and managing stormwater runoff.

Requirements

OPTION 1 — EXISTING IMPERVIOUSNESS IS LESS THAN OR EQUAL TO 50%

Implement a stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the one- and two-year, 24-hour design storms.

OR

Implement a stormwater management plan that protects receiving stream channels from excessive erosion by implementing a stream channel protection strategy and quantity control strategies.

OR

OPTION 2 — EXISTING IMPERVIOUSNESS IS GREATER THAN 50%

Implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the two-year, 24-hour design storm.

Potential Technologies & Strategies

Design the project site to maintain natural stormwater flows by promoting infiltration. Specify vegetated roofs, pervious paving, and other measures to minimize impervious surfaces. Reuse stormwater volumes generated for non-potable uses such as landscape irrigation, toilet and urinal flushing and custodial uses.

SS | WE | EA | MR | EQ | ID

Credit 6.1

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

The approach to this credit may vary significantly depending on the condition of the project site at the beginning of the project. If the project is being constructed on a largely undeveloped site, the goal is to preserve stormwater flows and design the project to respond to the natural soil conditions, habitat, and rainfall characteristics. If the project is a redevelopment of a previously developed site, the goal is typically to improve stormwater management in a way that restores the natural functions of the site to the maximum extent practicable.

The approach to this credit also varies dramatically between different regions and climate zones. The strategies employed in an urban environment where water is discharged to concrete channels and then the ocean are different from the strategies employed at an inland site that discharges to a small stream and lake system.

The most effective method to minimize stormwater runoff volume is to reduce the amount of impervious area. By reducing impervious area, stormwater infrastructure can be minimized or deleted from the project. Strategies to minimize or mitigate impervious surfaces may include:

- ❑ Smaller building footprint
- ❑ Pervious paving materials
- ❑ Stormwater harvesting for reuse in irrigation and/or buildings
- ❑ Green roofs
- ❑ Bioswales/vegetated filter strips
- ❑ Retention ponds
- ❑ Clustering development to reduce paved surfaces (roads, sidewalks, etc.)

Guidelines for Capturing and Reusing Stormwater Runoff

Stormwater captured (or harvested) in cisterns, rain barrels, or other devices, is a primary source of water in many parts of the world. Stormwater should not be used for potable needs if there are sources available that pose less risk to public health. However, harvested stormwater may be used to reduce potable water needs for uses such as landscape irrigation, fire suppression, toilet and urinal flushing, and custodial uses.

Storage and reuse techniques range from small-scale systems (e.g., rain barrels) to underground cisterns that may hold large volumes of water. Whether large or small, stormwater harvesting system designs should consider the following:

1. Water need for the intended use—how will the harvested water be used and when will it be needed? For example, if the water is used to irrigate landscaping for four summer months, the amount of water needed and the how often the storage unit will refill must be considered. Usage requirements and the expected volume and frequency of rainfall must be determined.
2. Drawdown—storage system design must provide for the use or release of water between storm events for the design storage volume to be available.
3. Drainage Area—the size and nature (e.g., percent imperviousness) of the area draining to the storage system determines how much runoff will be available for harvesting.
4. Conveyance System—reused stormwater and graywater systems must not be connected to other domestic or commercial potable water systems. Pipes and storage units should be clearly marked (e.g., "Caution: Reclaimed Water, Do Not Drink").
5. Pretreatment—screens or filters may be used to remove debris and sedi-

ment from runoff and to minimize pollutants.

6. Pressurization—uses for harvested rainwater may require pressurization. For example, most irrigation systems require a water pressure of at least 15 psi to function properly. Stored water has a pressure of 0.43 psi per foot of water elevation, and the water pressure at the bottom of a ten-foot vault would be 4.3 psi (10 ft. x 0.43 psi). Pressurization (e.g., a pump, pressure tank and filter) costs more and creates a more useable system.

The amount of runoff reduced by a stormwater harvesting system may be considered equal to its storage volume. However, volume calculations must also consider how often the system is emptied and the interval between storm events.

Example:

Rainwater will be harvested from a 10,000 sq.ft. roof (100% imperviousness). The system will be designed to capture the runoff from 90% of the average annual rainfall (1 inch of rainfall for humid watersheds). The volume of the proposed storage system is the amount of runoff captured (Vr), which is calculated below in **Equation 1**:

Other design considerations – tank must be emptied before subsequent storm events. Use a tank that is 10 ft x 10 ft x 8 ft deep – Total storage volume (V_s) = 800 cu.ft. Using a design storm interval of three days (72 hours), the drawdown rate (Q_r) is calculated below in **Equation 2**:

In this example, the captured rain must be drained within 3 days or at a minimum rate of 1.4 gpm for the tank to be emptied for the next storm.

Different municipalities, state and local governments have various design requirements for capturing and reuse of stormwater runoff. These requirements range from where stormwater may be captured and used to length of time stormwater can be held in a cistern, to the type of water treatment required before reuse. Designers should check with the governing administrative authority to determine parameters which will affect collection, use, and distribution of captured stormwater.

Calculations

There are two compliance paths for this credit—one for largely undeveloped sites and one for largely developed sites.

Option 1—Existing Imperviousness Is Less Than Or Equal To 50% (Largely Undeveloped Sites)

Option 1-a: Discharge Rate and Quantity

Determine the pre-development discharge rate and quantity for the project. These values are typically calculated by the civil engineer using the surface characteristics of the site and data on storm event frequency, intensity and duration. Calculate

Equation 1

$$V_r = \frac{(P)(R_v)(A)}{12'} = \frac{(1')(0.95)(10{,}000\ SF)}{12'} = 791.67\ CF\ (5{,}922\ gal)$$

Where, $R_v = 0.05 + (0.009)(I) = 0.05 + (0.009)(100) = 0.95$
R_v = Volumetric Runoff Coefficient
I = Percent Imperviousness

Equation Source: 2000 Maryland Stormwater Design Manual, Vol. I & II (MDE, 2000)

Equation 2

$$Q_r = \frac{800 c.f.}{259{,}200\ sec} = 0.003\ cfs\ or\ 1.37\ gpm$$

SS | WE | EA | MR | EQ | ID

Credit 6.1

rate and quantity for the one-year and two-year, 24-hour design storms.

Determine the post-development discharge rate and quantity for the project consistent with the pre-development calculations. The post-development rate AND quantity must be equal to or less than the pre-development values to earn this credit.

Option 1-b: Stream Channel Protection

Describe the project site conditions, the measures taken, and controls implemented as part of the project scope that prevent excessive stream velocities and the associated erosion. Include in the description numerical values for pre-development and post-development conditions to demonstrate that the rate and quantity of stormwater runoff in the post-development condition are below critical values for the relevant receiving waterways.

Option 2—Existing Imperviousness is Greater Than 50% (Largely Developed Sites)

Determine the pre-development discharge rate and quantity for the project. These values are typically calculated by the civil engineer using the surface characteristics of the site and data on storm event frequency, intensity, and duration. Calculate rate and quantity for the one-year and two-year, 24-hour design storms.

Determine the post-development discharge rate and quantity for the project consistent with the pre-development calculations. The post-development rate AND quantity must be at least 25% less than the pre-development values to earn this credit.

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:

Option 1

- ❑ Provide the pre-development site runoff rate (cfs).
- ❑ Provide the pre-development site runoff quantity (cf).
- ❑ Provide the post-development site runoff rate (cfs).
- ❑ Provide the post-development site runoff quantity (cf).

OR

- ❑ Provide a narrative describing the project site conditions, measures taken, and controls implemented to prevent excessive stream velocities and associated erosion.

Figure 1 (Source Figure 1.4), excerpted from the Maryland Stormwater Design Manual, diagrams the potential increases in critical discharge rate from development.

Option 2

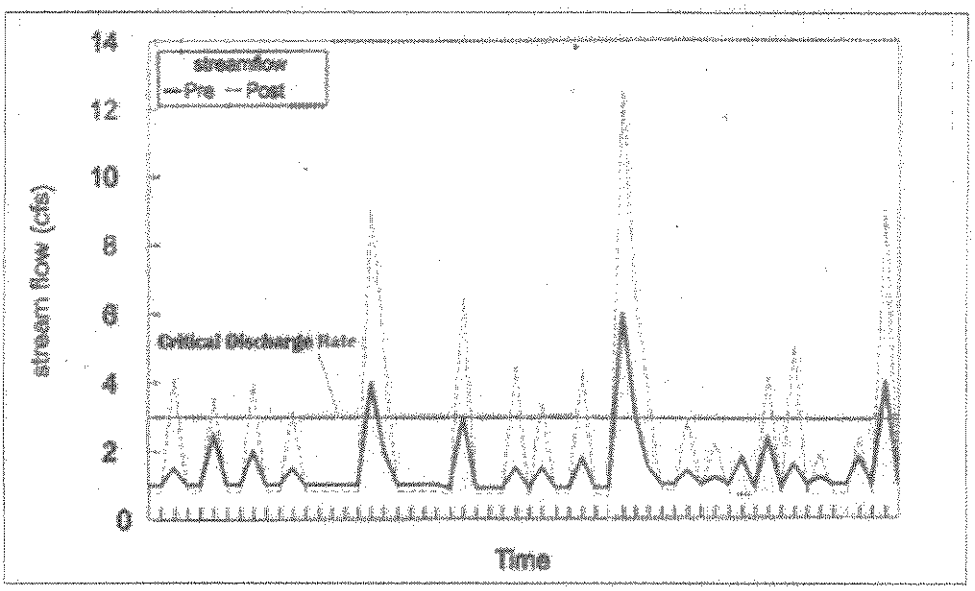
- ❑ Provide the pre-development site runoff rate (cfs).
- ❑ Provide the pre-development site runoff quantity (cf).
- ❑ Provide the post-development site runoff rate (cfs).
- ❑ Provide the post-development site runoff quantity (cf).

Considerations

Environmental Issues

The intent of this credit is to limit the disruption of the natural stormwater flows that results from development. Undevel-

Figure 1: Increased Frequency of Flows Greater than the Critical Discharge Rate in a Stream Channel after Development



oped land has a certain capacity to absorb rainfall in the soils, vegetation and trees. Clearing of vegetation and/or construction of impervious surfaces (i.e., roads, parking lots and buildings) reduce the capacity of the land to absorb rainfall and increase the amount of stormwater runoff.

As areas are constructed and urbanized, surface permeability is reduced, resulting in increased stormwater runoff volumes that are transported via urban infrastructure (e.g., gutters, pipes and sewers) to receiving waters. These stormwater volumes contain sediment and other contaminants that have a negative impact on water quality, navigation and recreation. Furthermore, conveyance and treatment of stormwater volumes requires significant municipal infrastructure and maintenance. Reducing the generation of stormwater volumes helps maintain the natural aquifer recharge cycle and assist in restoring depleted stream base flows. In addition, stormwater volumes do not have to be conveyed to receiving waters by the municipality, and receiving waters are not impacted.

The geometry and health of streams is closely linked to stormwater runoff velocities and volumes. Increases in the frequency and magnitude of stormwater runoff due to development can cause increased bankfull events. As a result, the stream bed and banks are exposed to highly erosive flows more frequently and for longer periods. The resultant impacts may include channel-widening or down-cutting or both.

Figures 2 and 3 (Source Figures 1.1 and 1.2), excerpted from the Maryland Stormwater Design Manual show the impact of development of stormwater flows and the increase in the volumetric runoff coefficient as a function of site imperviousness.

Economic Issues

If natural drainage systems are designed and implemented at the beginning of site planning, they can be integrated economically into the overall development. Water detention and retention features require cost for design, installation and maintenance. However, these features can also add significant value as site amenities if planned early in the design. Smaller stormwater collection and treatment systems lessen the burden on municipalities for maintenance and repair, resulting in a more affordable and stable tax base.

Figure 2: Water Balance at a Developed and Undeveloped Site (Source: Schueler, 1987)

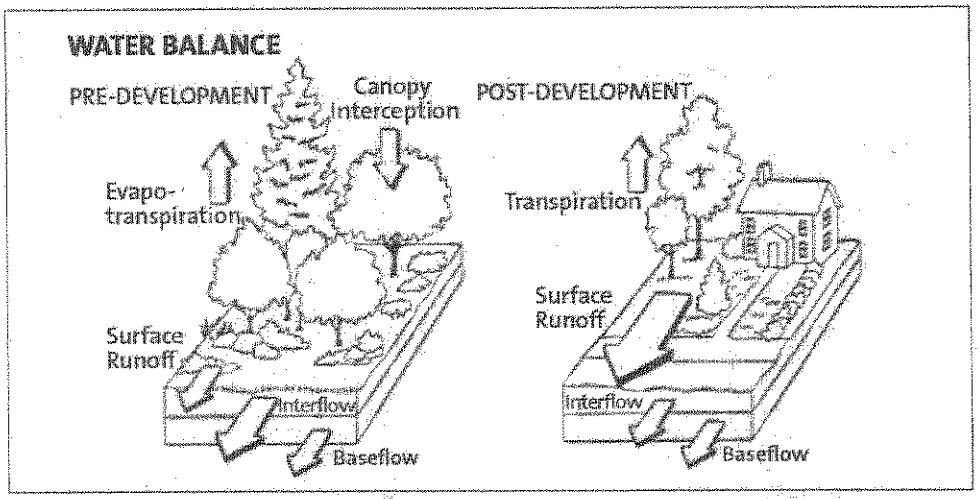
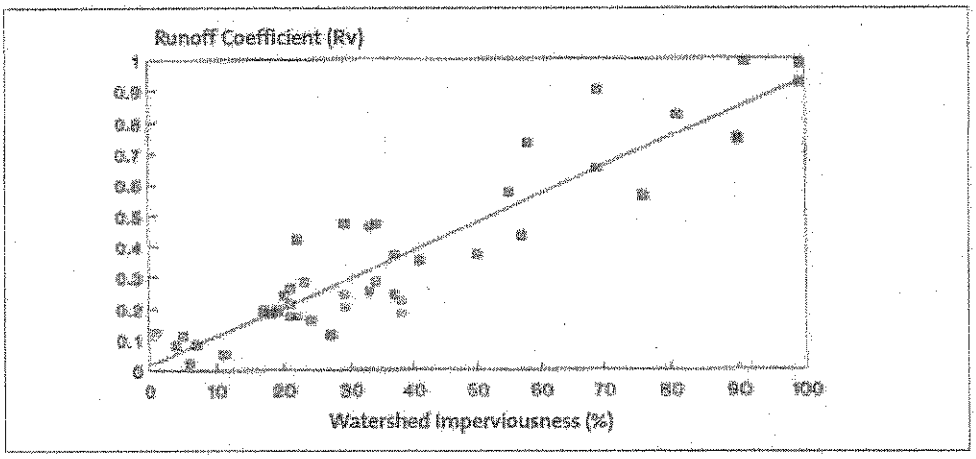


Figure 3: Relationship Between Impervious Cover and the Volumetric Runoff Coefficient (Source: Schueler, 1987)



Synergies and Trade-Offs

Stormwater runoff is affected significantly by site topography, site design, and especially quantity of impervious surface area to support transportation amenity design. It may be possible to reuse stormwater for non-potable water purposes such as flushing urinals and toilets, custodial applications, and building equipment uses. It is helpful to perform a water balance to determine the estimated volumes of water available for reuse. Stormwater runoff volumes can also be reduced by designing the building with underground parking, a strategy that also reduces heat island effects. Pervious paving systems usually have a limit on transportation loads and may pose problems for wheelchair accessibility and stroller mobility. If stormwater volumes are treated on site, additional site area may need to be disturbed to construct treatment ponds or underground facilities. Application of green roofs reduces stormwater volumes that may be intended for collection and reuse for non-potable applications.

Resources

Web Sites

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

Stormwater Best Management Practice Design Guide, EPA/600/R-04/121A, September 2004.

www.epa.gov/ORD/NRMRL/pubs/600r04121/600r04121a.pdf

Maryland Stormwater Design Manual

www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Definitions

Impervious Surfaces promote runoff of precipitation volumes instead of infiltration into the subsurface. The imperviousness or degree of runoff potential can be estimated for different surface materials.

Stormwater Runoff consists of water volumes that are created during precipitation events and flow over surfaces into sewer systems or receiving waters. All precipitation waters that leave project site boundaries on the surface are considered to be stormwater runoff volumes.

Credit 6.1

Credit 6.2

1 Point

Stormwater Design

Quality Control

Intent

Reduce or eliminate water pollution by reducing impervious cover, increasing on-site infiltration, eliminating sources of contaminants, and removing pollutants from stormwater runoff.

Requirements

Implement a stormwater management plan that reduces impervious cover, promotes infiltration, and captures and treats the stormwater runoff from 90% of the average annual rainfall[1] using acceptable best management practices (BMPs).

BMPs used to treat runoff must be capable of removing 80% of the average annual post development total suspended solids (TSS) load based on existing monitoring reports. BMPs are considered to meet these criteria if (1) they are designed in accordance with standards and specifications from a state or local program that has adopted these performance standards, or (2) there exists in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.

Potential Technologies & Strategies

Use alternative surfaces (e.g., vegetated roofs, pervious pavement or grid pavers) and nonstructural techniques (e.g., rain gardens, vegetated swales, disconnection of imperviousness, rainwater recycling) to reduce imperviousness and promote infiltration, thereby reducing pollutant loadings.

Use sustainable design strategies (e.g., Low Impact Development, Environmentally Sensitive Design) to design integrated natural and mechanical treatment systems such as constructed wetlands, vegetated filters, and open channels to treat stormwater runoff.

SS | WE | EA | MR | EQ | ID

Credit 6.2

Summary of Referenced Standard

Guidance Specifying Management Measures for Sources of Non-Point Pollution in Coastal Waters, January 1993 (Document No. EPA 840B92002)

Internet location: www.epa.gov/owow/nps/MMGI

Hardcopy or microfiche (entire document, 836 pages): National Technical Information Service (order # PB93-234672): www.ntis.gov, (800) 553-6847

U.S. Environmental Protection Agency Office of Water: www.epa.gov/OW

This document discusses a variety of management practices that can be incorporated to remove pollutants from stormwater volumes. Chapter 4, Part II addresses urban runoff and suggests a variety of strategies for treating and infiltrating stormwater volumes after construction is completed. See the Resources section later in this credit for a summary of best management practices listed in the EPA document.

Approach and Implementation

This credit may be achieved using either non-structural or structural stormwater management measures or a combination of the two.

Non-Structural Measures

Non-structural strategies, such as vegetated swales, disconnection of impervious areas, and pervious pavement, can be used to promote infiltration and limit runoff. In these cases, you are "capturing and treating" runoff by allowing it to naturally filter into the soil and vegetation. Pollutants are broken down by microorganisms in the soil and plants.

Structural Measures

Structural measures, such as rainwater cisterns, manhole treatment devices and ponds can be used to remove pollutants from runoff from impervious areas and sometimes reuse the water for irrigation or building flush fixtures.

Non-structural measures are often preferred because they may be less costly to construct and maintain and they help recharge groundwater supplies.

Structural measures are preferred on urban or constrained sites and make it possible to effectively clean the runoff with minimal space allocation and land use. For existing sites with greater than 50% imperviousness, structural techniques may include restoration and repair of deteriorated storm sewers, or separation of combined sewers.

The most effective method to minimize stormwater runoff volume and treatment requirements is to reduce the amount of impervious area. Strategies to minimize or mitigate impervious surfaces may include:

- ❑ Smaller building footprint
- ❑ Pervious paving materials
- ❑ Stormwater harvesting for reuse in irrigation and/or buildings
- ❑ Green roofs
- ❑ Bioswales/vegetated filter strips
- ❑ Retention ponds
- ❑ Clustering development to reduce paved surfaces (roads, sidewalks, etc.)

Calculations

As part of the stormwater management plan process, describe the Best Management Practices (BMPs) employed to capture and/or treat stormwater runoff. Describe how each measure contributes to reducing imperviousness and/or increasing infiltration. Describe how each measure is sized to capture and/or treat 90% of the annual rainfall volume.

Determine the annual rainfall using the following guidelines:

Humid watersheds are defined as those that receive at least 40 inches of rainfall each year, Semi-arid watersheds receive between 20 and 40 inches of rainfall per year, and Arid watersheds receive less than 20 inches of rainfall per year. For this credit, 90% of the average annual rainfall is equivalent to treating the runoff from:

1. Humid Watersheds – 1 inch of rainfall;
2. Semi-arid Watersheds – 0.75 inches of rainfall; and
3. Arid Watersheds – 0.5 inches of rainfall.

Where non-structural controls involving infiltration are employed, determine the soil type(s) and associated infiltration rates. Confirm that the soils have the capacity to infiltrate water at a rate and quantity sufficient to absorb at least 90% of the annual rainfall volume.

Where structural controls are used, confirm that the equipment has the capacity to treat at least 90% of the annual rainfall volume. If individual measures are designed to handle less than 90% of the annual rainfall volume, describe how the measures work together to satisfy the requirement.

Water that is infiltrated on-site is assumed to be 100% treated for the purposes of this credit.

Stormwater control measures (or BMPs) that discharge water off-site must meet the following criteria (repeated from the credit requirement):

1. Achieve 80% total suspended solids (TSS) removal.

AND

2. Be designed in accordance with standards and specifications from a state or local program that has adopted these performance standards.

   OR

   Be supported by in-field performance monitoring data demonstrating compliance with the criteria. Data must conform to accepted protocol (e.g., Technology Acceptance Reciprocity Partnership [TARP], Washington State Department of Ecology) for BMP monitoring.

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:

Non-Structural Controls

- ❑ Provide list of Best Management Practices (BMPs), including a description of the function of each BMP and the percent annual rainfall treated.

Structural Controls

- ❑ Provide list of structural controls, including a description of the pollutant removal of each control and the percent annual rainfall treated.

AND

- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the approach to the credit.

Considerations

Environmental Issues

As areas are constructed and urbanized, surface permeability is reduced, resulting in increased stormwater runoff volumes that are transported via urban infrastructure (e.g., gutters, pipes and sewers) to receiving

waters. These stormwater volumes contain sediment and other contaminants that have a negative impact on water quality, navigation and recreation. Furthermore, conveyance and treatment of stormwater volumes requires significant municipal infrastructure and maintenance.

Stormwater pollution sources include atmospheric deposition, vehicle fluid leaks, and mechanical equipment wastes. During storm events, these pollutants are washed away and discharged to downstream waters.

Synergies and Trade-Offs

Stormwater runoff is affected significantly by site selection and site design. It may be possible to reuse stormwater for non-potable water purposes such as flushing urinals and toilets, custodial applications, and building equipment uses. It is helpful to perform a water balance to determine the estimated volumes of water available for reuse. Stormwater runoff volumes can also be reduced by consolidating the building footprint and designing the building with underground parking, a strategy that also reduces heat island effects. Pervious paving systems usually have a limit on transportation loads and may pose problems for wheelchair accessibility and stroller mobility. If stormwater volumes are treated on site, additional site area may need to be disturbed to construct treatment ponds or underground facilities. Application of green roofs reduces stormwater volumes that may be intended for collection and reuse for non-potable applications.

Resources

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

Web Sites

Stormwater Best Management Practice Design Guide. EPA/600/R-04/121A. September, 2004.

www.epa.gov/ORD/NRMRL/pubs/600r04121/600r04121a.pdf

Maryland Stormwater Design Manual.

www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/stormwater_design/index.asp

Technology Acceptance and Reciprocity Partnership

www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/

Definitions

Total Suspended Solids (TSS) are particles or flocs that are too small or light to be removed from stormwater via gravity settling. Suspended solid concentrations are typically removed via filtration.

Case Study

Ford Rouge Visitors Center
Dearborn, MI

Owner: Ford Motor Company

Photo © Ford Photographic

In 2003, the Ford Rouge Visitors Center was awarded LEED® v2.1 Gold. The project demonstrated exceptional stormwater management practices, attaining both SS Credits 6.1 and 6.2. In times of rain and snow, sedum plants on the project's green roof capture and cleanse runoff before it returns to the natural watershed, thus preventing contaminated runoff from harming nearby rivers and lakes. Stormwater runoff that is not soaked up by the green roof is collected in stone basins under a porous paving parking lot, then filtered through natural wetlands and bioswales located around the site. The project's natural stormwater management system is potentially much cheaper than installing and operating a traditional stormwater treatment plant.

Heat Island Effect

Credit 7.1

1 Point

Non-Roof

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Requirements

OPTION 1

Provide any combination of the following strategies for 50% of the site hardscape (including roads, sidewalks, courtyards and parking lots):

❑ Shade (within 5 years of occupancy)

❑ Paving materials with a Solar Reflectance Index (SRI)[2] of at least 29

❑ Open grid pavement system

OR

OPTION 2

Place a minimum of 50% of parking spaces under cover (defined as underground, under deck, under roof, or under a building). Any roof used to shade or cover parking must have an SRI of at least 29.

Potential Technologies & Strategies

Shade constructed surfaces on the site with landscape features and utilize high-reflectance materials for hardscape. Consider replacing constructed surfaces (i.e., roof, roads, sidewalks, etc.) with vegetated surfaces such as vegetated roofs and open grid paving or specify high-albedo materials to reduce the heat absorption.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Limit the amount of impervious hardscape areas on the site in order to limit heat island effect. For features such as parking lots, roads and walkways, use open grid pavement systems that are at least 50% pervious, which remain cooler due to reduction of impervious surface area and increased evaporation from the open cell vegetation. Use light colored paving surfaces, and shade paved areas with landscaping. Utilize a parking deck to reduce parking footprint by 50%.

Darker paving materials, such as asphalt, generally exhibit low reflectance and consequently low SRI values. Grey or white concrete has a higher reflectance and a higher SRI. Concrete made with white cement may cost up to twice as much as that made with gray cement. Some blended cements (e.g., slag cements) are very light in color and cost the same or slightly less than portland-only based gray cement (Source: "Albedo: A Measure of Pavement Surface Reflectance," R&T Update #3.05, June 2002, American Concrete Pavement Association, http://www.pavement.com/Downloads/RT/RT3.05.pdf). Micro surfaces and coatings over asphalt pavement can be used to attain the required SRI value for this credit. Coatings and integral colorants can be used in cementitious pavers or cast-in-place parking surfaces to improve solar reflectance.

Vegetation can shade buildings and pavements from solar radiation and cool the air through evapotranspiration. Provide shade using native or adaptive trees, large shrubs and non-invasive vines. Trellises and other exterior structures can support vegetation to shade parking lots, walkways and plazas. Deciduous trees allow buildings to benefit from solar heat gain during the winter months. On-site locations where tree planting is not possible, use architectural shading devices to block direct sunlight radiance.

Alternatively, place parking under cover. This can include using multi-story or subterranean parking structures, or placing parking under a shade structure. Parking cover must also meet the same SRI requirements as non-roof impervious surfaces.

Calculations

Option 1

1. Identify all non-roof hardscape surfaces on the project site and sum the total area (T).
2. Identify all of the hardscape surfaces that have an open grid paving system that are at least 50% pervious and sum the total area (O).
3. Identify all of the hardscape features that have an SRI of at least 29 and sum the total area (R).

   SRI is calculated using the LEED Submittal Template by inserting both emissivity and reflectance values into the worksheet and pressing "Click to Calculate SRI". Emittance is calculated according to ASTM E 408 or ASTM C 1371 and Reflectance is calculated according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Alternatively, **Table 1** provides a list of SRI values for typical paving materials; where these materials are used, the SRI values from this table may be used in lieu of obtaining specific Emissivity and Reflectance measurements.
4. Identify all of the hardscape features that will be shaded by trees or other landscape features. Shade coverage shall be calculated at 10 a.m., 12 noon, and 3 p.m. on the summer solstice.

Table 1: Solar Reflectance Index (SRI) for Standard Paving Materials

Material	Emissivity	Reflectance	SRI
Typical New Gray Concrete	0.9	0.35	35
Typical Weathered* Gray Concrete	0.9	0.20	19
Typical New White Concrete	0.9	0.7	86
Typical Weathered* White Concrete	0.9	0.4	45
New Asphalt	0.9	.05	0
Weathered Asphalt	0.9	.10	6

*Reflectance of surfaces can be maintained with cleaning. Typical pressure washing of cementious materials can restore reflectance close to original value. Weathered values are based on no cleaning.

Equation 1

$Q = (O + R + S)$

Equation 2

$Q > T/2$

The arithmetic mean of these three values will be used as the effective shaded area. Calculate the effective shaded area (S).

5. Sum the open space paving, high reflectance paving and shaded areas to get the qualifying area (Q) (See **Equation 1**.)

   (Note that each surface should be counted only once. For example, a 10 square foot area that is 55% pervious, has an SRI of 30 and is shaded by a tree contributes only 10 square feet to the total.)

6. The total qualifying area must be greater than or equal to 50% of the total hardscape area (T), as in **Equation 2**.

Option 2

1. Calculate the total number of parking spaces for the project.
2. Calculate the number of parking spaces that are under cover (including underground, under the building, and under shade structures. This number must equal at least 50% of the total number of parking spaces.

Exemplary Performance

Projects may be awarded an innovation point for exemplary performance by demonstrating that either, 1) 100% of non-roof impervious surfaces have been constructed with high-albedo materials and/or open grid paving and/or will be shaded within five years; OR 2) 100% of the on-site parking spaces have been located under cover.

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 project site drawings, highlighting the location of specific paving materials, landscape shading, and/or underground or covered parking.

AND

Option 1

Provide the following data in the submittal template:

- ❑ The measured reflectance and emittance of each paving material installed on-site (to calculate the SRI—OR—the actual SRI for each paving material installed on-site—OR—the default SRI value for typical materials from **Table 1.**
- ❑ Total area of site hardscape
- ❑ Total area of hardscape to be shaded within 5 years

- ❑ Total area of installed SRI compliant hardscape materials
- ❑ Total area of open grid pavement

OR

Option 2

- ❑ Total number of parking spaces provided on-site
- ❑ Total number of covered parking spaces on-site

AND (For Either Compliance Option)

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.
- ❑ Confirm that the roof material covering (or shading) the parking has an SRI of at least 29.

Considerations

Environmental Issues

As the built environment grows and replaces natural settings, it also relinquishes associated ecological services. Vegetation cools the area surrounding it via shade and evapotranspiration. The use of dark, non-reflective surfaces for parking, roofs, walkways and other surfaces contributes to heat island effects created when radiation from the sun is absorbed and transferred through convection and conduction back to surrounding areas. As a result of heat island effects, ambient temperatures in urban areas can be artificially elevated by more than 10°F when compared with surrounding suburban and undeveloped areas. This results in increased cooling loads in the summer, requiring larger HVAC equipment and electrical demand resulting in more greenhouse gas and pollution generation, and increased energy consumption for building operations. Heat island effects can be mitigated through the application of shading and the use of materials that reflect the sun's heat instead of absorbing it.

Heat island effects are detrimental to site habitat, wildlife and migration corridors. Plants and animals are sensitive to higher temperatures and may not thrive in areas that are increasingly hot. Reduction of heat island effect minimizes disturbance of local microclimates. This can reduce summer cooling loads that in turn reduce energy use, greenhouse gas and pollution generation, and infrastructure requirements.

Higher reflectance pavements do increase overall light levels and may allow the designer to use fewer fixtures. Designers should weigh the benefits of using highly reflective pavements to reduce heat island effect against possible energy savings from reduced site lighting requirements. Lighting evaluations should include the evaluation of the inter-reflected component, and reflections off of high reflectance materials, such as white concrete, which can result in glare and cause disabled vision and increased light pollution. Steps should be taken to minimize the amount of light that is directed from site lighting fixtures directly down onto reflective paving surfaces.

Economic Issues

According to the EPA, about $40 billion is spent annually in the United States to air-condition buildings—one-sixth of all electricity generated in a year. Reduction in heat islands lowers the cost of cooling and HVAC equipment needs. Energy to cool buildings is a substantial cost over a building's lifetime. Higher initial costs may result from installation of additional trees and architectural shading devices. However, these items have an acceptable payback when integrated into a whole systems approach that maximizes energy savings.

Resources

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

Web Sites

American Concrete Pavement Association

www.pavement.com

(847) 966-2272

National association representing concrete pavement contractors, cement companies, equipment and material manufacturers, and suppliers. See the R&T Update #3.05, June 2002, "Albedo: A measure of Pavement Surface Reflectance" (http://www.pavement.com/Downloads/RT/RT3.05.pdf).

Heat Island Group

Lawrence Berkeley National Laboratory

http://eetd.lbl.gov/HeatIsland/

LBL conducts heat island research to find, analyze, and implement solutions to minimizing heat island effect, with current research efforts focusing on the study and development of more reflective surfaces for roadways and buildings.

Heat Island Effect

U.S. Environmental Protection Agency

www.epa.gov/heatisland

(202) 343-9343

Basic information about heat island effect, its social and environmental costs, and strategies to minimize its prevalence.

Definitions

Albedo is synonymous with solar reflectance.

Emissivity is the ratio of the radiation emitted by a surface to the radiation emitted by a black body at the same temperature.

Heat Island Effects occur when warmer temperatures are experienced in urban landscapes compared to adjacent rural areas as a result of solar energy retention on constructed surfaces. Principal surfaces that contribute to the heat island effect include streets, sidewalks, parking lots and buildings.

Infrared Emittance is a parameter between 0 and 1 that indicates the ability of a material to shed infrared radiation. The wavelength of this radiant energy is roughly 5 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum, and have an emittance of roughly 0.9. Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

Non-Roof Impervious Surfaces include all surfaces on the site with a perviousness of less than 50%, not including the roof of the building. Examples of typically impervious surfaces include parking lots, roads, sidewalks and plazas.

Open-Grid Pavement is defined for LEED purposes as pavement that is less than 50% impervious and contains vegetation in the open cells.

Perviousness is the percent of the surface area of a paving material that is open and allows moisture to pass through the material and soak into the earth below the paving system.

Solar Reflectance Index (SRI) is a measure of a material's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. For example, a standard black surface has a temperature rise of 90°F (50 °C) in full sun, and a standard white surface has a temperature rise of 14.6°F (8.1°C). Once the maximum temperature rise of a given material has been computed, the SRI can be computed by interpolating between the values for white and black.

Materials with the highest SRI values are the coolest choices for paving. Due to

the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can even exceed 100. (Lawrence Berkeley National Laboratory Cool Roofing Materials Database)

Underground Parking is a "tuck-under" or stacked parking structure that reduces the exposed parking surface area.

Heat Island Effect

Roof

1 Point

Intent

Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

Requirements

OPTION 1

Use roofing materials having a Solar Reflectance Index (SRI)[5] equal to or greater than the values in the table below for a minimum of 75% of the roof surface.

OR

OPTION 2

Install a vegetated roof for at least 50% of the roof area.

OR

OPTION 3

Install high albedo and vegetated roof surfaces that, in combination, meet the following criteria:

(Area of SRI Roof / 0.75) + (Area of Vegetated Roof / 0.5) >= Total Roof Area

Roof Type	Slope	SRI
Low-Sloped Roof	≤ 2:12	78
Steep-Sloped Roof	> 2:12	29

Potential Technologies & Strategies

Consider installing high-albedo and vegetated roofs to reduce heat absorption. SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

Summary of Referenced Standards

ASTM Standard E1980-01—Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces.

This standard describes how surface reflectivity and emissivity are combined to calculate a Solar Reflectance Index (SRI) for a roofing material or other surface. The standard also describes a laboratory and field testing protocol that can be used to determine SRI.

ASTM E408-71(1996)e1—Standard Test Methods for Total Normal Emittance of Surfaces Using Inspection-Meter Techniques

www.astm.org

(610) 832-9585

This standard describes how to measure total normal emittance of surfaces using a portable inspection-meter instrument. The test methods are intended for large surfaces where non-destructive testing is required. See the standard for testing steps and a discussion of thermal emittance theory.

ASTM E903-96—Standard Test Method for Solar Absorptance, Reflectance, and Transmittance of Materials Using Integrating Spheres

www.astm.org

(610) 832-9585

Referenced in the ENERGY STAR® roofing standard, this test method uses spectrophotometers and need only be applied for initial reflectance measurement. Methods of computing solar-weighted properties from the measured spectral values are specified. This test method is applicable to materials having both specular and diffuse optical properties. Except for transmitting sheet materials that are inhomogeneous, patterned, or corrugated, this test method is preferred over Test Method E1084. The ENERGY STAR roofing standard also allows the use of reflectometers to measure solar reflectance of roofing materials. See the roofing standard for more details.

ASTM E1918-97—Standard Test Method for Measuring Solar Reflectance of Horizontal And Low-Sloped Surfaces in the Field

www.astm.org

(610) 832-9585

This test method covers the measurements of solar reflectance of various horizontal and low-sloped surfaces and materials in the field, using a pyranometer. The test method is intended for use when the sun angle to the normal from a surface is less than 45 degrees.

ASTM C1371-04—Standard Test Method for Determination of Emittance of Materials Near Room Temperature Using Portable Emissometers

www.astm.org

(610) 832-9585

This test method covers a technique for determination of the emittance of typical materials using a portable differential thermopile emissometer. The purpose of the test method is to provide a comparative means of quantifying the emittance of opaque, highly thermally conductive materials near room temperature as a parameter in evaluating temperatures, heat flow, and derived thermal resistances of materials.

ASTM C1549-04—Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer

www.astm.org

(610) 832-9585

This test method covers a technique for determining the solar reflectance of flat opaque materials in a laboratory or in the field using a commercial portable solar

reflectometer. The purpose of the test method is to provide solar reflectance data required to evaluate temperature and heat flows across surfaces exposed to solar radiation.

Approach and Implementation

To maximize energy savings and minimize heat island effects, materials must exhibit a high reflectivity and a high emissivity over the life of the product. Since multiple testing methods are available for measuring emissivity and reflectance, check manufacturer literature carefully to ensure use of appropriate data. For example, some manufacturers measure visible reflectance, which differs from the solar reflectance measurement referenced in this credit. Visible reflectance correlates to solar reflectance but the two quantities are not equal because solar gain covers a wider range of wavelengths than visible light. A material that exhibits a high visible reflectance usually has a lower solar reflectance. Typically, white roof products exhibit higher performance characteristics than non-white products. Performance varies by roofing materials as well as brand. Check with roofing manufacturers and the Lawrence Berkeley National Laboratory's Cool Roofing Materials Database (http://eetd.lbl.gov/CoolRoofs) for specific information. Table 1 provides example SRI values for typical roof surfaces. These values are for reference only and are not for use as substitutes for actual manufacturer data. Individual products may perform better. Reflectance and emittance data for manufacturers are available from the Cool Roof Rating Council Web site, www.coolroofs.org. Note that the infrared emittance of aggregates and cementitious materials is always 0.9.

Green roofs are vegetated surfaces that reduce heat island effect by replacing heat-absorbing surfaces with plants, shrubs and small trees that cool the air through evapotranspiration (or evaporation of water from leaves). Green roofs provide insulating benefits, aesthetic appeal, and lower maintenance than standard roofs. Some green roofs require plant maintenance and are considered active gardens, while other gardens have grasses and plants that require no maintenance or watering. All types of green roofs require

Table 1: Solar Reflectance Index (SRI) for Typical Roofing Materials

Example SRI Values for Generic Roofing Materials	Solar Reflectance	Infrared Emittance	Temperature Rise	Solar Reflectance Index (SRI)
Gray EPDM	0.23	0.87	68F	21
Gray Asphalt Shingle	0.22	0.91	67F	22
Unpainted Cement Tile	0.25	0.9	65F	25
White Granular Surface Bitumen	0.26	0.92	63F	28
Red Clay Tile	0.33	0.9	58F	36
Light Gravel on Built-Up Roof	0.34	0.9	57F	37
Aluminum Coating	0.61	0.25	48F	50
White-Coated Gravel on Built-Up Roof	0.65	0.9	28F	79
White Coating on Metal Roof	0.67	0.85	28F	82
White EPDM	0.69	0.87	25F	84
White Cement Tile	0.73	0.9	21F	90
White Coating - 1 Coat, 8 mils	0.8	0.91	14F	100
PVC White	0.83	0.92	11F	104
White Coating - 2 Coats, 20 mils	0.85	0.91	9F	107

Source: LBNL Cool Roofing Materials Database. These values are for reference only and are not for use as substitutes for actual manufacturer data. Individual products may perform better.

semiannual inspection but have longer lifetimes than conventional roofs.

Calculations

1. Calculate the total roof surface area of the project. Deduct areas with equipment, solar energy panels, and appurtenances.
2. Determine the roof surface area that meets the applicable SRI criteria and/or the area that is covered by green roof.
3. Determine whether the areas of cool roof and green roof meet the credit requirement, using **Equation 1**.

   Note: a weighted average calculation may be performed for buildings with multiple roof surfaces to demonstrate that the total roof area has an average SRI that meets the credit requirements.

Exemplary Performance

This credit may be eligible for exemplary performance under the Innovation & Design section if 100% of the project's roof area (excluding mechanical equipment, photovoltaic panels, and skylights) is comprised of a green roof system.

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:

- ❑ Provide copies of the project's roof drawings to highlight the location of specific roof materials and/or green roof systems.

AND

Option 1

- ❑ Total area of installed SRI compliant roofing materials
- ❑ Provide a listing of installed roofing materials and their SRI values

OR

Option 2

- ❑ Total area of installed green roof systems

OR

Option 3

- ❑ Total area of installed green roof systems
- ❑ Total area of installed SRI compliant roofing materials
- ❑ Provide a listing of installed roofing materials and their SRI values

AND

- ❑ Provide an optional narrative to describe any special circumstances or non-standard compliance paths taken by the project.

Considerations

Environmental Issues

The heat island effect raises the localized temperature, impacting local microclimate. Plants and animals that are sensitive to large fluctuations in daytime and nighttime temperatures may not thrive in areas affected by heat islands. Heat islands also exacerbate air pollution for two reasons. First, smog is produced faster at higher temperatures. Secondly, rising temperatures lead to increased cooling requirements, requiring energy and causing associated emissions.

Equation 1

(Area of SRI Roof / 0.75) + (Area of vegetated roof / 0.5) >= Total Roof Area

Garden roofs reduce stormwater volumes that may be collected and used for nonpotable purposes. Stormwater runoff volumes from garden roofs depend on the local climate, depth of soil, plant types, and other variables. However, all garden roofs decrease runoff volumes substantially.

Economic Issues

Green roofs or roofs with high Solar Reflectance Indexes reduce costs associated with cooling and HVAC equipment. Green roofs typically require an additional up-front investment, while cool roofs may or may not cost more than other roofs. However, any up-front investment is likely to result in energy cost savings throughout the lifecycle of the project. In addition, an increasing number of localities are beginning to require the use of cool roofs on new building projects.

Buildings in very cold climates may not experience year-round energy benefits from reflective roofing due to high emittance and low absorption, which may increase heating costs. However, increasing the reflectance of a roof reduces annual cooling energy use in almost all climates.

Resources

Web Sites

Cool Roof Rating Council

www.coolroofs.org

A nonprofit organization dedicated to implementing and communicating fair, accurate, and credible radiative energy performance rating systems for roof surfaces, supporting research into energy-related radiative properties of roofing surfaces, including durability of those properties, and providing education and objective support to parties interested in understanding and comparing various roofing options.

EPA ENERGY STAR® Roofing Products

www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products

This site provides solar reflectance levels required to meet ENERGY STAR labeling requirements.

Extensive Green Roofs

http://www.wbdg.org/design/greenroofs.php

This Whole Building Design Guide article by Charlie Miller, PE details the features and benefits of constructing green roofs.

Greenroofs.com

www.greenroofs.com

The green roof industry resource portal offers basic information, product and service directory, and research links.

Lawrence Berkeley National Laboratory Heat Island Group–Cool Roofs

http://eetd.lbl.gov/HeatIsland/CoolRoofs/

This site offers a wealth of information about cool roof research and technology, including links to the Cool Roofing Materials Database.

Penn State Center for Green Roof Research

http://hortweb.cas.psu.edu/research/greenroofcenter/

The Center has the mission of demonstrating and promoting green roof research, education and technology transfer in the Northeastern United States.

Definitions

Albedo is synonymous with solar reflectance.

Heat Island Effects occur when warmer temperatures are experienced in urban landscapes compared to adjacent rural areas as a result of solar energy retention on constructed surfaces. Principal surfaces

that contribute to the heat island effect include streets, sidewalks, parking lots and buildings.

Infrared or Thermal Emittance is a parameter between 0 and 1 (or 0% and 100%) that indicates the ability of a material to shed infrared radiation (heat). The wavelength range for this radiant energy is roughly 3 to 40 micrometers. Most building materials (including glass) are opaque in this part of the spectrum, and have an emittance of roughly 0.9. Materials such as clean, bare metals are the most important exceptions to the 0.9 rule. Thus clean, untarnished galvanized steel has low emittance, and aluminum roof coatings have intermediate emittance levels.

Solar Reflectance (albedo) is the ratio of the reflected solar energy to the incoming solar energy over wavelengths of approximately 0.3 to 2.5 micrometers. A reflectance of 100% means that all of the energy striking a reflecting surface is reflected back into the atmosphere and none of the energy is absorbed by the surface. The best standard technique for its determination uses spectro-photometric measurements with an integrating sphere to determine the reflectance at each different wavelength. An averaging process using a standard solar spectrum then determines the average reflectance (see ASTM Standard E903).

Solar Reflectance Index (SRI) is a measure of a material's ability to reject solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. For example, a standard black surface has a temperature rise of 90°F (50°C) in full sun, and a standard white surface has a temperature rise of 14.6°F (8.1°C). Once the maximum temperature rise of a given material has been computed, the SRI can be computed by interpolating between the values for white and black.

Materials with the highest SRI values are the coolest choices for roofing. Due to the way SRI is defined, particularly hot materials can even take slightly negative values, and particularly cool materials can even exceed 100. (Lawrence Berkeley National Laboratory Cool Roofing Materials Database)

Light Pollution Reduction

SS WE EA MR EQ ID

Credit 8

1 Point

Intent

Minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction, and reduce development impact on nocturnal environments.

Requirements

FOR INTERIOR LIGHTING

The angle of maximum candela from each interior luminaire as located in the building shall intersect opaque building interior surfaces and not exit out through the windows.

OR

All non-emergency interior lighting shall be automatically controlled to turn off during non-business hours. Provide manual override capability for after hours use.

AND

FOR EXTERIOR LIGHTING

Only light areas as required for safety and comfort. Do not exceed 80% of the lighting power densities for exterior areas and 50% for building facades and landscape features as defined in ASHRAE/IESNA Standard 90.1-2004, Exterior Lighting Section, without amendments.

All projects shall be classified under one of the following zones, as defined in IESNA RP-33, and shall follow all of the requirements for that specific zone:

LZ1 — Dark (Park and Rural Settings)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.01 horizontal and vertical footcandles at the site boundary and beyond. Document that 0% of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ2 — Low (Residential Areas)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.10 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 10 feet beyond the site boundary. Document that no more than 2% of the total initial designed fixture lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

LZ3 — Medium (Commercial/Industrial, High-Density Residential)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.20 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site. Document that no more than 5% of the total initial designed fixture

lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

LZ4 — High (Major City Centers, Entertainment Districts)

Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.60 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site. Document that no more than 10% of the total initial designed site lumens are emitted at an angle of 90 degrees or higher from nadir (straight down). For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

Potential Technologies & Strategies

Adopt site lighting criteria to maintain safe light levels while avoiding off-site lighting and night sky pollution. Minimize site lighting where possible and model the site lighting using a computer model. Technologies to reduce light pollution include full cutoff luminaires, low-reflectance surfaces and low-angle spotlights.

Summary of Referenced Standard

ASHRAE/IESNA Standard 90.1-2004, Energy Standard for Buildings Except Low-Rise Residential - Lighting, Section 9 (without amendments)

American Society of Heating Refrigeration 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, multifamily 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. The standard provides criteria in the following general categories: building envelope (section 5); heating, ventilating and air-conditioning (section 6); service water heating (section 7); power (section 8); lighting (section 9); and other equipment (section 10). 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. However, in all cases, the mandatory provisions must still be met.

Section 9 of the Standard provides requirements for the lighting of buildings. Only the exterior lighting requirements (exterior site lighting & exterior building feature/façade lighting) apply to this credit. Table 1 lists the ASHRAE 90.1-2004 allowable building exterior lighting power densities.

Approach and Implementation

The credit is comprised of three main compliance requirements that deal with light pollution through the control of; 1) interior building lighting; 2) exterior lighting power density; and 3) exterior light distribution.

Interior Building Lighting

Option 1

Design interior lighting to maintain the majority of direct beam illumination within the building. To accomplish this, project teams should strive to locate interior lighting fixtures in such a way that the direct beam illumination produced by the interior luminaires intersects solid/opaque building surfaces, preventing light spill through transparent and translucent surfaces to exterior areas. Manufacturer's candela plots or photometric data should be used to determine the direction of maximum luminous intensity for each fixture type. Overlay the data for each fixture type on building plans and sections to confirm that the maximum candela angle does not intersect transparent or translucent building surfaces that face exterior areas.

Option 2

An alternate compliance path requires that all non-emergency interior lighting fixtures be automatically controlled and programmed to turn off following regular business hours. Controls may be automatic sweep timers, occupancy sensors, or programmed master lighting control panels.

Table 1: ASHRAE 90.1-2004 Lighting Power Densities for Building Exteriors (Table 9.4.5)

	Applications	Lighting Power Densities
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**Uncovered Parking Areas**	
	Parking Lots and drives	0.15W/ft2
	Building Grounds	
	Walkways less than 10 feet wide	1.0W/linear foot
	Walkways 10 feet wide or greater Plaza areas Special Feature Areas	0.2W/ft2
	Stairways	1.0W/ft2
	Building Entrances and Exits	
	Main entries	30W/linear foot of door width
	Other doors	20W/linear foot of door width
	Canopies and Overhangs	
	Canopies (free standing and attached and overhangs)	1.25W/ft2
	Outdoor Sales	
	Open areas (including vehicle sales lots)	.05W/ft2
	Street frontage for vehicle sales lots in addition to "open area" allowance	20W/linear foot
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	**Building Facades**	0.2W/ft2 for each illuminated wall or surface or 5.0W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270W per location plus 90W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	1.25W/ft2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5W/ft2 of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Drive-up windows at fast food restaurants	400W per drive-through
	Parking near 24-hour retail entrances	800W per main entry

Manual override capabilities that enable lights to be turned on for after-hours use must be included in the design.

Exterior Lighting Power Density

Design the project's exterior lighting to achieve lighting power densities that are less than the requirements set forth in ASHRAE 90.1-2004, Section 9, Table 9.4.5. Lighting for exterior areas, such as parking lots, building grounds and plazas, should be designed to achieve an overall lighting power density that is 20% below the referenced standard. Building façade and landscape feature lighting should be designed to achieve an overall

lighting power density that is 50% below the referenced standard. Projects should consider selecting efficient fixtures using efficacious sources to reduce lighting power and illumination intensity.

Exterior Light Distribution

Design the project's exterior lighting to comply with the light pollution requirements for the specific project zone. The lighting requirements address the overall site illumination level and the luminaire distribution. The exterior lighting must meet the light distribution requirements under pre-curfew conditions (prior to 10 p.m. or business closing). Curfew timers and controls can be effective components of the overall lighting strategy, and may be used to mitigate a specific, extenuating circumstances; but controls cannot be used to make otherwise non-compliant exterior areas comply with the credit.

Projects should consider the use of low intensity, shielded fixtures as well as curfew controllers to turn off non-essential site lighting after 10:00 p.m. or immediately after closing (whichever is later) to further reduce the effects of light pollution. Projects should minimize the lighting of architectural and landscape features. Where lighting is required for safety, security, egress or identification, utilize down-lighting techniques rather than up-lighting.

For example, in environments that are primarily dark (Zone LZ1), no landscape features should be illuminated, and architectural lighting should be designed only as a last resort when other strategies cannot provide the minimum amount of required lighting. In areas of high ambient brightness (Zones LZ3 & 4), some low level (subtle) lighting of features, facades or landscape areas may be appropriate in pedestrian environments or for identification and way finding in other areas where light trespass is not likely to be an issue. However, even in areas of high ambient brightness, all non-essential lighting, including landscape and architectural lighting, should be minimized or turned off after hours. If shielded, low brightness sources are used to selectively light features, they should be properly aimed so that light from the luminaires cannot be measured across project boundaries. In all cases, controls should be used wherever possible to turn off non-essential lighting after normal operating hours or in post-curfew periods. Consider at least the following strategies when designing the exterior lighted environment:

1. Employ a lighting professional to assess the project's lighting needs and provide recommendations based specifically on lighting for a sustainable design environment.
2. Carefully review and respond to any applicable lighting ordinances or by-laws that might impact the lighting design for the project site.
3. Determine the type of environmental zone that the project falls under from Wilderness Area (Zone LZ1) to High-Population City Centers (Zone LZ4). Understand the design implications of the environmental zone that best fits the project and study neighboring areas to identify potential light trespass problems.
4. Use the least amount of lighting equipment possible to achieve the goals of the project, but balance the quantity of equipment used with the need to provide for glare control and uniform lighting. In most cases, it is better to have two luminaires with lower light output and good glare control than one higher output luminaire.
5. Select all lighting equipment carefully. Any type of luminaire, whether it is full cut-off, semi-cutoff or non-cutoff, can produce excessive brightness in the form of glare. For example, horizontal lamp positions in full cutoff luminaires tend to produce much less glare than vertical lamps. Selecting high-perfor-

mance equipment of good quality is not only essential in maintaining visual quality and providing sustainable lighting, but also will quickly pay for itself in reduced maintenance costs.

6. Design exterior lighting to produce minimal upward illumination from reflected light sources. Select luminaire locations carefully to control glare and contain light within the design area. Pay special attention to luminaires that are located near the property line to ensure that minimal measurable light from these luminaires crosses the project boundary.
7. Use the minimum amount of light necessary and only light areas that require it. Design and develop a control scheme to minimize, or turn lighting off, after hours or during post-curfew periods.
8. Create a computer model of the proposed electric lighting design and simulate system performance. Use this tool to provide point by point horizontal illuminance information or an iso-footcandle contour map demonstrating that illuminance values are as required at the project boundary. Where luminaires are within 2.5 times their mounting height from the project boundary and the light levels are not zero at the boundary, light trespass is more likely to be a problem.
9. After the lighting system is constructed, it should be commissioned to ensure that it is installed and operating properly. Maintenance should be performed on the system on a regular basis to ensure that it continues to operate correctly, and that light pollution is minimized.

Calculations

Interior Building Lighting

The direction of maximum luminous intensity can be determined from the photometric data published by the manufacturer. For example, in **Table 2**, the maximum intensity of 869 candela occurs at a horizontal angle of 45 degrees and a vertical angle of 5 degrees.

Table 2: Sample Fixture Candela Table

Angle	0	22.5	45	67.5	90
0	862	862	862	862	862
5	848	847	869	860	862
10	838	837	858	848	850
15	814	815	845	840	844
20	785	790	819	818	824
25	747	754	785	786	792
30	693	704	738	751	759
35	636	652	695	712	723
40	566	589	642	669	682
45	492	524	586	622	636
50	409	454	525	566	580
55	331	385	465	509	523
60	257	315	398	439	438
65	189	247	328	327	323
70	135	188	235	224	210
75	85	127	142	119	106
80	44	64	61	40	33
85	15	15	11	13	13
90	0	0	0	0	0

This direction is then traced from each luminaire position (where this fixture type is used) to determine if this particular light ray will directly reach any exterior areas.

Exterior Lighting Power Density

Calculate the lighting power density (LPD) for the project's exterior lighting fixtures using the fixture wattage (lamp & ballast) provided by the manufacturer. Separate the exterior fixtures into two categories: 1) Exterior Areas—includes parking, walkway, plaza, and other outdoor area lighting; and 2) Facades/Landscape Areas—includes any vertical surface illumination (façade/signage) and any accent or landscape lighting. **Calculation 1** provides an example of the calculation methodology.

After calculating the LPDs for the project, determine if the lighting design complies with the requirements for LPD reduction.

Exterior Light Trespass

In order to measure compliance with the light trespass requirements, projects should utilize lighting design software to develop a site illumination model. The model should show the full extents of the site and all installed exterior lighting fixtures. A horizontal calculation grid should be set up to measure the site illumination at the ground plane and vertical calculation grid should be set at the property boundary and at the extents of the LZ requirements (10 feet beyond the site boundary for LZ2 and 15 feet beyond the site boundary for LZ3/LZ4) to measure vertical illumination. The calculation grid spacing should be a maximum of 10' x 10' and should exclude building interior areas. Additionally, teams should utilize the model to determine maximum and minimum illumination levels and the overall site uniformity (max/min ratio).

Utilizing manufacturers' fixture data, determine the initial lamp lumens for each luminaire. Additionally, from photometric data, determine the number of initial lamp lumens that are emitted at or above 90 degrees from nadir. Enter this data into **Table 3** to determine the percentage of lumens at or above 90 degrees. This number must be less than or equal to the value referenced for the selected site LZ.

Calculation 1: Sample Exterior Lighting Power Density Calculation

Site Lighting Power Density Calculation						
Site Lighting Fixture	**Fixture Power (Watts)**	**Total Fixtures (Qty)**	**Total Fixture Power (Watts)**	**Site Location**	**Site Area (SF)**	**LPD (W/SF)**
Pole Fixture 1	250	14	3,500	Parking 1	32,000	0.11
Pole Fixture 1	250	8	2,000	Parking 2	18,000	0.11
Pole Fixture 2	115	1	115	Walkways 1	875	0.13
Bollard Fixture 1	40	4	160	Walkways 1	875	0.18
Bollard Fixture 1	40	6	240	Courtyard 1	1,500	0.16
Wall Washer 1	50	5	250	Building Facade N	2,500	0.10
Site Areas						
Identification	**Area (SF)**	**ASHRAE 90.1.2004 Allowable LPD (W/SF)**	**Actual LPD (From Site Lighting Table)**	**Actual LPD Reduction (%)**	**Required LPD Reduction (%)**	**Complies (Yes/No)**
Parking 1	32,000	0.25	0.11	27%	20%	YES
Parking 2	18,000	0.15	0.11	26%	20%	YES
Walkways 1 (10' wide)	875	0.2	0.16	21%	20%	YES
Courtyard 1	1,500	0.2	0.16	20%	20%	YES
Building Facade N	2,500	0.2	0.10	50%	50%	YES

Table 3: Lamp Lumen Calculation

Luminaire Type	Quantity of Installed Luminaires	Initial Fixture Lumens per Luminaire	Total Fixture Lumens (column 2 x column 3)	Initial Fixture Lumens from Luminaire above 90 Degrees (from nadir-straight down)	Total Fixture Lumens above 90 Degrees (column 2 x column 5)
A	10	4,600	46,000	100	1,000
B	20	11,900	238,000	0	0
C	5	2,000	10,000	2,000	10,000
Total			**294,000**		**11,000**

Note: luminaires without photometric distribution shall be assumed to have 100% of its initial lamp lumens at or above 90 degrees. Luminaires with limited adjustability shall be assumed to have maximum tilt applied and lumens at or above 90 degrees shall be calculated from maximum tilted orientation. Luminaires with full range of adjustability (those that can be aimed above 90 degrees from nadir) shall be assumed to have 100% of the emitted fixture lumens at or above 90 degrees.

Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation & Design section.

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:

- ❑ Provide copies of the project lighting drawings (interior and site) to document the location and type of fixtures installed. Interior drawings should clearly show exterior building surfaces to confirm that the maximum candela from interior fixtures does not intersect transparent or translucent building surfaces.
- ❑ Provide confirmation that the interior lighting design has been evaluated to ensure that the maximum candela from each interior luminaire intersects opaque interior surfaces and does not exit through windows, OR, that automatic controls have been installed to turn off interior lighting during non-occupied hours.

AND

For Projects With No Exterior Lighting

- ❑ Confirm that no exterior lighting has been installed.

For Projects With Exterior Lighting

- ❑ Complete the Lighting Power Density tables on the Submittal Template for both exterior site lighting and façade/landscape lighting. The following data will be required to complete the template: location and ID of each installed exterior luminaire; site area (sq.ft.) to be illuminated by the luminaire(s); installed LPD; and ASHRAE-allowable LPD.
- ❑ Confirm the site zone classification for the project.
- ❑ Complete the Site Lumen Calculation on the submittal template. The following data will be required to complete the template: luminaire type/ID; quantity installed; initial lamp lumens per luminaire; initial lamp lumens above 90 degrees from nadir.

AND

- ❑ Provide a narrative that includes specific information regarding the light trespass analysis conducted to determine compliance. Please provide any additional comments or notes regarding special circumstances or considerations regarding the project's credit approach.

Considerations

Environmental Issues

Outdoor lighting is necessary for illuminating connections between buildings and support facilities such as sidewalks, parking lots, roadways and community gathering places. However, light trespass from poorly designed outdoor lighting systems can affect the nocturnal ecosystem on the site, and light pollution limits night sky access. Through thoughtful design and careful maintenance, outdoor lighting can address night sky visibility issues and site illumination requirements, while minimizing the negative impact on the environment.

Sensitively designed outdoor lighting can extend access and use of many areas into the nighttime hours. We can gain a unique appreciation for a place at night because of sensitively and creatively designed lighting systems. But any time lighting is added to an exterior environment, the potential of light pollution exists. Even with the best full cutoff luminaires and the lowest wattage lamp packages, the added light will be reflected off surfaces and into the atmosphere. Using the minimum amount of lighting equipment, limiting or eliminating all landscape lighting, and avoiding light pollution through the careful selection of lighting equipment and controls allows nocturnal life to thrive while still providing for nighttime activity.

Economic Issues

Carefully designed exterior lighting solutions can reduce infrastructure costs and energy use when compared to common practice solutions. Energy and maintenance savings over the lifetime of the project can be substantial.

Community Issues

Minimizing light pollution allows for night sky access by the surrounding community. Another key benefit is better visual comfort and improved visibility. Sensitively designed lighting systems that minimize glare and provide more uniform light at lower levels will help create aesthetically pleasing environments that are safer and more secure. A carefully designed and maintained outdoor lighting system can help a project be a non-intrusive member of the community.

Resources

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

Web Sites

American Society of Heating Refrigeration and Air-Conditioning Engineers

www.ashrae.org

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

Illuminating Engineering Society of North America

www.iesna.org

This organization provides general exterior lighting design guidance and acts as a link to other IESNA outdoor lighting

California Energy Commission (CEC) - 2005 California Energy Efficiency Building Standards – Lighting Zones

www.energy.ca.gov/title24/2005standards/outdoor_lighting/2004-09-30_LIGHTING_ZONES.PDF

Provides a description of the outdoor lighting zones developed for use in the 2005 California Energy Efficiency Building Standards (Title 24).

International Dark-Sky Association

www.darksky.org/ida/ida_2/index.html

A nonprofit agency dedicated to educating and providing solutions to light pollution.

New England Light Pollution Advisory Group

http://cfa-www.harvard.edu/cfa/ps/nelpag.html

A volunteer group to educate the public on the virtues of efficient, glare-free outdoor night lighting as well as the benefits of no lighting for many outdoor applications.

Sky &Telescope

http://skytonight.com/resources/darksky

Includes facts on light pollution and its impact on astronomy, and information about purchasing light fixtures that minimize light pollution.

Print Media

Concepts in Practice Lighting: Lighting Design in Architecture by Torquil Barker, B.T. Batsford Ltd., 1997.

The Design of Lighting by Peter Tregenza and David Loe, E & FN Spon, 1998.

Definitions

Angle of Maximum Candela is the direction in which the luminaire emits the greatest luminous intensity.

Curfew Hours are locally determined times when greater lighting restrictions are imposed. When no local or regional restrictions are in place, 10:00 p.m. is regarded as a default curfew time.

Footcandle (fc) is a unit of illuminance and is equal to one lumen of light falling on a one-square foot area from a one candela light source at a distance of one foot.

Light Pollution is waste light from building sites that produces glare, is directed upward to the sky or is directed off the site.

Outdoor Lighting Zone Definitions (Developed by IDA for the Model Lighting Ordinance) provide a general description of the site environment/context and basic site lighting criteria.

Outdoor Lighting Zone Definitions

Zone	Ambient Illumination	Criteria
LZ1	Dark	For population densities of less than 200 people per square mile, according the last U.S. census. Also for developed areas in state and national parks, areas near astronomical observatories, zoos, and ANY area where residents have expressed a desire to maintain a natural nighttime environment.
LZ2	Low	For population densities of 200-3,000 people per square mile, according the last U.S. census. This would include most areas zoned "residential" and is the default zone for residential areas.
LZ3	Medium	For population densities greater than 3,000 people per square mile, according the last U.S. Census. This lighting zone is intended for high density urban neighborhoods, shopping and commercial districts and industrial parks. This is the default zone for commercial and industrial areas.
LZ4	High	This is for major city centers (with population densities greater than 100,000, according to the last U.S. Census), thematic attractions, entertainment districts and major auto sale districts.

Endnotes

[1] In the United States, there are three distinct climates that influence the nature and amount of rainfall occurring on an annual basis. Humid watersheds are defined as those that receive at least 40 inches of rainfall each year, Semi-arid watersheds receive between 20 and 40 inches of rainfall per year, and Arid watersheds receive less than 20 inches of rainfall per year. For this credit, 90% of the average annual rainfall is equivalent to treating the runoff from:

(a) Humid Watersheds – 1 inch of rainfall;

(b) Semi-arid Watersheds – 0.75 inches of rainfall; and

(c) Arid Watersheds – 0.5 inches of rainfall.

[2] The Solar Reflectance Index (SRI) is a measure of the constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. To calculate the SRI for a given material, obtain the reflectance value and emittance value for the material. SRI is calculated according to ASTM E 1980-01. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

[3] The Solar Reflectance Index (SRI) is a measure of the constructed surface's ability to reflect solar heat, as shown by a small temperature rise. It is defined so that a standard black (reflectance 0.05, emittance 0.90) is 0 and a standard white (reflectance 0.80, emittance 0.90) is 100. To calculate the SRI for a given material, obtain the reflectance value and emittance value for the material. SRI is calculated according to ASTM E 1980. Reflectance is measured according to ASTM E 903, ASTM E 1918, or ASTM C 1549. Emittance is measured according to ASTM E 408 or ASTM C 1371.

Water Efficiency

In the United States, approximately 340 billion gallons of fresh water are withdrawn per day from rivers, streams and reservoirs to support residential, commercial, industrial, agricultural and recreational activities. This accounts for about one-fourth of the nation's total supply of renewable fresh water. Almost 65% of this water is discharged to rivers, streams and other water bodies after use and, in some cases, treatment.

Additionally, water is withdrawn from underground aquifers. In some parts of the United States, water levels in these aquifers have dropped more than 100 feet since the 1940s. On an annual basis, the water deficit in the United States is currently estimated at about 3,700 billion gallons. In other words, Americans extract 3,700 billion gallons per year more than they return to the natural water system to recharge aquifers and other water sources.

On a positive note, U.S. industries today use 36% less water than they did in 1950 although industrial output has increased significantly. This reduction in water use is largely due to the rigorous water reuse strategies in industrial processes. In addition, the Energy Policy Act of 1992 mandated the use of water-conserving plumbing fixtures to reduce water use in residential, commercial and institutional buildings.

Using large volumes of water increases maintenance and lifecycle costs for building operations and increases consumer costs for additional municipal supply and treatment facilities. Conversely, facilities that use water efficiently can reduce costs through lower water use fees, lower sewage volumes to treat energy and chemical use reductions, and lower capacity charges and limits. Many water conservation strategies involve either no additional cost or rapid paybacks. Other water conservation strategies such as biological wastewater treatment, rainwater harvesting and graywater plumbing systems often involve more substantial investment.

Water efficiency measures in commercial buildings can easily reduce water usage by 30% or more. In a typical 100,000-square-foot office building, low-flow fixtures coupled with sensors and automatic controls can save a minimum of 1 million gallons of water per year, based on 650 building occupants each using an average of 20 gallons per day. Non-potable water volumes can be used for landscape irrigation, toilet and urinal flushing, custodial purposes and building systems. Utility savings, though dependent on the local water costs, can save thousands of dollars per year, resulting in rapid payback on water conservation infrastructure.

Water Efficiency Credit Characteristics

Table 1 shows which credits were substantially revised for LEED for New Construction 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

WE Credit 1.1
Water Efficient Landscaping—Reduce by 50%

WE Credit 1.2
Water Efficient Landscaping—No Potable Water Use or No Irrigation

WE Credit 2
Innovative Wastewater Technologies

WE Credit 3.1
Water Use Reduction —20%

WE Credit 3.2
Water Use Reduction —30%

Table 1: WE Credit Characteristics

Credit	Significant Change from Version 2.1	Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
WEc1.1: Water Efficient Landscaping: Reduce by 50%	*	*			*	
WEc1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation		*		*	*	
WEc2: Innovative Wastewater Technologies		*			*	
WEc3.1: Water Use Reduction: 20%		*			*	
WEc3.2: Water Use Reduction: 30%		*			*	

SS | WE | EA | MR | EQ | ID

Credit 1.1

1 Point

Water Efficient Landscaping

Reduce by 50%

Intent

Limit or eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation.

Requirements

Reduce potable water consumption for irrigation by 50% from a calculated mid-summer baseline case.

Reductions shall be attributed to any combination of the following items:

- ❑ Plant species factor
- ❑ Irrigation efficiency
- ❑ Use of captured rainwater
- ❑ Use of recycled wastewater
- ❑ Use of water treated and conveyed by a public agency specifically for non-potable uses

Potential Technologies & Strategies

Perform a soil/climate analysis to determine appropriate plant material and design the landscape with native or adapted plants to reduce or eliminate irrigation requirements. Where irrigation is required, use high-efficiency equipment and/or climate-based controllers.

SS | WE | EA | MR | EQ | ID

Credit 1.2

1 Point
in addition to
WE Credit 1.1

Water Efficient Landscaping

No Potable Water Use or No Irrigation

Intent

Eliminate the use of potable water, or other natural surface or subsurface water resources available on or near the project site, for landscape irrigation.

Requirements

Achieve WE Credit 1.1 and:

Use only captured rainwater, recycled wastewater, recycled graywater, or water treated and conveyed by a public agency specifically for non-potable uses for irrigation.

OR

Install landscaping that does not require permanent irrigation systems. Temporary irrigation systems used for plant establishment are allowed only if removed within one year of installation.

Potential Technologies & Strategies

Perform a soil/climate analysis to determine appropriate landscape types and design the landscape with indigenous plants to reduce or eliminate irrigation requirements. Consider using stormwater, graywater, and/or condensate water for irrigation.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Design landscaping with climate-tolerant plants that can survive on natural rainfall quantities after initial establishment. Contour the land to direct rainwater runoff through the site to give vegetation an additional water supply. Minimize the amount of site area covered with turf, and use techniques such as mulching, alternative mowing and composting to maintain plant health. These practices conserve water and help foster optimal soil conditions.

Recommended design principals

1. Planning and Design
   - Develop a site map showing existing or planned structures, topography, orientation, sun and wind exposure, use of space and existing vegetation.
   - Perform shadow profiles of landscape areas for each season, based on middle of the day conditions and illustrate the plant selection within the profiles.
   - Reduce heat island effect by providing adequate shade from trees and buildings; plant hard wood trees to increase shade canopy as necessary.
   - Plan water use zones:

     High – regular watering

     Moderate – occasional watering

     Low – natural rain fall
2. Practical turf areas

   Plant turf grasses only for functional benefits such as recreational areas, pedestrian use, or specifically for soil conservation.
3. Soil analysis and preparation
   - Analyze soil in each zone.
   - Amend soil accordingly.
4. Appropriate use of plant materials
   - Choose plants that will easily adapt to the site.

     A. Consider the mature size and form when choosing plant material for the location and intended purpose.

     B. Consider growth rate.

     C. Determine that texture and color combine with surrounding plantings and building background.

     D. Use no mono-species or excessive multi-species selections.

     E. Diversify species to prevent elimination of a species from diseases or pestinfestation.
5. Effective and efficient watering practices
   - Regularly check irrigation systems for efficient and effective operation; verify watering schedules and duration on a monthly basis.
   - Use drip, micro misters, and subsurface irrigation systems where applicable, and smart irrigation controllers throughout. Provide computer interface for monitoring and schedule modifications from a central location.
   - No irrigation of plants and turf in the months of November to April.
   - No irrigation of shrubs from September to June.
6. Use of mulch on trees, shrubs and flower beds
   - Keep landscape areas mulched to conserve moisture and preventing evaporative water loss from the soil surface to reduce the need for

supplemental irrigation during periods of limited rainfall.

A number of factors, including owner preference, event uses, and maintenance expertise, may also impact plant selection, but the intent of this credit is to create a landscape that maximizes the use of on-site natural resources to limit or eliminate the use of potable water for irrigation. This goal can be achieved by selecting native or adapted plants that require little or no irrigation after initial establishment. This goal also can be achieved by using high-efficiency irrigation equipment, captured rainwater, recycled graywater or treated wastewater to reduce the consumption of potable water. Often times, it is appropriate to use a combination of these strategies to first reduce potable water demand and then meet the irrigation demand in the most sustainable manner.

The use of native or adapted plants is an excellent approach because water conservation is built-in and is not reliant on high-tech equipment and controls. In some climates, it is possible to eliminate the need for permanent irrigation with this strategy. In other climates, irrigation requirements can be cut by 50% or greater compared to conventional building landscapes simply by plant selection.

Technologies

The use of irrigation technology, rainwater capture, and/or advanced wastewater treatment is another excellent approach to achieving this credit because it allows for a broader plant species palette, while still conserving potable water supplies. High-efficiency irrigation strategies include micro-irrigation systems, moisture sensors, rain shut-offs, and weather-based evapotranspiration controllers. Drip systems apply water slowly and directly to the roots of plants, using 30%–50% less water than sprinkler irrigation[1]. Moisture and rain sensors save water by ensuring that plants only receive water when necessary.

A rainwater collection system (e.g., cisterns, underground tanks, ponds) can significantly reduce or completely eliminate the amount of potable water used for irrigation. Rainwater can be collected from roofs, plazas and paved areas and then filtered by combination of graded screens and paper filters to prepare it for use in irrigation. Metal, clay or concrete-based roofing materials are ideal for rainwater harvest, as asphalt or lead-containing materials will contaminate the water. Rainwater with high mineral content or acidity may damage systems or plantings, but pollutants can be filtered out by soil or mechanical systems prior to being applied to plantings. It is important to check local rainfall quantity and quality, as collection systems may be inappropriate in areas with rainfall of poor quality or low quantity.

Wastewater recovery can be accomplished either on-site or at the municipal level. On-site systems include graywater and/or wastewater treatment. Graywater consists of wastewater from sinks, showers and washing machines; cooling tower bleed down water; condensation from air conditioning systems; and other building activities that do not involve human waste or food processing. In addition, many municipalities treat sewage to tertiary standards in central treatment plants and re-distribute that water regionally for irrigation use.

Calculations

To calculate the percent reduction in potable use for this credit, establish a baseline water use rate for your project and then calculate the as-designed water use rate according to the steps listed below.

Standard Assumptions & Variables

- ❑ All calculations are based on irrigation during the month of July.

- The **Landscape Coefficient** (KL) indicates the volume of water lost via evapotranspiration and is dependent on the landscape species, the microclimate and the planting density. The formula for determining the landscape coefficient is given in **Equation 1**.
- The **Species Factor** (ks) accounts for variation of water needs by different plant species. The species factor can be divided into three categories (high, average and low) depending on the plant species considered. To determine the appropriate category for a plant species, use plant manuals and professional experience. This factor is somewhat subjective but landscape professionals should have a general idea of the water needs of particular plant species. Landscapes can be maintained in acceptable condition at about 50% of the reference evapotranspiration (ET_o) value and thus, the average value of ks is 0.5. (Note: If a species does not require irrigation once it is established, then the effective ks = 0 and the resulting KL = 0.)
- The **Density Factor** (kd) accounts for the number of plants and the total leaf area of a landscape. Sparsely planted areas will have lower evapotranspiration rates than densely planted areas. An average kd is applied to areas where ground shading from trees is in the range of 60% to 100%. This is also equivalent to shrubs and ground cover shading 90% to 100% of the landscape area. Low kd values are found where ground shading from trees is less than 60% or shrub and groundcover is less than 90%. For instance, a 25% ground shading from trees results in a kd value of 0.5. In mixed landscape plantings where trees cover understory groundcover and shrubs, evapotranspiration increases. This represents the highest level of landscape density and the kd value should be between 1.0 and 1.3.
- The **Microclimate Factor** (kmc) accounts for environmental conditions specific to the landscape, including temperature, wind and humidity. For instance, parking lot areas increase wind and temperature effects on adjacent landscapes. The average kmc is 1.0 and this refers to conditions where the landscape evapotranspiration rate is unaffected by buildings, pavements, reflective surfaces and slopes. Higher kmc conditions occur where evaporative potential is increased due to landscapes surrounded by heat-absorbing and reflective surfaces or are exposed to particularly windy conditions. Examples of high kmc areas include parking lots, west sides of buildings, west and south sides of slopes, medians, and areas experiencing wind tunnel effects. Low microclimate areas include shaded areas and areas protected from wind. North sides of buildings, courtyards, areas under wide building overhangs, and north sides of slopes are low microclimate areas.

Equation 1

$$K_L = k_s \times k_d \times k_{mc}$$

Step 1—Create Design Case

Determine the landscape area for the project. This number must represent the as-designed landscape area and must use the same project boundary as is used in all other LEED credits. Sort the total landscape area into the major vegetation types (trees, shrubs, groundcover, mixed, and turfgrass), listing the area for each.

Determine the following characteristics for each landscape area: Species Factor (k_s), Density Factor (k_d), and Microclimate Factor (k_{mc}). Recommended values for each of these factors are provided in

Table 1. Select the "low," "average," or "high" value for each parameter as appropriate for your design. Any variance from these recommended values should be explained in the credit narrative.

Calculate the Landscape Coefficient (K_L) by multiplying the three area characteristics as shown in **Equation 1**.

Determine the reference evapotranspiration rate (ET_0) for your region. The **evapotranspiration rate** is a measurement of the total amount of water needed to grow a certain reference plant (such as grass or alfalfa) expressed in millimeters or inches. The Resources section provides a link to ET data. The ET_0 for July is used in the LEED calculation because this is typically the month with the greatest evapotranspiration effects and, therefore, the greatest irrigation demands.

Calculate your project-specific evapotranspiration rate (ET_L) for each landscape area by multiplying the (ET_0) by your KL, as shown in **Equation 2**.

Determine your **Irrigation Efficiency** (IE) by listing the type of irrigation used for each landscape area and the corresponding efficiency. **Table 2** lists irrigation efficiencies for different irrigation systems.

Determine, if applicable, the Controller Efficiency (CE). CE is the percent reduction in water use from any weather-based controllers or moisture sensor-based systems. This number must be supported by either manufacturer documentation or detailed calculations by the landscape designer.

Determine, if applicable, the volume of reuse water (captured rainwater, recycled graywater, or treated wastewater) available in the month of July. Reuse water volumes may depend on rainfall volume/frequency, building-generated graywater/wastewater, and on-site storage capacity. On-site reuse systems should be modeled to predict volumes generated on a monthly basis as well as optimal storage capacity. For captured rainwater calculations, project teams may use either the collected rainwater total for July based on historical average precipitation, or the historical data for each month in order to model collection and reuse throughout the year. The latter method allows the project team to determine what volume of water is expected to be in the storage cistern at the beginning of July and add it to the expected rainwater volume collected during the month. This approach also allows the project team to determine the optimal size of the rainwater cistern.

Table 2: Irrigation Types

Irrigation Type	IE
Sprinkler	0.625
Drip	0.90

Table 1: Landscape Factors

Vegetation Type	Species Factor (k_s)			Density Factor (k_d)			Microclimate Factor (k_{mc})		
	low	average	high	low	average	high	low	average	high
Trees	0.2	0.5	0.9	0.5	1.0	1.3	0.5	1.0	1.4
Shrubs	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.3
Groundcovers	0.2	0.5	0.7	0.5	1.0	1.1	0.5	1.0	1.2
Mixed: trees, shrubs, groundcovers	0.2	0.5	0.9	0.6	1.1	1.3	0.5	1.0	1.4
Turfgrass	0.6	0.7	0.8	0.6	1.0	1.0	0.8	1.0	1.2

Equation 2

ET_L [in] = ET_0 x K_L

Now you are ready to calculate your Total Water Applied (TWA) and Total Potable Water Applied (TPWA) for each landscape area and the Design Case. **Equations 3 and 4** show how to calculate these values.

Step 2—Create Baseline Case

The Baseline Case is calculated by setting the Species Factor (ks), Density Factor (kd), and Irrigation Efficiency (IE) to average values representative of conventional equipment and design practices. The same Microclimate Factors (kMC), and the reference Evapotranspiration Rate (ETo) are used in both the Design and Baseline cases. If the design of the project included substitutions of low water-using landscape types (such as shrubs) for high water-using types (such as turfgrass), the landscape areas can be re-allocated in the baseline case, but the total landscape area must remain the same in the two cases. Also, it is unreasonable to assume that the baseline is 100% turfgrass if the project includes substantial areas of trees, shrubs, and planting beds.

Calculate your TWA for the Baseline Case using **Equation 5**.

Step 3—Calculate Percent Reduction in Total Irrigation Water Use (Potable and Reuse) AND Percent Reduction of Potable Water Use for Irrigation

Calculate your percent reduction of potable water use according to **Equation 6**.

If the Percent Reduction of Potable Water is equal to or greater than 50%, WE Credit 1.1 is earned.

If the Percent Reduction of Potable Water is 100%, you must also calculate the Percent Reduction of Total Water (Potable plus Reuse) according to **Equation 7**.

If the Percent Reduction of Potable Water is 100% AND the Percent Reduction of Total Water is equal to or greater than 50%, WE Credit 1.2 is earned in addition to WE Credit 1.1.

Example

An office building in Austin, Texas, has a total site area of 6,000 square feet. The site consists of three landscape types: groundcover, mixed vegetation and turf grass. All of the site areas are irrigated with a combination of potable water and gray-water harvested from the building. The

Equation 3

Design Case TWA [gal] = (Area [sf] x (ET_L [in] / IE)) x CE x 0.6233 gal/sf/in

Equation 4

Design Case TPWA [gal] = TWA [gal] – Reuse Water [gal]

Equation 5

Baseline Case TWA [gal] = Area [sf] x (ET_L [in] / IE) x 0.6233 gal/sf/in

Equation 6

Percent Reduction of Potable Water [%] = (1 – Design TPWA / Baseline TWA) x 100

Equation 7

Percent Reduction of Total Water [%] = (1 – Design TWA / Baseline TWA) x 100

reference evapotranspiration rate (ET_o) for Austin in July was obtained from the local agricultural data service and is equal to 8.12. The high-efficiency landscape irrigation case utilizes drip irrigation with an efficiency of 90% and reuses an estimated 4,200 gallons of graywater during the month of July. **Table 3** shows the calculations to determine potable water use for the design case.

The baseline case uses the same reference evapotranspiration rate and total site area. However, the baseline case uses sprinklers for irrigation (IE = 0.625), does not take advantage of graywater harvesting, and uses only shrubs and turf grass. Calculations to determine potable water use for the baseline case are presented in **Table 4**.

The example illustrates that the design case has an irrigation water demand of 23,474 gallons. Graywater reuse provides 4,200 gallons towards the demand, and this volume is treated as a credit in the water calculation. Thus, the total potable water applied to the design case in July is 19,274 gallons. The baseline case has an irrigation demand of 62,518 gallons and reuses no graywater. The difference between the two cases results in potable water savings of 69% for the design case.

Exemplary Performance

There is no exemplary performance point available for this credit.

Submittal Documentation

This credit is submitted in the **Design Submittal**.

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

- ❑ The project's calculated baseline Total Water Applied (TWA) (gal). This data can be obtained using **Equation 5**.
- ❑ The project's calculated design case Total Water Applied (TWA) (gal). This data can be obtained using **Equation 5**.
- ❑ The total non-potable water supply (gal) available for irrigation purposes.
- ❑ Narrative describing the landscaping and irrigation design strategies

Table 3: Design Case (July)

Landscape Type	Area [sf]	Species Factor (k_s)	Density Factor (k_d)	Microclimate Factor (k_{mc})	KL	ETL	IE	TPWA [gal]
Shrubs	1,200	Low 0.2	Avg 1.0	High 1.3	0.3	2.11	Drip	2,815
Mixed	3,900	Low 0.2	Avg 1.1	High 1.4	0.3	2.50	Drip	10,837
Turfgrass	900	Avg 0.7	Avg 1.0	High 1.2	0.8	6.82	Sprinkler	9,822
							Subtotal [gal]	**23,474**
							July Rainwater and Graywater Harvest [gal]	(4,200)
							Net GPWA [gal]	**19,274**

Table 4: Base line Case (July)

Landscape Type	Area [sf]	Species Factor (k_s)	Density Factor (k_d)	Microclimate Factor (k_{mc})	KL	ETL	IE	TPWA [gal]
Shrubs	1,200	Avg 0.5	Avg 1.0	High 1.3	0.7	5.28	Sprinkler	10,134
Turfgrass	4,800	Avg 0.7	Avg 1.0	High 1.2	0.8	6.82	Sprinkler	52,384
							Net GPWA [gal]	**62,518**

employed by the project; description of the water use calculation methodology used to determine savings; and for projects using non-potable water, specific information regarding source and available quantity of non-potable supplies.

Considerations

Landscape irrigation practices in the United States consume large quantities of potable water. Outdoor uses, primarily landscaping, account for 30% of the 26 billion gallons of water consumed daily in the United States[2]. Improved landscaping practices can dramatically reduce and even eliminate irrigation needs. Maintaining or reestablishing native or adapted plants on building sites fosters a self-sustaining landscape that requires minimal supplemental water and provides other environmental benefits. Improved irrigation systems can also reduce water consumption. Irrigation typically uses potable water, although non-potable water (e.g., rainwater, graywater or reclaimed water) is equally effective. Irrigation system efficiency varies widely, and high-efficiency irrigation systems can also reduce potable water consumption. For example, high-efficiency drip irrigation systems can be 95% efficient, while sprinkler or spray irrigation systems are only 60% to 70% efficient.[3]

Environmental Issues

Reduction in the amount of potable water used for irrigation lessens demand on limited supplies. Since landscape irrigation uses large amounts of potable water, it is an important opportunity to reduce overall consumption. Native or adapted landscaping can reduce the amount of water needed for irrigation while also attracting native wildlife and creating a building site integrated with its natural surroundings. In addition, native or adapted plants tend to require less fertilizer and pesticides, and thus reduce water quality degradation and other environmental impacts.

Economic Issues

Currently, the most effective strategy to avoid escalating water costs for irrigation is to design landscaping adapted to the local climate and the site's microclimate. The cost can be reduced or eliminated through thoughtful planning and careful plant selection and layout. Native or adapted plants further reduce operating costs because they require less fertilizer and maintenance than turf grass. Although the additional design cost for a drip irrigation system may make it more expensive than a conventional system, a drip system usually costs less to install and has lower water use and maintenance requirements. This usually leads to a very short payback period. Many municipalities offer rebates or incentives for water-efficient irrigation systems, dedicated water meters and rain or moisture sensors.

Community Issues

Water-efficient landscaping helps to conserve local and regional potable water resources. Maintaining natural aquifer conditions is important to providing reliable water sources for future generations. Consideration of water issues during planning can encourage development when resources can support it, and prevent development if it exceeds the resource capacity.

Synergies and Trade-Offs

Successful water-efficient landscaping depends on site location and design. It is advantageous to couple landscape improvements with water use reduction strategies. The use of native or adapted plants can reduce site maintenance needs. Landscape plantings can mitigate climate conditions and reduce building energy consumption, for example by shading south-facing windows. Vegetation can aid passive solar design, serve as a windbreak, provide pleasant views for building oc-

cupants, and muffle off-site noise. Native plants can restore habitat for wildlife. In addition to reducing potable water consumption, rainwater capture systems can be used to manage rainwater runoff. Using graywater for irrigation reduces the amount of wastewater delivered to water treatment facilities.

Resources

Web Sites

America Rainwater Catchment Systems Association (ARCSA)

www.arcsa-usa.org

ARCSA was founded to promote rainwater catchment systems in the United States. Its web site provides regional resources, publications, suppliers and membership information.

Graywater Systems, Compost Toilets, & Rain Collection

www.rmi.org/sitepages/pid287.php

This web resource from the Rocky Mountain Institute provides general information and links to resources on rain collection and graywater systems.

The Irrigation Association

www.irrigation.org

This nonprofit organization focuses on promoting products that efficiently use water in irrigation applications.

Rain Bird® ET Manager™ Scheduler Software (right hand side under "Helpful tools")

http://www.rainbird.com/landscape/products/controllers/etmanager.htm

This free software provides sufficient local evapotranspiration data for the United States and Canada. Use data from the closest or most climate-appropriate location.

Texas Water Development Board Web Site

www.twdb.state.tx.us

This Web site provides data from the state of Texas regarding water resources and services, such as groundwater mapping and water availability modeling. The site also provides published brochures regarding indoor and outdoor water efficiency strategies.

Water-Efficient Landscaping

http://muextension.missouri.edu/xplor/agguides/hort/g06912.htm

This Web site has general descriptions and strategies for water efficiency in gardens and landscapes.

Water-Efficient Landscaping: Preventing Pollution and Using Resources Wisely

http://www.epa.gov/OW-OWM.html/water-efficiency/docs/water-efficient_landscaping_508.pdf

This manual from the Environmental Protection Agency provides information about reducing water consumption through creative landscaping techniques.

Water Wiser: The Water Efficiency Clearinghouse

www.awwa.org/waterwiser/

This clearinghouse provides articles, reference materials and papers on all forms of water efficiency.

Print Media

Landscape Irrigation: Design and Management by Stephen W. Smith, John Wiley and Sons, 1996. This text is comprehensive guide to landscape irrigation strategies, techniques, and hardware.

Turf Irrigation Manual, Fifth Edition by Richard B. Choate and Jim Watkins, Telsco Industries, 1994. This manual covers all aspects of turf and landscape irrigation.

Definitions

Conventional Irrigation refers to the

most common irrigation system used in the region where the building is located. A common conventional irrigation system uses pressure to deliver water and distributes it through sprinkler heads above the ground.

Drip Irrigation is a high-efficiency irrigation method in which water is delivered at low pressure through buried mains and sub-mains. From the sub-mains, water is distributed to the soil from a network of perforated tubes or emitters. Drip irrigation is a type of micro-irrigation.

Graywater is defined by the Uniform Plumbing Code (UPC) in its Appendix G, titled "Graywater Systems for Single-Family Dwellings," as "untreated household wastewater which has not come into contact with toilet waste. Graywater includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It shall not include wastewater from kitchen sinks or dishwashers." The International Plumbing Code (IPC) defines graywater in its Appendix C, titled "Graywater Recycling Systems," as "wastewater discharged from lavatories, bathtubs, showers, clothes washers, and laundry sinks." Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences with the UPC and IPC definitions can probably be found in state and local codes. Project teams should comply with graywater definitions as established by the authority having jurisdiction in their areas.

The **Landscape Area** of the site is equal to the total site area less the building footprint, paved surfaces, water bodies, patios, etc.

Micro-irrigation involves irrigation systems with small sprinklers and micro-jets or drippers designed to apply small volumes of water. The sprinklers and micro-jets are installed within a few centimeters of the ground, while drippers are laid on or below grade.

Potable Water is water suitable for drinking and supplied from wells or municipal water systems.

Case Study

20 River Terrace (Solaire)

New York, NY

Owner: River Terrace Associates, LLC

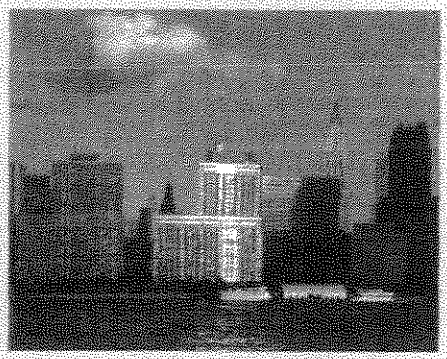


Photo © Jeff Goldberg, Esto

Located within the boundaries of Ground Zero in lower Manhattan, the Solaire is a 27-story green residential high-rise building which earned LEED v2.0 Gold in April 2004. The project excelled in Water Efficiency, earning all five WE credits, plus one Innovation & Design credit for exemplary performance in WE Credit 3. A wastewater treatment system treats 100% of the wastewater from the building; water recaptured by the system is used to supply the cooling tower and the building's toilets, and 5,000 gallons per day are provided to the adjacent public park. A stormwater storage tank which harvests rainwater is used for all irrigation needs. 50% less potable water is needed from the municipal water supply than would be used in a conventional apartment building, and no potable water is used outdoors. Low-flow appliances and fixtures were used, and the public restroom facilities use waterless urinals, contributing to a water use reduction of 88% within the building.

Innovative Wastewater Technologies

1 Point

Intent

Reduce generation of wastewater and potable water demand, while increasing the local aquifer recharge.

Requirements

OPTION 1

Reduce potable water use for building sewage conveyance by 50% through the use of water-conserving fixtures (water closets, urinals) or non-potable water (captured rainwater, recycled graywater, and on-site or municipally treated wastewater).

OR

OPTION 2

Treat 50% of wastewater on-site to tertiary standards. Treated water must be infiltrated or used on-site.

Potential Technologies & Strategies

Specify high-efficiency fixtures and dry fixtures such as composting toilet systems and non-water using urinals to reduce wastewater volumes. Consider reusing stormwater or graywater for sewage conveyance or on-site wastewater treatment systems (mechanical and/or natural). Options for on-site wastewater treatment include packaged biological nutrient removal systems, constructed wetlands, and high-efficiency filtration systems.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Potable water is used for many functions that do not require high-quality water such as toilet and urinal flushing, and landscape irrigation. Rainwater and graywater systems can significantly reduce potable water demand. Graywater systems reuse the wastewater collected from sinks, showers and other sources for the flushing of toilets, landscape irrigation, and other functions that do not require potable water. Graywater treatment may be required prior to reuse according to end use and state jurisdiction. If it is likely that a graywater system will be used in the future, install dual plumbing lines during the initial construction to avoid the substantial costs and difficulty in adding them later. Rainwater systems provide non-potable water suitable for landscape irrigation, flushing toilets and urinals, and process water needs. Rainwater systems have significantly fewer code requirements than graywater systems and are often less expensive than graywater systems. Rainwater from roofs or site can also be collected and harvested to help displace potable water demand. Rainwater collected from impervious surfaces reduces rainwater runoff and control infrastructure requirements. Rainwater retention or detention systems can be designed with cisterns to hold rainwater runoff for non-potable usage.

The necessity and availability of wastewater reuse and treatment strategies is heavily influenced by the project's size and location. Very large projects or campus settings may provide sufficient economic reason to warrant on-site wastewater treatment. Close proximity to a municipal or private treatment facility can provide an opportunity to reuse treated wastewater to displace potable water demand. In remote locations, it may be more cost-effective to use an on-site wastewater treatment system than to extend existing infrastructure.

Conversely, a project located in a dense urban environment with little available site area may not be able to achieve this credit through development of on-site wastewater systems, graywater or rainwater systems, but may be able to utilize municipally provided recycled water to reduce potable water demand.

This credit has close ties to water efficiency efforts because a greater amount of potable water saved often results in less blackwater generated. For instance, water efficient water closets, urinals, showerheads and faucets not only reduce potable water demand but also reduce blackwater volumes created. Thus, performance results will often overlap with those of WE Credit 3.

Additional energy use may be needed for certain on-site treatment operations or for reuse strategies. These active systems also require commissioning and measurement & verification attention. Reuse of an existing building could hinder adoption of an on-site wastewater treatment facility.

When considering an on-site rainwater, graywater collection or blackwater treatment system it is important to first check with local government agencies for regulations governing the use of this water for irrigation and the permits required.

Each state has its own standards and requirements for the installation and operation of rainwater, graywater and water treatment systems. Texas and California, for example, have standards that encourage the use of graywater systems while other states have regulations that may limit or prohibit graywater use. In many areas, irrigation with graywater must be

subsurface, although some regions allow above-ground irrigation.

Projects that plan to treat wastewater on-site should consider a treatment system such as constructed wetlands, a mechanical recirculating sand filter, or anaerobic biological treatment reactor.

In the case of any specialized system, is it imperative that key maintenance staff be trained in the operations and maintenance of the water systems.

Calculations

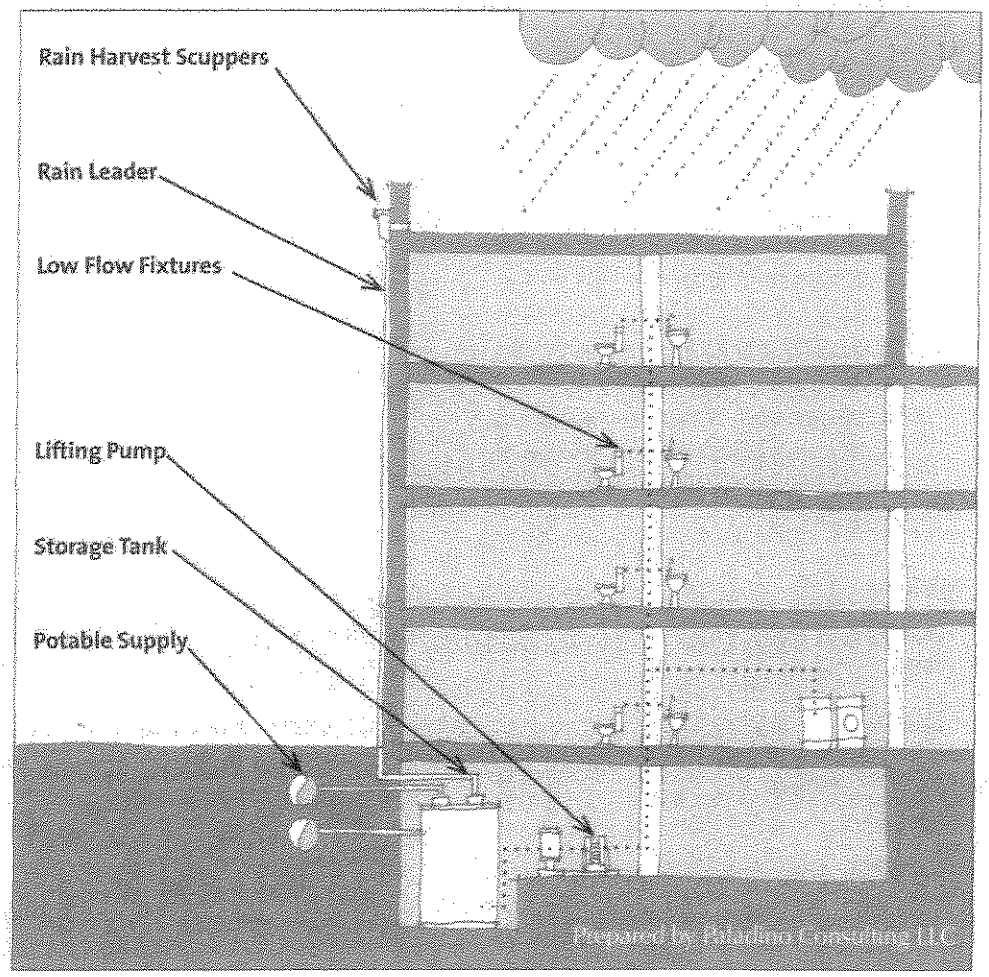
The following calculation methodology is used to support achievement of **Option 1**.

Occupancy

Calculate the **Full-Time Equivalent (FTE)** building occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0 while a part-time occupant has an FTE value based on their hours per day divided by 8. (Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits.) In buildings with multiple shifts, use the number of FTEs from all shifts, since this credit is based on annual water consumption.

Estimate the **Transient** building occupants, such as students, visitors and customers. Since this credit is based on an-

Figure 1: An illustration of a Rain Harvesting System



nual water consumption, use a transient occupancy number that is a representative daily average.

If the building has both FTE and Transient occupants, calculate the water use for each fixture separately for each occupancy type. This separation is necessary to represent the unique use patterns. For residential projects, the number of residents is used as the occupancy number.

Note: WE Credit 3, Table 2 provides default fixture use values for different occupancy types.

Design Case

Wastewater calculations are based on the annual generation of blackwater volumes from plumbing fixtures such as water closets and urinals. The calculations compare the design case with a baseline case. The steps to calculate the design case are as follows:

1. Create a spreadsheet listing each type of blackwater-generating fixture and frequency-of-use data. Frequency-of-use data includes the number of female and male daily uses, and the sewage generated per use. Use the daily use assumptions shown in **Table 1** as the basis for the calculations, unless alternate assumptions on daily use can be supported by specific back-up documentation. Using these values, calculate the total sewage generated for each fixture type and gender (see **Equation 1**).
2. Sum all of the sewage generation volumes used for each fixture type to obtain male and female daily sewage generation volumes.
3. Multiply the male and female sewage generation volumes by the number of male and female building occupants and sum these volumes to obtain the daily total sewage generation volume (see **Equation 2**).
4. Multiply the total daily sewage volume by the number of workdays in a typical year to obtain the total annual sewage generation volume for the building (see **Equation 3**).
5. If rainwater harvest or graywater reuse strategies are employed in the building, subtract these annual volumes from the annual sewage generation volume. The result shows how much potable water is used for sewage conveyance annually.

Table 1 shows example potable water calculations for sewage conveyance for a two-story office building with a capacity of 300 occupants. The calculations are based on a typical 8-hour workday. It is assumed that building occupants are 50% male and 50% female. Male occupants are assumed to use water closets once and urinals twice in a typical work day. Female occupants are assumed to use water closets three times.

When using graywater and rainwater volumes, calculations are required to demonstrate that these reuse volumes are

Equation 1

$$\text{Sewage Volume [gal]} = \text{Uses} \times \text{Duration [mins or flushes]} \times \frac{\text{Water Volume [gal]}}{\text{Use [min or flush]}}$$

Equation 2

$$\text{Daily Sewage Generation [gal]} = \left(\text{Male Occupants} \times \text{Male Sewage Generation [gal]}\right) + \left(\text{Female Occupants} \times \text{Female Sewage Generation [gal]}\right)$$

Equation 3

$$\text{Annual Sewage Generation [gal]} = \text{Total Sewage Generation}\left[\frac{\text{gal}}{\text{day}}\right] \times \text{Workdays [days]}$$

Table 1: Design Case

Fixture Type	Daily Uses	Flowrate [GPF]	Occupants	Sewage Generation [gal]
Low-Flow Water Closet (Male)	0	1.1	150	0
Low-Flow Water Closet (Female)	3	1.1	150	495
Composting Toilet (Male)	1	0.0	150	0
Composting Toilet (Female)	0	0.0	150	0
Waterless Urinal (Male)	2	0.0	150	0
Waterless Urinal (Female)	0	0.0	150	0
		Total Daily Volume [gal]		**495**
		Annual Work Days		260
		Annual Volume [gal]		128,700
		Rainwater or Graywater Volume [gal]		(36,000)
		TOTAL ANNUAL VOLUME [gal]		**92,700**

sufficient to meet water closet demands. These quantities are then subtracted from the gross daily total because they reduce potable water usage. In the example in **Table 1**, 36,000 gallons of rainwater are harvested and directed to water closets for flushing.

Baseline Case

Repeat the above calculation methodology for the baseline case. Use Energy Policy Act of 1992 fixture flow rates for the baseline case (see **WE Credit 3, Table 1**). Do not change the number of building occupants, the number of workdays, or the frequency data. Do not include graywater or rainwater harvest volumes.

Table 2 provides a summary of baseline calculations. The baseline case estimates that 327,600 gallons of potable water per year are used for sewage conveyance.

Comparison of the baseline to the designed building indicates that a 72% reduction in potable water volumes used for sewage conveyance is realized (1 – 92,700/327,600). Thus, this strategy earns one point for this credit. When developing the baseline, only the fixtures, sewage generation rates and the water reuse credit are different from the designed building. Usage rates, occupancy and number of workdays are identical for the design case and the baseline case. See **Table 3** for sample fixture flow rates.

When reusing graywater volumes from the building, it is necessary to model the system on an annual basis to determine graywater volumes, generated storage capacity of the system and any necessary treatment processes before reusing the water volumes. Graywater volumes may or may not be consistently available

Table 2: Baseline Case

Fixture Type	Daily Uses	Flowrate [GPF]	Occupants	Sewage Generation [gal]
Water Closet (Male)	1	1.6	150	240
Water Closet (Female)	3	1.6	150	720
Urinal (Male)	2	1.0	150	300
Urinal (Female)	0	1.0	150	0
		Total Daily Volume [gal]		**1,260**
		Annual Work Days		260
		TOTAL ANNUAL VOLUME [gal]		**327,600**

Table 3: Sample Fixture Types and GPFs

Fixture Type	[GPF]
Conventional Water Closet	1.6
Low-Flow Water Closet	1.1
Ultra Low-Flow Water Closet	0.8
Composting Toilet	0.0
Conventional Urinal	1.0
Waterless Urinal	0.0

throughout the year because these volumes are dependent on building occupant activities. For instance, in a typical office building, graywater volumes will change slightly due to vacation schedules and holidays but should be relatively consistent over the year.

In contrast, graywater volumes in a school building will substantially decrease in summer months due to the school calendar, and therefore, graywater volumes may not be available for irrigation.

If the project uses rainwater volume as a substitute for potable volumes in water closets or urinals, it is necessary to calculate water savings over a time period of one year. Rain harvest volume depends on the amount of precipitation that the project site experiences, the rainwater collection surface's area and efficiency, and storage tank capacity. See **Equation 4** and consult a rainwater harvesting guide for more detailed instruction. Rainfall data is available from the local weather service (see the Resources section). Rainwater volume depends on variations in precipitation, and thus, it is necessary to model the reuse strategy on an annual basis. A model of rainwater capture based on daily precipitation and occupant demand is helpful to determine the rainwater volumes captured and storage tank size. Subtract annual rainwater use for sewage conveyance in the design case calculations.

The following calculation methodology is used to support achievement of **Option 2.**

1. Create a spreadsheet listing each type of blackwater-generating fixture and frequency-of-use data. Frequency-of-use data includes the number of female and male daily uses, and the sewage generated per use. Use the daily use assumptions shown in **Table 1** as the basis for the calculations, unless alternate assumptions on daily use can be supported by specific back-up documentation. Using these values, calculate the total sewage generated for each fixture type and gender (see **Equation 1**).
2. Sum all of the sewage generation volumes used for each fixture type to obtain male and female daily sewage generation volumes.
3. Multiply the male and female sewage generation volumes by the number of male and female building occupants and sum these volumes to obtain the daily total sewage generation volume (see **Equation 2**).
4. Multiply the total daily sewage volume by the number of workdays in a typical year to obtain the total annual sewage generation volume for the building (see **Equation 3**).
5. Divide the annual volume of wastewater that is treated and reused and/or infiltrated on site by the calculated annual sewage generation volume for the building to determine the percent reduction of wastewater that is released into the municipal sewer system.

Exemplary Performance

Projects that demonstrate a 100% reduction in potable water use for sewage

Equation 4

Rainwater Volume [gal] = collection area [sf] x collection efficiency [%] x average rainfall [in] x 0.6233 gal/sf/in

conveyance, OR, on-site treatment and re-use/infiltration of 100% of generated wastewater will be considered for one additional point under the Innovation in Design category.

Submittal Documentation

This credit is submitted in the **Design Submittal.**

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

- ❑ Upload the applicable plumbing drawings from the construction documents that provide data regarding any on-site wastewater treatment facilities.
- ❑ The project's calculated occupants. The template will use a default one-to-one men to women ratio. Projects with special occupancy situations that result in an unbalanced ratio may enter project specific data for this credit.
- ❑ The project's calculated baseline water usage for sewage conveyance. This data is calculated using typical fixture types (provided in the template) and the project's mix of occupants.
- ❑ The project's calculated design case water usage for sewage conveyance. This data is calculated using project specified fixture types and the project's mix of occupants. Note: project teams must provide the following fixture information for each typical installed flush fixture type: fixture manufacturer, fixture model, flush rate in gallons per flush (gpf).
- ❑ For projects using non-potable water for sewage conveyance, provide the total non-potable water supply (gal) available for sewage conveyance purposes.
- ❑ For projects treating wastewater on-site, provide the annual quantity (gal) of water treated, the annual quantity (gal) of treated water that is infiltrated, and the annual quantity (gal) of treated water that is re-used on-site.
- ❑ Narrative describing the potable water reduction strategies employed by the project. For projects using non-potable water, include specific information regarding any reclaimed water usage (graywater re-use/rainwater reuse/ on-site or municipally treated wastewater). If the project is treating wastewater on-site to tertiary standards, include specific information regarding the use(s) of the treated wastewater.

Considerations

Cost Issues

Commercial and industrial facilities that generate large amounts of wastewater can realize considerable savings by recycling graywater. For example, car washes and truck maintenance facilities generate large volumes of graywater that can be effectively treated and reused. Often, a separate tank, filter and special emitters are necessary for a graywater irrigation system. Dual sanitary and graywater distribution piping doubles construction piping costs. In addition, local codes requiring filtration, disinfection treatment, overflow protection, etc., add to the cost of construction, operation, and maintenance; all of which should be considered by the owner when making a decision to collect graywater. Collection and use of rainwater for non-potable water applications has significantly fewer code requirements and associated costs. The highest cost in most rainwater systems is for water storage. Storage tanks and cisterns come in a variety of sizes and materials. Designers can lower construction costs by finding synergies such as adding a cistern to collect rainwater to a stormwater detention system. In some systems, pumps are required for distribution, incurring additional energy costs required for operation.

Water recovery systems are most cost-effective in areas where there is no municipal water supply, where the developed wells are unreliable, or if well water requires treatment. Collecting and using rainwater or other site water volumes reduces site runoff and the need for runoff devices. It also minimizes the need for utility-provided water, thus reducing some initial and operating costs. In some areas with a decentralized population, collection of rainwater offers a low-cost alternative to a central piped water supply.

A constructed wetland for wastewater treatment can add value to a development as a site enhancement. Wetlands are beneficial because they provide flood protection and stabilize soils on site. Currently, packaged biological wastewater systems have an initial high cost, relative to the overall building cost, due to the novelty of the technology.

Environmental Issues

On-site wastewater treatment systems transform perceived "wastes" into resources that can be used on the building site. These resources include treated water volumes for potable and non-potable use, as well as nutrients that can be applied to the site to improve soil conditions. Reducing wastewater treatment at the local wastewater treatment works minimizes public infrastructure, energy use and chemical use. In rural areas, on-site wastewater treatment systems avoid aquifer contamination problems prevalent in current septic system technology.

By reducing potable water use, the local aquifer is conserved as a water resource for future generations. In areas where aquifers cannot meet the needs of the population economically, rainwater and other recovered water is the least expensive alternative source of water.

Economic Issues

Wastewater treatment systems and water recovery systems involve an initial capital investment in addition to the maintenance requirements over the building's lifetime. These costs must balance with the anticipated savings in water and sewer bills. This savings can minimize the amount of potable water that a municipality must provide, thereby leading to more stable water rates, and resources needed for economic growth.

Regional Issues

Local precipitation throughout the year should be factored into determining the feasibility of rainwater harvesting systems for use in reduction of potable water for plumbing fixture flushing, and landscape irrigation. Local building and health codes/ordinances vary with regards to allowance of graywater or harvested rainwater systems; and they are prohibited in some states. Additionally, codes differ in how alternative plumbing fixtures, such as dual-flush water closets, composting toilets and non-water using urinals are handled. It is critical to confirm acceptability of non-traditional approaches with code officials prior to commitment to specific water saving strategies.

Supply water quality from graywater and recycled water systems should also be considered in fixture selection. Project teams should identify if minimum supply water quality standards have been established for specific fixtures by manufacturers. When recycled graywater or collected rainwater is used with plumbing fixtures designed for use with municipally supplied potable water, it is good practice to verify that supply water quality is acceptable and will not compromise long-term fixture performance.

Resources

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

Web Sites

American Rainwater Catchment Systems Association

www.arcsa-usa.org

Includes a compilation of publications, such as the Texas Guide to Rainwater Harvesting.

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat: 17 Case Studies

U.S. EPA

EPA Publication No. 832/B-93-005, 1993.

www.epa.gov/owow/wetlands/construc/

The case studies in this document provide brief descriptions of 17 wetland treatment systems that provide water quality benefits while also providing habitat. The projects described include systems involving constructed and natural wetlands, habitat creation and restoration, and the improvement of municipal effluent, urban stormwater and river water quality.

How to Conserve Water and Use it Effectively

U.S. EPA

http://www.epa.gov/OWOW/nps/chap3.html

A U.S. EPA document that provides guidance for commercial, industrial and residential water users on saving water and reducing sewage volumes.

On-site Wastewater Treatment Systems Manual

U.S. EPA

http://www.epa.gov/OW-OWM.html/septic/pubs/septic_management_handbook.pdf

This manual provides a focused and performance-based approach to on-site wastewater treatment and system management, including information on a variety of on-site sewage treatment options.

Print Media

Mechanical & Electrical Equipment for Buildings, Eighth Edition by Benjamin Stein and John Reynolds, John Wiley and Sons, 1992.

Sustainable Building Technical Manual, Public Technology, Inc., 1996. (www.pti.org)

On-site Wastewater Treatment Systems Manual

www.epa.gov/owm/septic/pubs/septic_2002_osdm_all.pdf

Provides a focused and performance-based approach to on-site wastewater treatment and system management. This document provides valuable information on a variety of on-site sewage treatment options.

Definitions

Aquatic Systems are ecologically designed treatment systems that utilize a diverse community of biological organisms (e.g., bacteria, plants and fish) to treat wastewater to advanced levels.

Blackwater does not have a single definition that is accepted nationwide. Wastewater from toilets and urinals is, however, always considered blackwater.

Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs may be considered blackwater by state or local codes. Project teams should comply with the blackwater definition as established by the authority having jurisdiction in their areas.

Composting Toilet Systems are dry plumbing fixtures that contain and treat human waste via microbiological processes.

Graywater (also spelled greywater and gray water) is defined by the Uniform Plumbing Code (UPC) in its Appendix G, titled "Gray water Systems for Single-Family Dwellings," as "untreated household wastewater which has not come

into contact with toilet waste. Grey water includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It shall not include wastewater from kitchen sinks or dishwashers."

The International Plumbing Code (IPC) defines graywater in its Appendix C, titled "Graywater Recycling Systems," as "wastewater discharged from lavatories, bathtubs, showers, clothes washers, and laundry sinks."

Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences with the UPC and IPC definitions can probably be found in state and local codes. Project teams should comply with the graywater definitions as established by the authority having jurisdiction in their areas.

On-site Wastewater Treatment uses localized treatment systems to transport, store, treat and dispose of wastewater volumes generated on the project site.

Non-potable Water is water that is not suitable for human consumption without treatment that meets or exceeds EPA drinking water standards.

Potable Water is water that is suitable for drinking and is supplied from wells or municipal water systems.

Process Water is water used for industrial processes and building systems such as cooling towers, boilers and chillers.

Tertiary Treatment is the highest form of wastewater treatment that includes the removal of nutrients, organic and solid material, along with biological or chemical polishing (generally to effluent limits of 10 mg/L BOD_5 and 10 mg/L TSS).

A **Non-Water-Using Urinal** is a urinal that uses no water, but instead replaces the water flush with a specially designed trap that contains a layer of buoyant liquid that floats above the urine layer, blocking sewer gas and urine odors from the room.

Credit 3.1

1 Point

Water Use Reduction

20% Reduction

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 20% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. Calculations are based on estimated occupant usage and shall include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks.

Potential Technologies & Strategies

Use high-efficiency fixtures, dry fixtures such as composting toilet systems and non-water using urinals, and occupant sensors to reduce the potable water demand. Consider reuse of stormwater and graywater for non-potable applications such as toilet and urinal flushing and custodial uses.

SS | WE | EA | MR | EQ | ID

Credit 3.2

1 Point
in addition to
We Credit 3.1

Water Use Reduction

30% Reduction

Intent

Maximize water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

Requirements

Employ strategies that in aggregate use 30% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 fixture performance requirements. Calculations are based on estimated occupant usage and shall include only the following fixtures (as applicable to the building): water closets, urinals, lavatory faucets, showers and kitchen sinks.

Potential Technologies & Strategies

Use high-efficiency fixtures, dry fixtures such as composting toilets and waterless urinals, and occupant sensors to reduce the potable water demand. Consider reuse of stormwater and graywater for non-potable applications such as toilet and urinal flushing, mechanical systems and custodial uses.

Summary of Referenced Standard

The Energy Policy Act (EPAct) of 1992

This Act was promulgated by the U.S. government and addresses energy and water use in commercial, institutional and residential facilities. The water usage requirements of the Energy Policy Act of 1992 are provided in **Table 1**.

Approach and Implementation

Water use strategies depend on the site location and site design. Project sites with no access to municipal potable water service typically use groundwater wells to satisfy potable water demands. Site locations with significant precipitation volumes may determine that reuse of these volumes is more cost-effective than creating stormwater treatment facilities. Potable water use is significant for irrigation applications and is directly correlated with the amount of wastewater generated on-site.

Some water-saving technologies impact energy performance and require commissioning and Measurement & Verification (M&V) attention. Reuse of existing buildings may hinder water efficiency measures due to space constraints or characteristics of existing plumbing fixtures.

While graywater collection and storage may not be a water reduction method that many owners and designers have the opportunity to include in their projects, high-efficiency plumbing fixtures are. Early planning should focus on the code related issues associated with installation and use of water harvesting and collection systems, and high-performance plumbing fixtures such as non-water-using urinals.

Effective methods to reduce potable water use include: reuse of roof runoff or collected graywater volumes for non-potable applications; installation and maintenance of automatic fixture sensors or metering controls; installation of flow restrictors and/or reduced flow aerators on lavatory, sink, and shower fixtures; installation of low-consumption fixtures such as dual-flush water closets and ultra-low flush urinals; installation of dry fixtures such as composting toilet systems and non-water-using urinals.

Although water efficient dishwashers, clothes washers and other water consuming fixtures are not counted in the calculations for this credit they may be included in exemplary performance calculations. (See Exemplary Performance for this credit) A variety of low-flow plumbing fixtures and appliances are currently available in the marketplace and can be installed in the same manner as conventional fixtures.

To determine the most effective strategies for a particular condition, the project team should analyze the water conservation options available to the project based on location, code compliance, and overall project function. Using the EPAct num-

Table 1: Design Case

Fixture	Energy Policy Act of 1992 Flow Requirement
Water Closets [gpf]	1.6
Urinals [gpf]	1.0
Showerheads [gpm]*	2.5
Faucets [gpm]*	2.5
Replacement Aerators [gpm]*	2.5
Metering Faucets [gal/cy]	0.25

**At flowing water pressure of 80 pounds per square inch (psi)*

bers as a baseline, estimate the potable water needs for the project based on estimated occupant uses. Determine areas of high water usage and evaluate potential alternative water saving technologies. Using the same calculation method, examine the impacts of alternative fixture types and technologies. Compare the design case water usage to the calculated EPAct baseline to determine the optimal water savings for the project.

In order to ensure continued water savings and owner/occupant satisfaction, it is imperative that key maintenance staff is trained in the operations and maintenance of any specialized equipment. For example, non-water using urinals generally need to be cleaned according to manufacturer's specifications and their chemical traps appropriately maintained.

Calculations

The following section describes the calculation methodology for determining water use savings under this credit. The calculated water use reduction for the project is the difference between the calculated design case and a baseline case. The credit percentage is determined by dividing the design case usage by the baseline usage.

The methodology differs from traditional plumbing design where the calculations are based on fixture counts; under this credit, the water use calculation is based on estimated occupant usage and fixture flow rates. Estimated occupant usage is determined by calculating Full-Time Equivalent (FTE) and transient occupants and applying appropriate fixture use rates to each type of occupant.

Occupancy

Calculate the **Full-Time Equivalent (FTE)** building occupants based on a standard 8-hour occupancy period. An 8-hour occupant has an FTE value of 1.0 while a part-time occupant has an FTE value based on their hours per day divided by 8. (Note that FTE calculations for the project must be used consistently for all LEED for New Construction credits.) In buildings with multiple shifts, use the number of FTEs from all shifts, since this credit is based on annual water consumption.

Estimate the **Transient** building occupants, such as students, visitors, and customers. Since this credit is based on annual water consumption, use a transient occupancy number that is a representative daily average.

If the building has both FTE and Transient occupants, calculate the water use for each fixture separately for each occupancy type. This separation is necessary to represent the unique use patterns. For residential projects, the number of residents is used as the occupancy number.

Table 2 provides default fixture use values for different occupancy types. These values should be used in the calculations for this credit unless special circumstances exist within the project to require modification. The FTE uses are identical to those used in LEED for New Construction v2.1. The uses for the other occupancy types are provided as compromise default values based on v2.1 projects. Note that most buildings with Student/Visitor and Retail Customer occupants will also have FTE occupants. The Student/Visitor category is intended for college buildings, libraries, museums, and similar building types. 50% of all Student/Visitor occupants are assumed to use a flush fixture and a lavatory faucet in the building and are not expected to use a shower or kitchen sink. 20% of Retail Customer occupants are assumed to use a flush and a flow fixture in the building and no shower or kitchen sink. The default for Residential occupants is 5 uses per day of flush and flow fixtures, 1 shower, and 4 kitchen sink uses.

For consistency across LEED projects,

Table 2: Standard Fixture Uses by Occupancy Type

Fixture Types	FTE	Student/ Visitor	Retail Customer	Resident
	Uses/Day			
Water Closet				
female	3	0.5	0.2	5
male	1	0.1	0.1	5
Urinal				
female	0	0	0	n/a
male	2	0.4	0.1	n/a
Lavatory Faucet (duration 15 sec; 12 sec with autocontrol)	3	0.5	0.2	5
Shower (duration 300 sec)	0.1	0	0	1
Kitchen Sink, non-residential (duration 15 sec)	1	0	0	n/a
Kitchen Sink, residential (duration 60 sec)	n/a	n/a	n/a	4

the calculations require the use of a balanced, one-to-one gender ratio unless specific project conditions warrant an alternative. For these special situations, the project team will need to provide a narrative description to explain the unique circumstances.

The total fixture uses by all occupants must be consistent in the design and baseline cases.

Design Case

The design case annual water use is determined by totaling the annual volume of each fixture type and subtracting any reuse of stormwater/graywater. The design case must use the actual flow rates and flush volumes for installed fixtures. The flow and flush data should be obtained from manufacturer's published product literature.

In addition to the typical fixtures shown on the flush and flow fixture charts (**Table 3**), the project team may add others, as applicable.

Table 4 provides an example design case water use calculation. Note that flush fixtures, which include water closets and urinals, differentiate between females and males. The calculation should ensure that both the male and female occupants are appropriately represented. Zeros may be used when appropriate.

Table 3: Eaxmple Flush and Flow Fixtures and Baseline Flow Rates

Flush Fixture	Flowrate [GPF]	Flow Fixture	Flowrate [GPM]
Conventional Water Closet	1.6	Conventional Lavatory	2.5
Low-Flow Water Closet	1.1	Low-Flow Lavatory	1.8
Dual-Flush Water Closet (Full-Flush)	1.6	Ultra Low-Flow Lavatory	0.5
Dual-Flush Water Closet (Low-Flush)	0.8	Kitchen Sink	2.5
Composting Toilet	0.0	Low-Flow Kitchen Sink	1.8
Conventional Urinal	1.0	Shower	2.5
Low-Flow Urinal	0.5	Low-Flow Shower	1.8
Non-Water Urinal	0.0		

Where on-site collected graywater or rainwater is used for sewage conveyance, the project team should enter the estimated quantity in the calculation. The total annual graywater quantity is subtracted from the total annual design case water usage.

Baseline Case

The baseline case annual water use is determined by duplicating the Design Case table and then setting the fixture flush rates and flow rates to the EPAct default values (as opposed to actual installed values in the Design Case). **Table 5** provides an example design case water use calculation, based on the Design Case presented in **Table 4**.

Eligible Fixtures

This credit is limited to savings generated

Table 4: Sample Design Case Water Use Calculation

Flush Fixture	Daily Uses	Flowrate [GPF]	Duration [flush]	Occupants	Water Use [gal]
Ultra Low-Flow Water Closet (Male)	0	0.8	1	150	0
Ultra Low-Flow Water Closet (Female)	3	0.8	1	150	360
Composting Toilet (Male)	1	0.0	1	150	0
Composting Toilet (Female)	0	0.0	1	150	0
Waterless Urinal (Male)	2	0.0	1	150	0
Waterless Urinal (Female)	0	0.0	1	150	0

Flush Fixture	Daily Uses	Flowrate [GPM]	Duration [sec]	Occupants [gal]	Water Use [gal]
Conventional Lavatory	3	2.5	12	300	450
Kitchen Sink	1	2.5	12	300	150
Shower	0.1	2.5	300	300	375
				Total Daily Volume [gal]	**1335**
				Annual Work Days	260
				Annual Volume [gal]	347,100
				Rainwater or Graywater Volume [gal]	(36,000)
				TOTAL ANNUAL VOLUME [gal]	**311,100**

Table 5: Baseline Case

Flush Fixture	Daily Uses	Flowrate [GPF]	Duration [flush]	Auto Controls N/A	Occupants	Water Use [gal]
Conventional Water Closet (Male)	1	1.6	1		150	240
Conventional Water Closet (Female)	3	1.6	1		150	720
Conventional Urinal (Male)	2	1.0	1		150	300
Conventional Urinal (Female)	0	0.0	1		150	0

Flush Fixture	Daily Uses	Flowrate [GPM]	Duration [sec]	Occupants [gal]	Water Use [gal]
Conventional Lavatory	3	2.5	15	300	563
Kitchen Sink	1	2.5	15	300	188
Shower	0.1	2.5	300	300	375
				Total Daily Volume [gal]	**2,386**
				Annual Work Days	260
				TOTAL ANNUAL VOLUME [gal]	**620,360**

by water using fixtures regulated by the Energy Policy Act of 1992. EPAct covers the following fixture types: lavatories, kitchen sinks, showers, hand wash fountains, janitor sinks, water closets and urinals. Project teams are encouraged to apply for Innovation in Design credits for water use reduction in non-EPAct regulated and process water consuming fixtures. Examples of non-regulated and process water use include but are not limited to dishwashers, clothes washers and cooling towers.

Exemplary Performance

In addition to earning WE Credits 3.1 and 3.2, project teams that achieve a projected water savings of 40% are eligible for an exemplary performance ID credit.

Project teams may also achieve an ID credit for demonstrating potable water use reduction in process and non-regulated water consuming fixtures. The calculation methodology for demonstrating process and non-regulated water savings is similar to the calculation outlined above for regulated water use. Project teams define reasonable usage assumptions and calculate design and baseline water consumption based on high efficiency and standard water use fixtures. Process and non-regulated water use savings is then compared to regulated water use. If the process and non-regulated water use savings is at least 10% of the total design regulated water use, the project team is eligible for an Innovation in Design point.

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:

- ❑ The project's calculated occupant(s). The template will use a default one-to-one men to women ratio. Projects with special occupancy situations that result in an unbalanced ratio may enter project specific data for this credit.
- ❑ The project's calculated design case water usage (flush and flow fixtures.) This data is calculated using project specified fixture types and the project's mix of occupants. Note: project teams must provide the following fixture information for each typical installed flush fixture type: fixture manufacturer, fixture model, flush rate in gallons per flush (gpf) or flow rate in gallons per minute (gpm).
- ❑ The project's calculated baseline water usage (flush and flow fixtures.) This data is calculated using typical fixture types (provided in the template) and the project's mix of occupants.
- ❑ For projects using non-potable water for sewage conveyance, provide the total non-potable water supply (gal) available for sewage conveyance purposes.
- ❑ Narrative describing the potable water reduction strategies employed by the project. For projects using non-potable water, include specific information regarding any reclaimed water usage (graywater re-use/rainwater reuse/on-site treated wastewater).

Considerations

Cost Issues

Water-conserving fixtures that use less water than requirements in the Energy Policy Act of 1992 may have higher initial costs. Additionally, there may be a longer lead time for delivery because of their limited availability. However, installation of water-efficient fixtures and equipment can result in significant, long-term financial and environmental savings.

For example, the first cost of non-water-using urinals is marginally higher than conventional urinals and additional train-

ing of maintenance personnel is required to ensure that O&M staff understands the specific cleaning and maintenance procedures. Minor construction savings may be realized by eliminating the urinal supply piping. Significant long-term operational savings can occur as a result of reduced sewage generation and elimination of potable water use.

Environmental Issues

The reduction of potable water use in buildings for toilets, showerheads and faucets reduces the total amount withdrawn from rivers, streams, underground aquifers and other water bodies. Another benefit of potable water conservation is reduced energy use and chemical inputs at municipal water treatment works.

Water use reductions, in aggregate, allow municipalities to reduce or defer the capital investment needed for water supply and wastewater treatment infrastructure. These strategies protect the natural water cycle and save water resources for future generations.

Economic Issues

Reductions in water consumption minimize overall building operating costs. Reductions can also lead to more stable municipal taxes and water rates. By handling reduced water volumes, water treatment facilities can delay expansion and maintain stable water prices.

Accelerated retrofits of high-efficiency plumbing fixtures through incentive programs has become a cost-effective way for some municipalities to defer, reduce or avoid capital costs of needed water supply and wastewater facilities.

Regional Issues

Local weather conditions should be factored into determining the feasibility of rainwater harvesting systems for use in reduction of potable water for flushing. Local building and health codes/ordinances vary with regards to allowance of graywater or harvested rainwater for use in sewage conveyance. Additionally, codes differ in how alternative plumbing fixtures, such as dual-flush water closets, composting toilets and non-water using urinals are handled. It is critical to confirm acceptability of non-traditional approaches with code officials prior to commitment to specific water saving strategies.

Supply water quality from graywater and recycled water systems should also be considered in fixture selection. Project teams should identify if minimum supply water quality standards have been established for specific fixtures by manufacturers. When recycled graywater or collected rainwater is used with plumbing fixtures designed for use with municipally supplied potable water, it is good practice to verify that supply water quality is acceptable and will not compromise long-term fixture performance.

Resources

Web Sites

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

American Rainwater Catchment Systems Association

www.arcsa-usa.org

Includes a compilation of publications, such as the Texas Guide to Rainwater Harvesting.

Choosing a Toilet

www.taunton.com/finehomebuilding/pages/h00042.asp

An article in *Fine Homebuilding* that includes several varieties of water efficient toilets.

Composting Toilet Reviews

www.buildinggreen.com/features/mr/waste.html

(802) 257-7300

An *Environmental Building News* article on commercial composting toilets.

National Climatic Data Center

www.ncdc.noaa.gov/oa/climate/aasc.html

Useful site for researching local climate data, such as rainfall data for rainwater harvesting calculations. Includes links to state climate offices.

Rocky Mountain Institute

www.rmi.org/sitepages/pid15.php

This portion of RMI's Web site is devoted to water conservation and efficiency. The site contains information on commercial, industrial and institutional water use, watershed management, and articles on policy and implementation.

Smart Communities Network

http://www.smartcommunities.ncat.org/

This U.S. Department of Energy project provides information about water efficiency and national and regional water efficiency assistance programs, and links to additional resources.

Terry Love's Consumer Toilet Reports

www.terrylove.com/crtoilet.htm

This Web site offers a plumber's perspective on many of the major toilets used in commercial and residential applications.

Water Closet Performance Testing

www.ebmud.com/conserving_&_recycling/toilet_test_report/default.htm

This site provides two reports on independent test results for flush performance and reliability for a variety of different toilets.

Water Efficiency Manual for Commercial, Industrial and Institutional Facilities

www.p2pays.org/ref/01/00692.pdf

A straightforward manual on water efficiency from a number of different North Carolina government departments.

Water Measurement Manual: A Water Resources Technical Publication

www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/

This U.S. Department of the Interior publication is a guide to effective water measurement practices for better water management.

Water Use Efficiency Program

www.epa.gov/owm/water-efficiency

This Web site provides an overview of the U.S. EPA's Water Use Efficiency Program and information about using water more efficiently.

Water Wiser: The Water Efficiency Clearinghouse

www.awwa.org/waterwiser

(800) 926-7337

This Web clearinghouse provides articles, reference materials and papers on all forms of water efficiency.

Definitions

Blackwater does not have a single definition that is accepted nationwide. Wastewater from toilets and urinals is, however, always considered blackwater.

Wastewater from kitchen sinks (perhaps differentiated by the use of a garbage disposal), showers, or bathtubs may be considered blackwater by state or local codes. Project teams should comply with the blackwater definition as established by the authority having jurisdiction in their areas.

Composting Toilet Systems are dry plumbing fixtures that contain and treat human waste via microbiological processes.

Automatic Fixture Sensors are motion sensors that automatically turn on/off lavatories, sinks, water closets and urinals. Sensors may be hard wired or battery operated.

Graywater (also spelled greywater, gray water) is defined by the Uniform Plumbing Code (UPC) in its Appendix G, titled "Gray water Systems for Single-Family Dwellings " as "untreated household wastewater which has not come into contact with toilet waste. Gray water includes used water from bathtubs, showers, bathroom wash basins, and water from clothes-washer and laundry tubs. It shall not include wastewater from kitchen sinks or dishwashers. "

The International Plumbing Code (IPC) defines graywater in its Appendix C, titled "Gray Water Recycling Systems "as "wastewater discharged from lavatories, bathtubs, showers, clothes washers, and laundry sinks."

Some states and local authorities allow kitchen sink wastewater to be included in graywater. Other differences with the UPC and IPC definitions can probably be found in state and local codes. Project teams should comply with the graywater definitions as established by the authority having jurisdiction in their areas.

Metering Controls are generally manual on/automatic off controls which are used to limit the flow time of water. These types of controls are most commonly installed on lavatory faucets and on showers.

Potable Water is water that is suitable for drinking and is supplied from wells or municipal water systems.

Process Water is water used for industrial processes and building systems such as cooling towers, boilers and chillers.

A **Non-Water-Using Urinal** is a urinal that uses no water, but instead replaces the water flush with a specially designed trap that contains a layer of buoyant liquid that floats above the urine layer, blocking sewer gas and urine odors from the room.

Endnotes

[1] Bilderback, T.E., and M.A. Powell. Efficient Irrigation. North Carolina Cooperative Extension Service, Publication Number AG-508-6, March 1996. 21 January 2005. www.bae.ncsu.edu/programs/extension/publicat/wqwm/ag508_6.html

[2] United States Environmental Protection Agency, Office of Water. Water-Efficient Landscaping. EPA Publication 832-F-02-002, September 2002. 21 January 2005. http://www.epa.gov/OW-OWM.html/water-efficiency/docs/water-efficient_landscaping_508.pdf

[3] Connellan, Goeff. Efficient Irrigation: A Reference Manual for Turf and Landscape. University of Melbourne. 2002. 21 January 2005. www.sewl.com.au/sewl/upload/document/WaterConManual.pdf

Endnotes

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 for New Construction 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

EA Prerequisite 1
Fundamental Commissioning of the Building Energy Systems

EA Prerequisite 2
Minimum Energy Performance

EA Prerequisite 3
Fundamental Refrigerant Management

EA Credit 1
Optimize Energy Performance

EA Credit 2
On-Site Renewable Energy

EA Credit 3
Enhanced Commissioning

EA Credit 4
Enhanced Refrigerant Management

EA Credit 5
Measurement & Verification

EA Credit 6
Green Power

Table 1: EA Credit Characteristics

Credit	Significant Change from Version 2.1	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 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 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 for New Construction 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 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 for New Construction 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 for New Construction 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 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

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

specifications. Placing all commissioning requirements in one location puts 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 Web site at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Web Sites

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.

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Prerequisite 1

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 Web site 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

http://www.bcxa.org/resources/index.shtm

"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 1					

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; 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.

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 for New Construction 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 for thermostats (off-hours including setback and optimum start/stop), stair and elevator vents, outdoor air supply and exhaust vents, heat pump auxiliary 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 Web site at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Web Sites

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.

Fundamental Refrigerant Management

SS | WE | EA | MR | EQ | ID

Prerequisite 3

Required

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. 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.

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 (CO_2)	0	1.0	
Ammonia (NH_3)	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. En-

vironmental 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 Web site at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Web Sites

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.

Optimize Energy Performance

SS | WE | **EA** | MR | EQ | ID

Credit 1

1–10 points

2 Points mandatory for LEED for New Construction projects registered after June 26, 2007

GREENING OPPORTUNITY

Can assist in certification under LEED for Existing Buildings

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.

NOTE: LEED for New Construction projects registered after June 26th, 2007 are required to achieve at least two (2) points under EAc1.

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 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

** Note: Only projects registered prior to June 26, 2007 may pursue 1 point under EAc1.*

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;
- ❑ 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. 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: Advanced Buildings™ Core Performance™ Guide (2–5 Points)

Comply with the prescriptive measures identified in the Advanced Buildings™ Core Performance™ Guide developed by the New Buildings Institute.

- ❑ The Core Performance Guide is applicable for buildings under 100,000 square feet.
- ❑ The Core Performance Guide is NOT applicable for health care, warehouse or laboratory projects.
- ❑ Project teams must fully comply with Sections One, Design Process Strategies and Two, Core Performance Requirements.

Minimum points achieved under Option 3 (2–3 points):

- ❑ 3 points are available for all office, school, public assembly, and retail projects under 100,000 square feet that comply with Sections One and Two of the Core Performance Guide.
- ❑ 2 points are available for all other project types under 100,000 square feet (except health care, warehouse, or laboratory projects) that implement the basic requirements of the Core Performance Guide

Additional points available under Option 3 (up to 2 additional points):

❑ Up to 2 additional points are available to projects that implement performance strategies listed in Section Three, Enhanced Performance. For every three strategies implemented from this section, one point is available.

Any strategies applicable to the project may be implemented within this section except:

❑ 3.1-Cool Roofs

❑ 3.8-Night Venting

❑ 3.13-Additional Commissioning

These strategies are addressed by different aspects of the LEED program and are not eligible for additional points under EA Credit 1.

OR

OPTION 4 — PRESCRIPTIVE COMPLIANCE PATH (1 Point)

Note: projects registered after June 26, 2007 may not use this option

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.

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)

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

American Society of Heating, Refrigerating and Air-Conditioning Engineers

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 Core Performance Program

The Advanced Buildings Core Performance program has been adopted by the USGBC as a prescriptive path alternative to energy modeling for projects under 100,000 sf. Following the requirements of the Core Performance program can achieve 2–5 LEED points under EA credit 1. (See the application language in the credit discussion for project specific application and energy point achievement).

The Advanced Buildings program was developed by the New Buildings Institute to provide a prescriptive program to exceed the energy performance requirements of ASHRAE 90.1. The program was designed to provide a predictable alternative to energy performance modeling, and a simple set of criteria that can be implemented by design teams to significantly increase building energy performance.

The Advanced Buildings Core Performance program is an updated version of the Advanced Buildings Benchmark program. Core Performance is calibrated to exceed the requirements of ASHRAE 90.1-2004 in all climate zones.

Information about the Core Performance program requirements and a range of additional reference material is available at www.advancedbuildings.net.

There are several aspects the Core Performance program that overlap with other LEED credits and prerequisites. Following the Core Performance program is not an alternative path to achieving any LEED credits other than EA credit 1, although some aspects of Core Performance may also support achievement of the requirements of other LEED credits and prerequisites.

OPTION 4—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 4, 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

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

energy cost calculated for a proposed design." The term "Baseline Building Performance" refers to "the annual energy cost for a building design intended for 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 Core Performance Guide describes the requirements of the program. The

Guide is divided into five basic sections, describing different elements of the program requirements. In the Core Performance program, specific program requirements are referred to as criteria.

Introduction

The introduction section includes a brief overview of the Core Performance program, including the analysis protocols used to develop the program. The introduction also includes a Quick Start Guide that provides a program overview, and a table that correlates the program criteria (requirements) to other LEED credits.

Section 1 - Design Process Requirements - (REQUIRED under Option 3)

This section describes a series of requirements that address the design process to encourage the development of a more integrated building design. Most of the criteria in this section are typically implemented by LEED project teams, and can help the team to track building performance issues more effectively through the design and construction process. LEED projects following the prescriptive path for points under EA credit 1 must implement all of the criteria listed in this section of the Core Performance Guide.

The specific criteria in this section of Core Performance are:

1.1 Identify Design Intent
1.2 Communicating Design Intent
1.3 Building Configuration
1.4 Mechanical System Design
1.5 Acceptance Testing
1.6 Operator Training
1.7 Performance Data Review

Section 2 Core Performance Requirements - (REQUIRED under Option 3)

This section includes the specific energy performance measures that form the basis of achievement of energy savings under the Core Performance program, compared to ASHRAE 90.1-2004. Projects using the program to achieve EA credit 1 points prescriptively must implement all of the criteria listed in this section of the Core Performance Guide. (Note that under some specific conditions, certain criteria in Core Performance may not be applicable to specific projects. For example projects without server rooms need not implement the Dedicated Mechanical Systems criteria).

The specific criteria in this section of Core Performance are:

1.1 Energy Code Compliance
1.2 Air Barrier Performance
1.3 Indoor Air Quality
1.4 Below Grade Insulation
1.5 Envelope Performance
1.6 Fenestration
1.7 Lighting Controls
1.8 Lighting Power Density
1.9 Mechanical Efficiency
1.10 Dedicated Mechanical Systems
1.11 Demand Control Ventilation
1.12 Hot Water System Efficiency
1.13 Fundamental Economizer Performance

Section 3 - Enhanced Performance Strategies-(OPTIONAL for additional points)

The criteria identified in this section are not required when using the Core Performance program as a prescriptive path in LEED. These strategies can be used to increase the number of LEED points achieved using the Core Performance program. For each three (3) additional Enhanced Performance Strategies implemented by a project, one (1) additional EA credit 1 point can be achieved. (A maximum of two (2) additional points can be achieved, in addition to the points achieved from the required measures under Sections One and Two.)

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Credit 1

Several of the criteria in the Enhanced Performance section of Core Performance do not qualify for additional points under EAc1. These strategies are addressed by different aspects of the LEED program. The list below identifies all of the Enhanced Strategy Criteria which can be used to achieve additional LEED EA credit 1 points:

3.1 (not applicable)

2.2 Daylighting and Controls

2.3 Additional Lighting Power Reductions

2.4 Plug Loads/Appliance Efficiency

2.5 Supply Air Temperature Reset (VAV)

2.6 Indirect Evaporative Cooling

2.7 Heat Recovery

2.8 (not applicable)

2.9 Premium Economizer Control

2.10 Variable Speed Drives

2.11 Demand Responsive Buildings

2.12 Renewable Energy

2.13 (not applicable)

2.14 Fault Detection Diagnostics

Not all of the criteria listed in the Enhanced Strategy section can be applied effectively to all projects. The design team must evaluate the measures described to decide on applicability on a project by project basis.

Section 4 - Energy Modeling (NOT APPLICABLE for Option 3 prescriptive path under EAc1)

The Core Performance program is designed as a prescriptive path for energy performance. Energy modeling is included as an option in Core Performance for projects that wish to demonstrate comparable performance under some state and utility programs. This is not a part of the LEED prescriptive path option. Projects which undertake energy modeling for LEED credit must comply with the energy performance requirements described in LEED, using ASHRAE 90.1-Appendix G as a baseline.

The Core Performance program is designed as a prescriptive measure program, and as such is calibrated to the prescriptive requirements of ASHRAE 90.1-2004. Projects which use Appendix G as a baseline may be required to utilize a different mechanical system baseline, and therefore may not be able to demonstrate the same level of relative energy savings as suggested by the Core Performance program. The relative performance of the baseline does not affect the predicted energy use of the proposed building, but does affect the performance of the project relative to LEED.

OPTION 4

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, 3 and 4 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 for New Construction 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 construc-

tion, 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 for New Construction 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

> trick Question

Figure 1: 3-D Rendering of Proposed Design

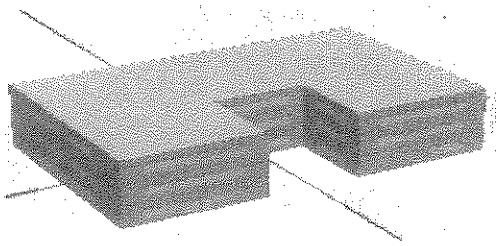
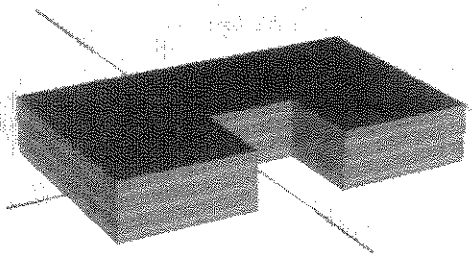


Figure 2: 3-D Rendering of Baseline Design



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 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 modeler 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

Projects pursuing EAc1, Option 1, that demonstrate a percentage improvement in the proposed building performance rating compared to the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2004 by the following

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 with 3,680 equivalent full load hours of operation	Telecom rooms, one per floor, 2.3kW peak with 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 Btu/h]	Energy [10^6 Btu]	Peak [10^6 Btu/h]	Energy [10^6 Btu]	Peak [10^6 Btu/h]	Energy [10^6 Btu]	Peak [10^6 Btu/h]	Energy [10^6 Btu]	Peak [10^6 Btu/h]	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 [10^6 Btu]	Energy Cost [$/yr]	Energy Consumption [10^6 Btu]	Energy Cost [$/yr]	Energy Consumption [10^6 Btu]	Energy Cost [$/yr]	Energy Consumption [10^6 Btu]	Energy Cost [$/yr]	Energy Consumption [10^6 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%**

minimum energy cost savings percentages will be considered for one additional point under the Innovation in Design category:

- ❑ New Buildings: 45.5%
- ❑ Existing Buildings: 38.5%

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 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 Web site at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Web Sites

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 COMcheck-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 Web site 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

(303) 275-3000

and

Sustainable Buildings Industry Council (SBIC)

http://www.nrel.gov/buildings/energy10.html

(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

http://www.eere.energy.gov/buildings/

(877) 337-3463

This extensive Web site 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

SS | WE | EA | MR | EQ | ID

Credit 1

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

Advanced Buildings™ Core Performance™ Guide

The Advanced Buildings program was developed by the New Buildings Institute to provide a prescriptive program to exceed the energy performance requirements of ASHRAE 90.1. The program was designed to provide a predictable alternative to energy performance modeling, and a simple set of criteria that can be implemented by design teams to significantly increase building energy performance.

http://advancedbuildings.net/corePerf.htm

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.

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 points, the headquarters building for the Alberici Corporation was awarded LEED® Platinum rating under LEED for New Construction v2.0. 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.

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.

SS	WE	EA	MR	EQ	ID
Credit 1					

On-Site Renewable Energy

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 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 3: EA Credit 2 Eligible & Ineligible Bio-Fuels

For the purposes of EA Credit 2, energy 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
Energy 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.

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

An innovation in design point for exemplary performance may be available when the next incremental percentage threshold is achieved. For on-site renewable energy, the % of renewable energy must be 17.5% or greater.

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 Web site at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Web Sites

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 Web site 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 Web site 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 Web site at http://www.eere.energy.gov/greenpower/markets/netmetering.shtml.

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.

Enhanced Commissioning

SS | WE | EA | MR | EQ | ID

Credit 3

1 point

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 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 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 for New Construction addresses building commissioning in two places, EA Prerequisite 1 and EA Credit 3. The exact scope of services for commissioning a LEED for New Construction 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

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

commissioning process activities into the construction documents; aids in the coordination of static and dynamic system testing; verifies staff training; and concludes with warranty verification and commissioning documentation.

The specific tasks satisfying this LEED for New Construction 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 setpoints
- ❑ 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. 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 Web site 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.

Enhanced Refrigerant Management

Credit 4

1 point

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 Gross ARI rated 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 = Gross ARI rated cooling capacity of an individual HVAC or refrigeration unit (Tons)

Qtotal = Qtotal = Total Gross ARI rated 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 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 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 typical service life of different types of

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

Refrigerant	10 Year Life (Room or Window AC & Heat Pumps)	15 Year Life (Unitary, split and packaged AC and heat pumps)	20 Year Life (Reciprocating compressors & chillers)	23 Year Life (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

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 Gross ARI rated 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 ≤ 100

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

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

Where

- Qunit = Gross ARI rated cooling capacity of an individual HVAC or refrigeration unit (tons)
- Qtotal = Total Gross ARI rated 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

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	352	508.6	1017
1	1	R22	1,780	0.04	2.1	10	2%	10%	30%	112.1	252	364.1	364
Qtotal:	63 tons											Subtotal:	6825
Average Refrigerant Atmospheric Impact = [∑ (LCGWP + LCODP x 105) x Qunit] / Qtotal :													108.3

- ❑ (12) 2-ton telephone/data room split system cooling units with HCFC-22

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 trade-offs 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."

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	210	303	15173
5	10	R22	1,780	0.04	2.4	15	2%	10%	40%	113.9	256	369.9	18496
Qtotal:	**600 tons**											**Subtotal:**	**52608**
Average Refrigerant Atmospheric Impact = [∑ (LCGWP + LCODP x 105) x Qunit] / Qtotal :													**87.7**

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 10^5) x Qunit] / Qtotal :													**96.9**

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

- ❑ 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 Web site at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Web Sites

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.

Measurement & Verification

SS | WE | EA | MR | EQ | ID

Credit 5

1 point

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.evo-world.org/ipmvp.php

Efficiency Valuation Organization (EVO) 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 **Construction 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 Web site at www.usgbc.org/resources for more specific resources on materials sources and other technical information.

Web Sites

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

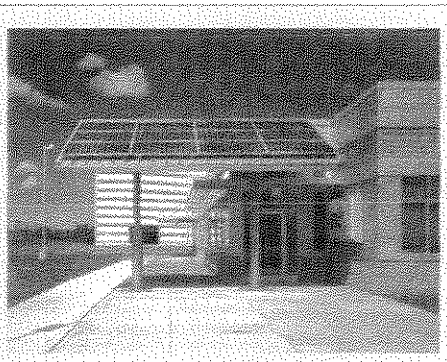
Energy Conservation Measures (ECMs) are installations of equipment or systems, or modifications of equipment or systems, for the purpose of reducing energy use and/or costs.

Case Study

Frito-Lay Jim Rich Service Center

Rochester, NY

Owner: Frito Lay, Inc.



The Frito-Lay Jim Rich Service Center is a LEED for New Construction 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 photovoltaics, 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.

Green Power

1 point

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

NOTE: The power product purchased to comply with credit requirements need not be Green-e certified, but projects are required to document to USGBC that their renewable supplier has 1) met the Green-e criteria, and 2) properly accounted for the eligible renewable resources sold. This documentation to USGBC must include some type of meaningful verification work performed by a qualified, disinterested third party.

Example documentation methods to USGBC that meet this requirement include: a) providing a state-mandated power disclosure label from the renewable supplier in states with meaningful regulatory requirements for renewable energy disclosure and accounting practices, as well as meaningful penalties for violations; b) providing a green power scorecard or rating from a credible, independent entity that performs meaningful verification of green power characteristics and accounting practices. In either case projects must confirm that the third-party entity's regulatory or verification programs are meaningful, summarizing those programs to USGBC as part of their certification application and highlighting any auditing or other independent checks the program performs. Other documentation methods will be considered on a case-by-case basis.

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.

Table 1: Commercial Buildings Energy Consumption Survey (CBECS) data, from U.S. DOE Energy Information Administration

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

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

Exemplary performance can be achieved by doubling the requirements, either by the amount of electricity or the length of contract.

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

Web Sites

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 Web site 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.

Materials and Resources

Building materials choices are important in sustainable design because of the extensive network of extraction, processing and transportation steps required to process them. Activities to create building materials may pollute the air and water, destroy natural habitats and deplete natural resources. Construction and demolition wastes constitute about 40% of the total solid waste stream in the United States.

Maintaining occupancy rates in existing buildings reduces redundant development and the associated environmental impact of producing and delivering all new materials. Reuse of existing buildings, versus building new structures, is one of the most effective strategies for minimizing environmental impacts. When rehabilitation of existing buildings components is included in the strategy, waste volumes can be reduced or diverted from landfills. Reuse results in less habitat disturbance and typically less infrastructure. An effective way to use salvaged interior components is to specify them in the construction documents. The actions of an increasing number of public and private waste management operations have reduced construction debris volumes by recycling these materials. Recovery activities typically begin with job-site separation into multiple bins or disposal areas. In some areas, regional recycling facilities are being constructed to accept comingled waste and separate the recyclable materials from those that must go to the landfill. These facilities are achieving waste diversion rates of 80% or greater in many areas.

When materials are selected for a project, it is important to evaluate new and different sources. Salvaged materials can be substituted for new materials, save costs and add character. Recycled-content materials reuse waste products that would otherwise be deposited in landfills. Use of local materials supports the local economy and reduces transportation. Use of rapidly renewable materials minimizes natural resource consumption and has the potential to better match the harvest cycle of the resource with the life of the material in buildings. Use of third-party certified wood improves the stewardship of forests and the related ecosystems.

Materials Cost

While projects are encouraged to determine the actual total materials cost (excluding labor and equipment) for calculation purposes, LEED for New Construction allows project teams to apply a 45% factor to total costs (including labor and equipment) to establish a default total materials cost for the project.

Materials & Resources Credit Characteristics

Table 1 shows which credits were substantially revised for 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.

The Materials and Resources credits are organized around several key parameters and categories. **Table 2** shows the metrics used to determine compliance with each credit, such as area, weight and cost. The table also shows which materials are included and excluded in the calculations. Materials that are blacked out in the table below are excluded from the corresponding credit calculations.

Overview of LEED® Prerequisites and Credits

MR Prerequisite 1
Storage & Collection of Recyclables

MR Credit 1.1
Building Reuse—Maintain 75% of Existing Walls, Floors & Roof

MR Credit 1.2
Building Reuse—Maintain 95% of Existing Walls, Floors & Roof

MR Credit 1.3
Building Reuse—Maintain 50% of Interior Non-Structural Elements

MR Credit 2.1
Construction Waste Management—Divert 50% from Disposal

MR Credit 2.2
Construction Waste Management—Divert 75% from Disposal

MR Credit 3.1
Materials Reuse—5%

MR Credit 3.2
Materials Reuse—10%

MR Credit 4.1
Recycled Content—10% (post-consumer + 1/2 pre-consumer)

MR Credit 4.2
Recycled Content—20% (post-consumer + 1/2 pre-consumer)

MR Credit 5.1
Regional Materials—10% Extracted, Processed & Manufactured Regionally

MR Credit 5.2
Regional Materials—20% Extracted, Processed & Manufactured Regionally

MR Credit 6
Rapidly Renewable Materials

MR Credit 7
Certified Wood

Table 1: MR Credit Characteristics

Credit	Significant Change from Version 2.1	Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
MRp1: Storage & Collection of Recyclables		*		*	*	
MRc1.1: Building Reuse, 75% of Walls, Floors, Roof			*	*	*	
MRc1.2: Building Reuse, 95% of Walls, Floors, Roof			*	*	*	
MRc1.3: Building Reuse, Maintain 50% of Interior Non-Structural Elements	*		*	*	*	
MRc2: Construction Waste Management			*			*
MRc3: Resource Reuse			*		*	*
MRc4: Recycled Content	*		*		*	*
MRc5: Regional Materials	*		*		*	*
MRc6: Rapidly Renewable Materials			*		*	*
MRc7: Certified Wood			*		*	*

Special notes:

- Materials qualifying as reused for MR Credit 3.1 and 3.2 cannot be applied to MR Credits 1, 2, 4, 6 or 7.
- Projects that are incorporating existing buildings but do not meet the requirements for MR Credit 1 may apply the reused portions of the existing buildings towards the achievement of MR Credit 2, Construction Waste Management.

Table 2: MR Credit Metrics

Material	MRc1: Building Reuse	MRc2: Construction Waste Management	MRc3: Materials Reuse	MRc4: Recycled Content	MRc5: Regional Materials	MRc6: Rapidly Renewable Materials	MRc7: Certified Wood
CSI Divisions 2 thru 10	Based on area	Based on weight or volume. Include demolition and construction waste	Based on replacement value ($)	Based on cost of qualifying materials as a percent of overall materials cost for Divisions 2–10 ($)			Based on cost of FSC wood as a percentage of all new wood ($)
Mechanical							
Electrical							
Plumbing							
Furniture & Furnishings (CSI Division 12)			May be included with Divisions 2–10, if done consistently for credits 3–7				

Overview

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Required

Storage & Collection of Recyclables

Intent

Facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.

Requirements

Provide an easily accessible area that serves the entire building and is dedicated to the collection and storage of non-hazardous materials for recycling, including (at a minimum) paper, corrugated cardboard, glass, plastics and metals.

Potential Technologies & Strategies

Coordinate the size and functionality of the recycling areas with the anticipated collection services for glass, plastic, office paper, newspaper, cardboard and organic wastes to maximize the effectiveness of the dedicated areas. Consider employing cardboard balers, aluminum can crushers, recycling chutes and collection bins at individual workstations to further enhance the recycling program.

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Dense urban areas typically have a recycling infrastructure in place while some less populated areas may still be developing this type of service. Building owners and designers must determine the most appropriate method for creating a dedicated recycling collection area that meets the project occupant's needs and also those of the collection infrastructure. It is possible that recyclable collection and storage space could increase the project footprint in some instances. It is important to address possible indoor environmental quality (IEQ) impacts on occupants due to recycling activities. Those activities that create odors, noise and air contaminants should be isolated or performed during non-occupant hours to maintain optimal IEQ. **Table 1** provides guidelines for the recycling storage area based on overall building square footage. The requirements of this prerequisite do not regulate the size of the recycling area. The intent is for the design team to size the facilities appropriate to the specific building operations, and the information provided below is intended as a resource for that exercise.

Designate well marked collection and storage areas for recyclables including office paper, cardboard, glass, plastic and metals. Locate a central collection and storage area in the basement or at the ground level that provides easy access for maintenance staff as well as collection vehicles. For projects with larger site areas, it may be possible to create a separate central collection area that is not located within the building footprint.

Design considerations for recycling areas should include signage to prevent contamination, protection from the elements, and security for high value materials. Security of recyclable collection areas should also be designed to discourage illegal disposal. Allocate recycling space in common areas as well as a centralized collection point. Common areas may be more easily maintained if recycling containers are no larger than 20–25 gallons. It may be beneficial to specify recycling bins that have wheeled carts to transport the recyclables from the common area to a centralized collection area. At the centralized collection point, it is useful to design enough space for a front-loader bin as well as a ramp up to the recycling area.

It may be helpful to research local recycling programs to find the best method of diverting recyclable materials from the waste stream for your particular building location. When allocating space for the centralized collection point of recyclables, it is beneficial to involve the local hauler who will be providing waste management services to the site. Space allocation needs can vary depending upon collection strategies used by the hauler such as comingled or source separated recyclables. For example, if the local hauler accepts comingled recyclables, then it may be possible to reduce the area that would be required if separate collection bins for each material were required. There is no requirement for projects to provide proof of contract for hauling services to achieve this prerequisite.

Table 1: Recycling Area Guidelines

Commercial Building Square Footage [sf]	Minimum Recycling Area [sf]
0 to 5,000	82
5,001 to 15,000	125
15,001 to 50,000	175
50,001 to 100,000	225
100,001 to 200,000	275
200,001 or greater	500

Where possible, provide instruction to occupants and maintenance personnel on recycling procedures. Encourage activities to reduce and reuse materials before recycling in order to reduce the amount of recyclable volumes handled. For instance, building occupants can reduce the solid waste stream by using reusable bottles, bags and other containers. Consider employing cardboard balers, aluminum can crushers, recycling chutes and other waste management technologies to further enhance the recycling program.

Calculations

There are no calculations required to demonstrate compliance with this prerequisite. **Table 1** is provided as a guideline for sizing recycling areas. The values in this table were developed by the city of Seattle in support of an ordinance requiring minimum areas for recycling and storage of recyclables in commercial buildings. The ordinance is based on the total square footage of the building. Minimum areas for residential buildings were also specified in that reference document.

Another potential source of guidelines for sizing recycling areas is the California Integrated Waste Management Board's (CIWMB) 1999 Statewide Waste Characterization Study, in which the waste disposal rates of 1,200 businesses were measured. See the References section of this prerequisite for details.

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 recycling collection areas have been provided, per requirements, to meet the needs of the project.
- ❑ Confirm the types of materials that are being collected for recycling.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's prerequisite approach.

Considerations

Environmental Issues

By creating convenient recycling opportunities for building occupants, a significant portion of the solid waste stream can be diverted from landfills. Recycling of paper, metals, cardboard and plastics reduces the need to extract virgin natural resources. For example, recycling one ton of paper prevents the processing of 17 trees and saves three cubic yards of landfill space. Recycled aluminum requires only 5% of the energy required to produce virgin aluminum from bauxite, its raw material. Recycling also reduces environmental impacts of waste in landfills. Land, water and air pollution impacts can all be reduced by minimizing the volume of waste sent to landfills.

Economic Issues

Recycling requires minimal initial cost and offers significant savings in reduced landfill disposal costs or tipping fees. However, recycling activities use floor space that could be used otherwise. In larger projects, processing equipment such as can crushers and cardboard balers are effective at minimizing the space required for recycling activities. Some recyclables can generate revenue which can help to offset the cost of their collection and processing.

Resources

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

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Web Sites

California Integrated Waste Management Board

www.ciwmb.ca.gov/WasteChar/

Solid Waste Characterization Database, Estimated Solid Waste Generation Rates

California Statewide Solid Waste Characterization Study

www.ciwmb.ca.gov/Publications/default.asp?pubid=1097

Alternative Waste Calculations

California Integrated Waste Management Board's (CIWMB) Statewide Waste Characterization Study in which the waste disposal rates of businesses are measured.

Earth 911

www.earth911.org/master.asp

(480) 889-2650 or 877-EARTH911

Information and education programs on recycling as well as regional links to recyclers.

Recycling at Work

U.S. Conference of Mayors

www.usmayors.org/USCM/recycle

(202) 293-7330

A program of the U.S. Conference of Mayors that provides information on workplace recycling efforts.

Waste at Work

Inform: Strategies for a Better Environment

www.informinc.org/wasteatwork.php

(212) 361-2400

An online document from Inform, Inc., and the Council on the Environment of New York City on strategies and case studies to reduce workplace waste generation.

Print Media

Composting and Recycling Municipal Solid Waste by Luis Diaz et al., CRC Press, 1993.

McGraw-Hill Recycling Handbook by Herbert F. Lund, McGraw-Hill, 2000.

Definitions

Recycling is the collection, reprocessing, marketing and use of materials that were diverted or recovered from the solid waste stream.

A **Landfill** is a waste disposal site for the deposit of solid waste from human activities.

SS | WE | EA | MR | EQ | ID

Credit 1.1

1 point

Building Reuse

Maintain 75% of Existing Walls, Floors & Roof

Intent

Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Maintain at least 75% (based on surface area) of existing building structure (including structural floor and roof decking) and envelope (exterior skin and framing, excluding window assemblies and non-structural roofing material). Hazardous materials that are remediated as a part of the project scope shall be excluded from the calculation of the percentage maintained. If the project includes an addition to an existing building, this credit is not applicable if the square footage of the addition is more than 2 times the square footage of the existing building.

Potential Technologies & Strategies

Consider reuse of existing, previously occupied buildings, including structure, envelope and elements. Remove elements that pose contamination risk to building occupants and upgrade components that would improve energy and water efficiency such as windows, mechanical systems and plumbing fixtures. Quantify the extent of building reuse.

SS | WE | EA | MR | EQ | ID

Credit 1.2

1 Point
in addition to
MR Credit 1.1

Building Reuse

Maintain 95% of Existing Walls, Floors & Roof

Intent

Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Maintain an additional 20% (95% total, based on surface area) of existing building structure (including structural floor and roof decking) and envelope (exterior skin and framing, excluding window assemblies and non-structural roofing material). Hazardous materials that are re-mediated as a part of the project scope shall be excluded from the calculation of the percentage maintained. If the project includes an addition to an existing building, this credit is not applicable if the square footage of the addition is more than 2 times the square footage of the existing building.

Potential Technologies & Strategies

Consider reuse of existing, previously occupied buildings, including structure, envelope and elements. Remove elements that pose contamination risk to building occupants and upgrade components that would improve energy and water efficiency such as windows, mechanical systems and plumbing fixtures. Quantify the extent of building reuse.

SS | WE | EA | MR | EQ | ID

Credit 1.3

1 point

Building Reuse

Maintain 50% of Interior Non-Structural Elements

Intent

Extend the life cycle of existing building stock, conserve resources, retain cultural resources, reduce waste and reduce environmental impacts of new buildings as they relate to materials manufacturing and transport.

Requirements

Use existing interior non-structural elements (interior walls, doors, floor coverings and ceiling systems) in at least 50% (by area) of the completed building (including additions). If the project includes an addition to an existing building, this credit is not applicable if the square footage of the addition is more than 2 times the square footage of the existing building.

Potential Technologies & Strategies

Consider reuse of existing, previously occupied buildings, including structure, envelope and interior non-structural elements. Remove elements that pose contamination risk to building occupants and upgrade components that would improve energy and water efficiency, such as mechanical systems and plumbing fixtures. Quantify the extent of building reuse.

SS	WE	EA	MR	EQ	ID
Credit 1					

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

For any project that is reusing portions of an existing building, it is recommended that the project team inventory the existing conditions. Develop a floor plan showing the location of existing structural components, finished ceilings, finished flooring, interior wall partitions, doors within the interior walls, exterior and party walls, and exterior windows and doors. If there are existing built-in case goods that will be reused, they should be documented as well. The drawings should provide the detail needed to determine the surface area of all these pre-existing elements.

Confirm that the items designated for reuse can be reused. Take the needed steps to retain them in the finished work. Fixed items, such as walls and doors that are found on-site are included in this credit and count toward the percentage of reuse when they perform the same function (i.e., doors reused as doors). If they are used for another purpose (i.e., doors made into tables), they contribute to earning MR Credits 3.1 and 3.2.

Projects that are incorporating existing buildings but do not meet the requirements for MR Credit 1 may apply the reused portions of the existing buildings toward the achievement of MR Credit 2, Construction Waste Management. To do so, project teams will be required to determine an approximate weight for existing building elements.

Calculations

MR Credit 1.1 / 1.2

This credit is based on surface areas of major existing building structural and envelope elements. Structural support elements, such as columns and beams, are considered to be a part of the larger surfaces they are supporting and are not required to be quantified separately. Prepare a spreadsheet listing all envelope and structural elements within the building. Quantify each item, listing existing area (sq.ft.) and retained area (sq.ft.). Determine the percent of existing elements that are retained by dividing the total retained materials area (sq.ft.) by the total existing materials area (sq.ft.). Projects that retain a minimum of 75% of existing envelope and structural components will be awarded 1 point for MR Credit 1.1. Projects that retain a minimum of 95% of existing envelope and structural components will be awarded 2 points (MR Credit 1.1 and MR Credit 1.2).

The area measurements are made in the same way as would be completed by a contractor preparing a bid for construction of a building. For structural floors and roof decking, calculate the square footage of each component. For existing exterior walls and existing walls adjoining other buildings or additions, calculate the exterior wall surface area (sq.ft.) only and subtract the area of exterior windows and exterior doors from both the existing and reused area tallies. For interior structural walls (i.e., shear walls), calculate the surface area (sq.ft.) of both sides of the existing wall element.

Table 1 below provides an example of the calculations for MR Credit 1.1 and 1.2.

Project teams should exclude the following items from this calculation: non-structural roofing materials; window assemblies; structural and envelope materials that are deemed to be unsound from a structural perspective; structural

Table 1: Example Building Structure / Envelope Reuse Calculation

Structure / Envelope Element	Existing Area (SF)	Reused Area (SF)	Percentage Reused (%)
Foundation / Slab on Grade	11,520	11,520	100%
2nd Floor Deck	11,520	10,000	87%
1st Floor Interior Structural Walls	240	240	100%
2nd Floor Interior Structural Walls	136	136	100%
Roof Deck	11,520	11,520	100%
North Exterior Wall (excl. windows)	8,235	7,150	87%
South Exterior Wall (excl. windows)	8,235	8,235	100%
East Exterior Wall (excl. windows)	6,535	6,535	100%
West Exterior Wall (excl. windows)	6,535	5,820	81%
TOTALS	**64,476**	**61,156**	**95%**

and envelope materials that are considered hazardous and pose a contamination risk to building occupants.

MR Credit 1.3

This credit is focused on reuse of interior, non-structural elements, and compares the retained/reused elements to the total completed area of interior elements. It is not necessary to calculate the total area of existing interior non-structural elements prior to demolition.

Prepare a spreadsheet listing all interior non-structural elements within the building. Quantify each item, listing total area (sq.ft.)—including new construction—and area (sq.ft.) of retained elements. Determine the percent of existing elements that are retained by dividing the total area (sq.ft.) of all retained interior non-structural elements by the total area (sq.ft.) of interior non-structural elements. Projects demonstrating that the total area (sq.ft.) of existing and/or reused non-structural interior components account for a minimum of 50% of the area of all interior non-structural building elements will be awarded 1 point for MR Credit 1.3. **Achievement of MR Credit 1.1 or 1.2 is not required for projects to be considered for MR Credit 1.3.**

Finished ceilings and finished flooring areas (tile, carpeting, etc.) are straightforward and should be calculated as simple areas (one sided). For interior non-structural walls, determine the finished area between floor and ceiling. Note: both sides of interior non-structural walls should be calculated. For example: an interior, non-structural wall that is 20 feet long and 10feet high (from floor to finished ceiling) should be counted as 400 sq.ft. (20 ft x 10 ft x 2) to account for both sides of the wall.

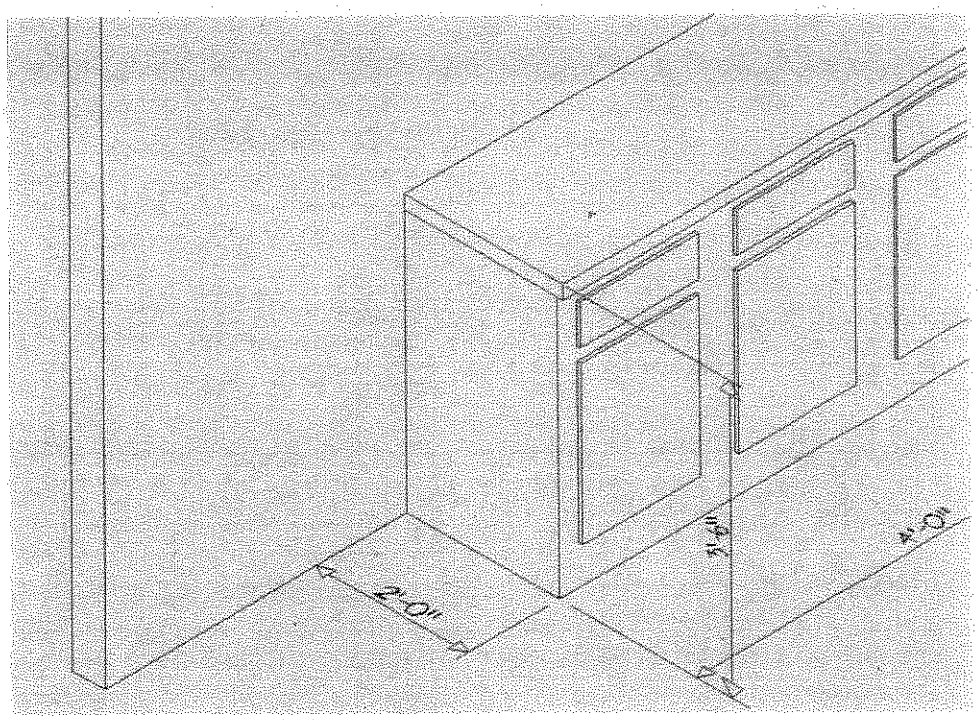
The surface area of interior doors should be calculated and counted only once. Interior casework that is retained should be calculated using the visible surface area of the assembly. **Figure 1** below provides an example of how to calculate casework.

Table 2 provides an example of a tabulation spreadsheet that can be used for determining credit compliance. In the example, the total area (sq.ft.) of all new and existing building materials (following construction) is entered in the "Total Area" column. The total area (sq.ft.) of only the existing/reused components is then entered in the "Existing/Reused Area" column. The sum of the existing materials is then divided by the sum of the total building materials to obtain the overall percentage of reused materials. Since the overall percentage of reused non-structural interior materials is greater than 50% of the total area of all non-structural interior building materials, the project would be eligible for one point under MR Credit 1.3.

SS | WE | EA | MR | EQ | ID

Credit 1

Figure 1: Area Calculation for Existing Casework



Surface	Area (SF)
Top	8
Left Side	7
Front	14
Rear	0
Right Side	0
TOTAL REUSED CASEWORK	**29**

Remember to include items that have been saved but may have been relocated in this tabulation, such as full-height demountable walls and doors that were re-hung in a new section of wall. Items counted in this credit are not to be included in MR Credits 3.1 and 3.2. However, if the project includes an addition that is greater than 200% of the existing building's square footage, the reused existing building's materials may be included in the calculations for MR Credit 2.

Exemplary Performance

There are no exemplary performance points available for these credits.

Submittal Documentation

These credits are 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:

MR Credit 1.1 / 1.2

- ❑ Confirm whether the project is strictly a renovation of an existing building or a renovation with an addition. For projects with additions, confirm the square footage of the new addition(s).
- ❑ Provide a tabulation of the existing and reused areas (sq.ft.) of each structural/envelope element.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's approach.

Table 2: Example: Interior Non-Structural Reuse Calculation

Interior Non-Structural Element	Total Area* (SF)	Existing / Reused Area (SF)	Percentage Reused (%)
Gypsum Board Wall Partitions – Full Height	5,400	3,600	67%
Gypsum Board Wall Partitions – Partial Height	650	650	100%
Carpeting	10,000	0	0%
Resilient Flooring	350	350	100%
Ceramic Tile	150	150	100%
Suspended Ceiling Systems	10,400	10,400	100%
Gypsum Board Ceilings	350	350	100%
Interior Doors (Wood)	525	420	80%
Interior Windows / Sidelights	56	56	100%
Interior Doors (Metal)	42	42	100%
Interior Casework / Cabinetry	235	150	64%
TOTALS	**28,158**	**16,168**	**57%**

** Note: The Total Area calculation includes both new and existing/reused materials.*

MR Credit 1.3

- ❑ Confirm whether the project is strictly a renovation of an existing building or a renovation with an addition. For projects with additions, confirm the square footage of the new addition(s).
- ❑ Provide a tabulation of the total and reused areas (sq.ft.) of each non-structural interior element.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's approach.

Considerations

Environmental Issues

Reusing existing buildings significantly reduces construction waste volumes. Reuse strategies also reduce environmental impacts associated with raw material extraction, manufacture and transportation.

Economic Issues

Reuse of existing components can reduce the cost of construction substantially. For instance, the Southern California Gas Company reused an existing building for its Energy Resource Center and estimated savings of approximately $3.2 million, based on typical first costs for a 44,000 square-foot building. The largest savings were realized in masonry (87% savings), site work (57% savings), concrete (49% savings) and carpentry (70% savings).

Resources

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

Print Media

How Buildings Learn: What Happens After They're Built by Stewart Brand.

Definitions

Prior Condition is the state the project space was in at the time it was selected. Removing the demolition work from the project scope by making it the building owner's responsibility defeats the objective of this credit.

Prior Condition Area is the total area of finished ceilings, finished floors, full height walls and demountable partitions, interior doors and built-in case goods that existed when the project area was selected; exterior windows and exterior doors are not considered.

SS | WE | EA | MR | EQ | ID

Credit 1

Completed Design Area is the total area of finished ceilings, finished floors, full height walls and demountable partitions, interior doors and built-in case goods in the space when the project is completed; exterior windows and exterior doors are not considered.

Retained Components are those portions of the finished ceilings, finished floors, full height walls and demountable partitions, interior doors and built-in case goods that existed in the prior condition that remained in the completed design.

Interior Non-Structural Components Reuse is determined by dividing the total area (sq. ft.) of retained interior, non-structural components by the total area (sq. ft.) of the interior, non-structural components included in the completed design.

Case Study

S.T. Dana Building Renovations
Ann Arbor, MI

Owner: University of Michigan

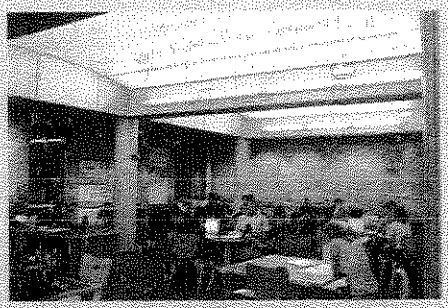


Photo © University of Michigan Photo Services

The S.T. Dana Building, of the University of Michigan's School of Natural Resources & Environment (SNRE), has been awarded LEED Gold Certification under LEED for New Construction for its green building renovations. During renovation, the project maintained 97% of the existing building structure, 98% of the existing building shell, and 61% of the non-shell areas. Where possible, demolished materials were salvaged and reused in the new construction. When designing renovation plans, the University of Michigan strove to create a building that was both a comfortable place to learn and work and simultaneously demonstrated state-of-the-art environmentally conscious design. The building now serves as a laboratory and educational center for ecological disciplines.

SS | WE | EA | MR | EQ | ID

Credit 2.1

1 point

Construction Waste Management

Divert 50% from Disposal

Intent

Divert construction and demolition debris from disposal in landfills and incinerators. Redirect recyclable recovered resources back to the manufacturing process. Redirect reusable materials to appropriate sites.

Requirements

Recycle and/or salvage at least 50% of non-hazardous construction and demolition. Develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or comingled. Excavated soil and land-clearing debris does not contribute to this credit. Calculations can be done by weight or volume, but must be consistent throughout.

Potential Technologies & Strategies

Establish goals for diversion from disposal in landfills and incinerators and adopt a construction waste management plan to achieve these goals. Consider recycling cardboard, metal, brick, acoustical tile, concrete, plastic, clean wood, glass, gypsum wallboard, carpet and insulation. Designate a specific area(s) on the construction site for segregated or comingled collection of recyclable materials, and track recycling efforts throughout the construction process. Identify construction haulers and recyclers to handle the designated materials. Note that diversion may include donation of materials to charitable organizations and salvage of materials on-site (see page 253).

SS | WE | EA | MR | EQ | ID

Credit 2.2

1 Point
in addition to
MR Credit 2.1

Construction Waste Management

Divert 75% from Disposal

Intent

Divert construction and demolition debris from disposal in landfills and incinerators. Redirect recyclable recovered resources back to the manufacturing process. Redirect reusable materials to appropriate sites.

Requirements

Recycle and/or salvage an additional 25% beyond MR Credit 2.1 (75% total) of non-hazardous construction and demolition debris. Excavated soil and land-clearing debris does not contribute to this credit. Calculations can be done by weight or volume, but must be consistent throughout.

Potential Technologies & Strategies

Establish goals for diversion from disposal in landfills and incinerators and adopt a construction waste management plan to achieve these goals. Consider recycling cardboard, metal, brick, acoustical tile, concrete, plastic, clean wood, glass, gypsum wallboard, carpet and insulation. Designate a specific area(s) on the construction site for segregated or comingled collection of recyclable materials, and track recycling efforts throughout the construction process. Identify construction haulers and recyclers to handle the designated materials. Note that diversion may include donation of materials to charitable organizations and salvage of materials on-site (see page 251).

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

MR Credits 2.1 and 2.2 address the extent to which waste material leaving the site is diverted from landfills. The percentage represents the amount diverted through recycling and salvage divided by the total waste generated.

Identify construction haulers and recyclers to handle the designated materials; they often serve as valuable partners in this effort. Make sure jobsite personnel understand and participate in the program, with updates throughout the construction process. Obtain and retain verification records (waste haul receipts, waste management reports, spreadsheets, etc.) to confirm the diverted materials have been recycled or salvaged as intended. Note that diversion may include donations to charitable organizations such as Habitat for Humanity®.

The availability of recycling opportunities tends to vary by region. In urban areas, recycling resources are typically more developed, and projects will have choices about whether to separate waste on-site or to hire a comingled waste recycler. Often, recycling construction waste can reduce project costs by significantly reducing landfill tipping fees. Comingled recycling may increase recycling costs but will simplify the waste management effort on-site and ensure that diversion rates will be high. This option is especially useful for projects with tight site constraints where there is no room for multiple collection bins. In more rural and remote areas, recyclers may be harder to find. The environmental benefits of recycling in these cases need to be balanced against the environmental impacts of transporting waste long distances to recycling centers.

Materials can be contaminated by other construction debris and food waste products. Beverages and other liquids can be particularly harmful to materials that may absorb these products, eliminating their ability to be recycled.

Projects that reuse existing buildings, but do not qualify for MR Credit 1, may apply the reused building materials towards achievement of this credit. Materials salvaged and reused on-site can contribute to this credit if they are not included in Credit 3 calculations.

Calculations

Calculations for these credits are based on the amount of waste diverted from the landfill or incineration compared to the total amount of waste generated on-site. Convert all materials to either weight or volume in order to calculate the percentage. Hazardous waste should be excluded from calculations, and should be disposed of appropriately according to relevant regulations. Additionally, excavated soil should be excluded from calculations. Projects that crush and reuse existing concrete, masonry or asphalt on-site should include these materials in the calculations for this credit. **Table 1** provides an example of a summary calculation for waste diversion.

If some data need to be converted to the chosen unit of measurement, use the conversion factors in **Table 2** or other defensible conversion (submit explanation and source for the latter).

For projects that use comingled recycling rather than on-site separation, summaries of diversion rates will be required from the recycler. Typically, the recycler should be required to provide monthly reports.

Exemplary Performance

Project teams may earn an Innovation in Design point for exemplary performance

Table 1: Sample Construction Waste Management Diversion Summary

Diverted / Recycled Materials Description	Diversion / Recycling Hauler or Location	Quantity of Diverted / Recycled Waste	Units (tons / cy)
Concrete	ABC Recycling	138.0	Tons
Wood	Z-Construction Reuse	10.2	Tons
Gypsum Wallboard	ABC Recycling	6.3	Tons
Steel	Re-Cycle Steel Collectors	1.1	Tons
Crushed Asphalt	On-Site Reuse	98.2	Tons
Masonry	ABC Recycling	6.8	Tons
Cardboard	ABC Recycling	1.6	Tons
TOTAL CONSTRUCTION WASTE DIVERTED		262.2	Tons
Landfill Materials Description	**Landfill Hauler or Location**	**Quantity of Diverted / Recycled Waste**	**Units (tons / cy)**
General Mixed Waste	XYZ Landfill	52.3	Tons
TOTAL CONSTRUCTION WASTE SENT TO LANDFILL		**52.3**	**Tons**
TOTAL OF ALL CONSTRUCTION WASTE		**314.5**	**Tons**
PERCENTAGE OF CONSTRUCTION WASTE DIVERTED FROM LANDFILL		**83.4%**	

Table 2: Solid Waste Conversion Factors

Material	Density (lbs/cy)
Cardboard	100
Gypsum Wallboard	500
Mixed Waste	350
Rubble	1,400
Steel	1,000
Wood	300

in Construction Waste Management when the percent of total waste diverted is 95% or greater.

Submittal Documentation

These credits are 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:

- ❑ Complete the construction waste calculation tables in the Submittal Template. The following information will be required to fill in these tables: general description of each type/category of waste generated; location of receiving agent (recycler/landfill) for waste; quantity of waste diverted (by category) in tons, or cubic yards.
- ❑ Provide a narrative describing the project's construction waste management approach. The narrative should include the project's Construction Waste Management Plan. Please provide any additional comments or notes to describe special circumstances or considerations regarding the project's credit approach.

Considerations

Environmental Issues

Construction and demolition (C&D) activities generate enormous quantities of solid waste. The U.S. EPA estimates that 136 million tons of C&D debris (versus 209.7 million tons of municipal solid waste) was generated in 1996—57% of it from non-residential construction, renovation and demolition activities. This equates to 2.8 pounds per capita per day. Commercial construction generates between 2 and 2.5 pounds of solid waste

per square foot, and the majority of this waste can potentially be recycled.

The greatest environmental benefit is achieved by source control—reducing the total waste generated.

Recycling opportunities are expanding rapidly in many communities. Metal, vegetation, concrete and asphalt recycling opportunities have long been available and economical in most communities. Paper, corrugated cardboard, plastics and clean wood markets vary by regional and local recycling infrastructure, but are recycled in most communities. Some materials, such as gypsum wallboard, have recycling opportunities only in communities where reprocessing plants exist or where soil can handle the material as a stabilizing agent. The recyclability of a demolished material is often dependant on the amount of contamination attached to it. Demolished wood, for instance, is often not reusable or recyclable unless it is deconstructed and de-nailed.

Recycling of construction and demolition debris reduces demand for virgin resources and, in turn, reduces the environmental impacts associated with resource extraction, processing and, in many cases, transportation. Landfills contaminate groundwater and encroach upon valuable green space. Through effective construction waste management, it is possible to extend the lifetime of existing landfills, avoiding the need for expansion or new landfill sites.

Economic Issues

In the past, when landfill capacity was readily available and disposal fees were low, recycling or reuse of construction waste was not economically feasible. Construction materials were inexpensive compared to the cost of labor; thus, construction jobsite managers focused on worker productivity rather than on materials conservation. In addition, recycling infrastructure and a recycled materials marketplace that processes and resells construction debris did not exist. In recent years, particularly with the advent of international competition for both raw and recycled materials, the economics of recycling have improved. During this same period disposal costs have increased. Recognition for, and enactment of, more stringent waste disposal regulations coupled with ever decreasing landfill capacity have changed the waste management equation.

Waste management plans require time and money to draft and implement but they can also provide the guidance to achieve substantial savings throughout the construction process.

Recyclable materials have differing market values depending on the presence of local recycling facilities, reprocessing costs and the availability of virgin materials on the market. In general, it is economically beneficial to recycle metals, concrete, asphalt and cardboard. In most cases it is possible to receive revenue as well as to avoid paying a landfill tipping fee. Market values normally fluctuate from month to month. When no revenue is received for materials, as is often the case for scrap wood and gypsum wallboard, it is still possible to benefit from potentially shorter hauling distances and by avoiding landfill tipping fees.

Resources

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

Web Sites

Construction and Demolition Debris Recycling Information

California Integrated Waste Management Board

www.ciwmb.ca.gov/ConDemo

(916) 341-6499

SS | WE | EA | MR | EQ | ID

Credit 2

A program by the California Integrated Waste Management Board including case studies, fact sheets and links.

Construction Materials Recycling Association

www.cdrecycling.org

(630) 585-7530

A nonprofit dedicated to information exchange within the North American construction waste and demolition debris processing and recycling industry.

Construction Waste Management Handbook

Smart Growth Online

www.smartgrowth.org/library/articles.asp?art=15

(202) 962-3623

A report by the NAHB Research Center on residential construction waste management for a housing development in Homestead, Florida.

Contractors' Guide to Preventing Waste and Recycling

Resource Venture

www.resourceventure.org/rv/issues/building/publications/index.php

(206) 389-7304

A guidebook on waste prevention in construction from the Business and Industry Resource Venture.

Government Resources

Check with the solid waste and natural resources departments in your city or county. Many local governments provide information about regional recycling opportunities.

Recycling and Waste Management During Construction

King County, OR

www.metrokc.gov/procure/green/wastemgt.htm

Specification language from city of Seattle and Portland Metro projects on construction waste management.

A Sourcebook for Green and Sustainable Building

www.greenbuilder.com/sourcebook/ConstructionWaste.html

A guide to construction waste management from the Sourcebook for Green and Sustainable Building.

Environmental Specifications for Research Triangle Park

U.S. Environmental Protection Agency

www.epa.gov/rtp/new-bldg/environmental/specs.htm

Waste management and other specifications.

Waste Spec: Model Specifications for Construction Waste Reduction, Reuse and Recycling

Triangle J Council of Governments

http://www.tjcog.dst.nc.us/regplan/wastspec.htm

(919) 558-9343

Model specifications developed by Triangle J Council of Governments in North Carolina. Ten case studies show results of using the specifications (downloadable PDF document).

Definitions

Construction and Demolition (C&D) Debris includes waste and recyclables generated from construction, renovation, and demolition or deconstruction of preexisting structures. Land clearing debris including soil, vegetation, rocks, etc. are not to be included.

Recycling is the collection, reprocessing, marketing and use of materials that were diverted or recovered from the solid waste stream.

Reuse is a strategy to return materials to active use in the same or a related capacity.

Tipping Fees are fees charged by a landfill for disposal of waste volumes. The fee is typically quoted for one ton of waste.

Case Study

Clearview Elementary School
Hanover, PA

Owner: Hanover Public School District

Photo © Jim Schafer Photos courtesy of L. Robert Kimball and Associates

On March 24, 2004, Clearview Elementary School in Hanover, PA, achieved LEED® v2.0 Gold, becoming the first elementary school to achieve LEED certification in Pennsylvania. Located in a mixed-use neighborhood as part of the Hanover Public School District, the project diverted 90% of their construction waste from the landfill by recycling materials, such as the concrete from the project—which was removed from the site and reused as clean back fill. The construction administration supervised the contractor's performance in managing the construction waste. In addition to constructing a LEED certified building, the school district has further committed to augmenting its curriculum to teach students about the building and its green features.

SS | WE | EA | MR | EQ | ID

Credit 3.1

1 point

Materials Reuse

5%

Intent

Reuse building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources.

Requirements

Use salvaged, refurbished or reused materials such that the sum of these materials constitutes at least 5%, based on cost, of the total value of materials on the project.

Mechanical, electrical and plumbing components and specialty items such as elevators and equipment shall not be included in this calculation. Only include materials permanently installed in the project. Furniture may be included, providing it is included consistently in MR Credits 3–7.

Potential Technologies & Strategies

Identify opportunities to incorporate salvaged materials into building design and research potential material suppliers. Consider salvaged materials such as beams and posts, flooring, paneling, doors and frames, cabinetry and furniture, brick and decorative items.

SS | WE | EA | MR | EQ | ID

Credit 3.2

1 Point
in addition to
MR Credit 3.1

Materials Reuse

10%

Intent

Reuse building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources.

Requirements

Use salvaged, refurbished or reused materials for an additional 5% beyond MR Credit 3.1 (10% total, based on cost).

Mechanical, electrical and plumbing components and specialty items such as elevators and equipment shall not be included in this calculation. Only include materials permanently installed in the project. Furniture may be included, providing it is included consistently in MR Credits 3–7.

Potential Technologies & Strategies

Identify opportunities to incorporate salvaged materials into building design and research potential material suppliers. Consider salvaged materials such as beams and posts, flooring, paneling, doors and frames, cabinetry and furniture, brick and decorative items.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Use of salvaged and refurbished materials in new building projects extends the life of materials and can reduce overall first costs of construction materials. Use of salvaged materials can also add character to the building and can be used effectively as architectural details. Some areas of the United States, such as New England, the Pacific Northwest and California, have well-developed markets for salvaged materials while other regions are just beginning to develop these markets.

For reused materials found on-site, there are two major groups. First are those items that were "fixed" components on-site before the project started. To qualify as reused for this credit, these fixed items must no longer be able to serve their original function, and must then have been reconditioned and installed for a different use or in a different location. An example would be a fire door removed and modified to serve as the counter top for the receptionist station. The remaining fixed items, such as walls, ceilings and flooring that remain as such in the new building are excluded from this credit, but are covered by MR Credits 1.2 and 1.3.

Another type of reused material found on-site is "finish" material that can be kept and refurbished. These reused components may continue to serve their original function, but have undergone refurbishment to become functional. An example would be refurbished door hardware.

For reused materials obtained from off-site, the primary stipulation for qualifying as reused is that they must have been previously used. Note: Materials eligible for reuse are not limited to materials used in buildings. These materials may be purchased as salvaged, similar to any other project material, or they may be relocated from another facility (including one previously used by the occupant). The salvaged materials from both on-site and off-site can be applied to MR Credit 5, Regional Materials, if they comply with the requirements of that credit. Materials contributing toward achievement of Credit 3 cannot be applied to MR Credits 1, 2, 4, 6 or 7. If MRc3 is not being attempted, applicable materials can be applied to another LEED credit if eligible.

Furniture and furnishings (CSI Division 12 components) are excluded from the calculations for this credit, unless they are included consistently across MR Credits 3–7. This credit applies primarily to CSI MasterFormat 1995 divisions 2–10. Mechanical and electrical components, along with appliances and equipment cannot be included in this credit, as they are generally not appropriate and/or feasible. This exclusion is consistent with MR Credits 4 and 5.

Calculations

List the reused or salvaged materials used on the project. Table 1 provides an example of a salvaged materials tracking log. Determine the cost of each material. This cost will either be the actual cost paid or the replacement value, if the material came from on-site. The replacement value can be determined by pricing a comparible material in the local market. When the actual cost paid for the reused or salvaged material is below the cost of an equivalent new item, use the higher value (or replacement cost) in the calculations. When the cost to reclaim an item found on-site is less than the cost of an equivalent new item, use the cost of the new item (or replacement cost) in the calculations.

Table 1: Sample Salvaged Materials Tracking Log

Salvaged / Reused Material Description	Source for Salvaged / Reused Material	Value / Product Cost ($)
Salvaged Brick	ABC Salvage Suppliers	$62,500
Salvaged Wood Floor	Salvage Company Y	$24,200
Remanufactured Wood Doors (Used as Built-in Countertops)	On-Site Salvage / Remanufacture	$4,200
SUB-TOTAL SALVAGED / REUSED MATERIALS		**$90,900**
TOTAL CONSTRUCTION MATERIALS COST – OR 45% DEFAULT MATERIALS VALUE		**$1,665,498**
SALVAGED / REUSED MATERIALS AS A PERCENTAGE OF TOTAL MATERIALS COST		**5.5%**

Determine the Total Materials Cost for the project. The Total Materials Cost may be derived by multiplying the total construction cost (hard costs only in CSI MasterFormat 1995 divisions 2–10) by 0.45. Alternately, the Total Materials Cost may be a tally of actual materials cost in CSI MasterFormat 1995 divisions 2–10 from the project Schedule of Values or a similar document. The benefit of using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost would find it easier to achieve the 5% and 10% credit thresholds, since total materials cost is in the denominator of the equation below.

Calculate Percent Reuse Materials according to Equation 1.

Exemplary Performance

An Innovation in Design point for exemplary performance is available when a project documents that the value of salvaged or reused materials used on the project is equal to at least 15% of the total materials cost.

Submittal Documentation

These credits are 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 total project materials cost (Divisions 2–10) or provide the total project cost for Divisions 2–10 to apply the 45% default materials value.
- ❑ Provide a tabulation of each salvaged/reused material used on the project. The tabulation must include a description of the material, the source/vendor for the material and the product cost.
- ❑ Provide a narrative describing the materials reuse strategy implemented by the project. Include specific information about reused/salvaged materials used on the project.

Considerations

Environmental Issues

Reuse strategies divert material from the construction waste stream, reducing the need for landfill space and environmental impacts pertaining to associated water and air contamination issues. Use of salvaged materials also reduces the environmental impacts of producing new construction products and materials. These impacts are significant since buildings account for

Equation 1

$$\text{Percent Reuse Materials} = \frac{\text{Cost of Reuse Materials (\$)}}{\text{Total Materials Cost (\$)}}$$

a large portion of our natural resources consumption, including 40% of raw stone, gravel and sand, and 25% of virgin wood.

Economic Issues

Some salvaged materials are more costly than new materials due to the high cost of labor involved in recovering and refurbishing processes. However, salvaged materials are often of higher quality and more durable than available new materials. Local demolition companies may be willing to sell materials recovered from existing buildings to avoid landfill tipping fees and to generate income. In some areas, municipalities and waste management companies have established facilities to sell salvaged building materials at landfill sites. Sometimes salvaged materials are offered at prices that appear to be cost-effective but may include hidden costs such as the need for reprocessing, exorbitant transportation costs or liabilities associated with toxic contamination. Conversely, certain salvaged materials may be impossible to duplicate (such as turn-of-the century lumber and casework) and may well be worth the higher cost compared to new but inferior materials.

Resources

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

Web Sites

California Materials Exchange California Integrated Waste Management Board

www.ciwmb.ca.gov/CalMAX

(877) 520-9703

A program of the California Integrated Waste Management Board, this site allows users to exchange non-hazardous discarded materials online.

Government Resources

Check with the solid waste authority and natural resources departments in your city or county. Many local governments provide information about regional materials exchanges and other sources.

Guide to Resource-Efficient Building Elements

www.crbt.org/index.html

The Center for Resourceful Building Technology Directory of environmentally responsible building products. This resource provides introductory discussions per topic and contact information for specific products, including salvaged materials. (The CRBT project is no longer active, and the CRBT Web site is no longer updated. The National Center for Appropriate Technology is providing this Web site for archival purposes only).

Materials Exchanges on the Web

Industrial Materials Exchange (IMEX) Local Hazardous Waste Management Program in King County, OR

www.govlink.org/hazwaste

(206) 296-4899

A listing of materials exchanges on the Web.

Reuse Development Organization (ReDO)

www.redo.org

(410) 669-7245

A national nonprofit located in Indianapolis, Indiana, that promotes reuse as an environmentally sound, socially beneficial and economical means of managing surplus and discarded materials. See the List of ReDO Subscribers for contacts around the United States.

Salvaged Building Materials Exchange

Green Building Resource Guide

www.greenguide.com/exchange/search.html

A searchable database of salvaged building materials.

Building Materials Reuse Association (formerly Used Building Materials Association)

www.ubma.org

(877) 221-UBMA

BMRA is a nonprofit, membership-based organization that represents companies and organizations involved in the acquisition and/or redistribution of used building materials.

Used Building Materials Exchange

www.build.recycle.net

(519) 767-2913

A free marketplace for buying and selling recyclables and salvaged materials.

Old to New: Design Guide, Salvaged Building Materials in New Construction

The Greater Vancouver Regional District (GVRD)

http://www.lifecyclebuilding.org/resources/Old%20to%20New%20Design%20Guide.pdf

A useful and detailed guide book, produced by the Greater Vancouver Regional District, to the use of salvaged materials, with real-life case studies.

Definitions

Chain-of-Custody is a tracking procedure to document the status of a product from the point of harvest or extraction to the ultimate consumer end use.

Salvaged or Reused Materials are construction materials recovered from existing buildings or construction sites and reused in other buildings. Common salvaged materials include structural beams and posts, flooring, doors, cabinetry, brick and decorative items.

Recycled Content

10% (post-consumer + 1/2 pre-consumer)

SS | WE | EA | MR | EQ | ID

Credit 4.1

1 point

GREENING OPPORTUNITY

Can assist in certification under LEED for Existing Buildings

Intent

Increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials.

Requirements

Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes at least 10% (based on cost) of the total value of the materials in the project.

The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

Mechanical, electrical and plumbing components and specialty items such as elevators shall not be included in this calculation. Only include materials permanently installed in the project. Furniture may be included, providing it is included consistently in MR Credits 3–7.

Recycled content shall be defined in accordance with the International Organization for Standardization document, *ISO 14021—Environmental labels and declarations—Self-declared environmental claims (Type II environmental labeling).*

Post-consumer material is defined as waste material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purpose.

Pre-consumer material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.

Potential Technologies & Strategies

Establish a project goal for recycled content materials and identify material suppliers that can achieve this goal. During construction, ensure that the specified recycled content materials are installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.

SS | WE | EA | MR | EQ | ID

Credit 4.2

1 Point
in addition to
MR Credit 4.1

Recycled Content

20% (post-consumer + 1/2 pre-consumer)

Intent

Increase demand for building products that incorporate recycled content materials, thereby reducing the impacts resulting from extraction and processing of virgin materials.

Requirements

Use materials with recycled content such that the sum of post-consumer recycled content plus one-half of the pre-consumer content constitutes an additional 10% beyond MR Credit 4.1 (total of 20%, based on cost) of the total value of the materials in the project.

The recycled content value of a material assembly shall be determined by weight. The recycled fraction of the assembly is then multiplied by the cost of assembly to determine the recycled content value.

Mechanical, electrical and plumbing components and specialty items such as elevators shall not be included in this calculation. Only include materials permanently installed in the project. Furniture may be included, providing it is included consistently in MR Credits 3–7.

Recycled content shall be defined in accordance with the International Organization for Standardization document, *ISO 14021—Environmental labels and declarations—Self-declared environmental claims (Type II environmental labeling)*.

Post-consumer material is defined as waste material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product, which can no longer be used for its intended purpose.

Pre-consumer material is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it.

Potential Technologies & Strategies

Establish a project goal for recycled content materials and identify material suppliers that can achieve this goal. During construction, ensure that the specified recycled content materials are installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.

Summary of Referenced Standard

International Standard ISO 14021 – 1999 - Environmental Labels and Declarations — Self-Declared Environmental Claims (Type II Environmental Labeling)

International Organization for Standardization (ISO)

www.iso.org

This International Standard specifies requirements for self-declared environmental claims, including statements, symbols and graphics, regarding products. It further describes selected terms commonly used in environmental claims and gives qualifications for their use. This International Standard also describes a general evaluation and verification methodology for self-declared environmental claims and specific evaluation and verification methods for the selected claims in this standard. The definitions section for this credit contains the relevant details, and thus the standard need not be acquired.

Approach and Implementation

Recycled content goals should be established during the design phase. Careful research may be required to determine the percentages of recycled content that can realistically be expected in specific products and materials. Project teams are encouraged to run a preliminary calculation during the design phase as soon as a project budget is available in order to set appropriate recycled content targets. Many standard materials in the marketplace contain recycled content as a matter of course due to the nature and economics of their manufacture (examples include steel, gypsum board, and acoustical ceiling tile). Other materials may require research by design and construction teams to achieve higher levels of recycled content or to verify which models of a certain product line feature the desired recycled content (examples include carpet and ceramic tile).

The project team should work with subcontractors and suppliers to verify availability of materials that contain recycled content. The contractor should run preliminary calculations based on the construction budget or schedule of values during the preconstruction phase whenever possible. This will allow the construction team to focus during the buy-out phase on those materials with the greatest contribution to the project recycled content value.

The project team is typically responsible for documenting the amounts and values of recycled content of any given material used on the project. The project team must identify products which contain recycled content and pursue documentation from suppliers, manufacturers and vendors directly or through the subcontractors to confirm the actual recycled content for each product.

It is also important to distinguish between post-consumer and pre-consumer recycled content when tracking materials for the purpose of credit calculations. Detailed definitions of these terms are provided in the Definitions section of this guide.

Calculations

To calculate the percentage of recycled content materials used on a project, list all recycled content materials and products and their costs. For each product, identify the percentage of post-consumer and/or pre-consumer recycled content by weight, and list the recycled content information source. Note that LEED requires that the information be from a reliable, verifiable source.

Calculate the Recycled Content Value of each material according to Equation 1.

Equation 1

Recycled Content Value ($) = (% post-consumer recycled content x material cost) + 0.5 x (% pre-consumer recycled content x material cost)

Determine the Total Materials Cost for the project.

The Total Materials Cost may be derived by multiplying the total construction cost (hard costs for CSI MasterFormat 1995 divisions 2–10 only) by 0.45. Alternately, the Total Materials Cost may be a tally of actual materials cost (CSI MasterFormat 1995 divisions 2–10 only) from the project Schedule of Values or similar document. The benefit of using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost would find it easier to achieve the 10% and 20% credit thresholds, since total materials cost is in the denominator of the equation below. The purpose of the default value is to streamline the documentation process, as it can be challenging to separate the materials costs from labor and equipment costs for all materials on the project.

Calculate the project Percent Recycled Content according to Equation 2.

Furniture and furnishings (CSI Division 12 components) are excluded from the calculations for this credit, unless they are included consistently across MR Credits 3–7. This credit applies primarily to CSI MasterFormat 1995 divisions 2–10. Mechanical, electrical and plumbing components, along with appliances and equipment cannot be included in this credit. These are excluded because, when compared with structural and finish materials, mechanical and electrical equipment tends to have a high dollar value relative to the amount of material it contains. That high dollar value would skew the results of the calculation, reducing the incentive to use recycled-content in high-mass materials.

Default Recycled Content

For steel products where no recycled content information is available, assume the recycled content to be 25% post-consumer. No other material has been recognized as having a similar consistent minimum recycled content. Note that many steel products will contain 90%, or higher, recycled content if manufactured by the electric arc furnace process, so it may be beneficial for a project to obtain actual information from the manufacturer rather than relying on the default value.

Calculating Assembly Recycled Content

Assemblies include all products that are composed of multiple materials, either in reaching a formulation for a material (i.e., composite wood panels), or of all the sub-components (i.e., a window system). For assembly recycled content values, consider the percents by weight of the post-consumer recycled content and the pre-consumer recycled content in the assembly. When there are sub-components, the final two percentages (post-consumer and pre-consumer) must be determined by using the weights of the smaller sub-component elements. No consideration is given to relative costs of the materials or the sub-components, when calculating these percentages of recycled content. For example, a pound of steel in a window assembly is of equal significance in determining recycled content of an assembly as a pound of fabric on a movable wall panel.

Equation 2

$$\text{Percent Recycled Content} = \frac{\text{Total Recycled Content Value ($)}}{\text{Total Materials Cost ($)}}$$

Supplementary Cementitious Materials

In the case of supplementary cementitious materials (SCMs) used in concrete that are recycled from other operations, it is allowable to calculate the recycled content value based on the mass of the cementitious materials only, rather than on the entire concrete mix. For example, if 150 pounds of coal fly ash is used per yard of concrete, the fly ash would represent only a small fraction (5%) of the roughly 3,000 pounds of materials in that concrete. The project team can choose instead to calculate it as a fraction of the cementitious materials only. To accomplish this, the value of the cementitious materials will have to be obtained from the concrete supplier separately from the total cost of the concrete. (See **Example 1**.) Note: fly ash is a Pre-Consumer Recycled Content material.

Exemplary Performance

Project teams may earn an Innovation in Design point for exemplary performance when the requirements reach the next incremental step. For recycled content, the total recycled value must be 30% or greater.

Submittal Documentation

These credits are 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 total project materials cost (Divisions 2–10) or provide the total project cost for Divisions 2–10 to apply the 45% default materials value.
- ❑ Provide a tabulation of each material used on the project that is being tracked for recycled content. The tabulation must include a description of the material, the manufacturer of the material, the product cost, the pre-consumer and/or post-consumer recycled content percentage, and the source of the recycled content data.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's credit approach.

Considerations

Environmental Issues

Building products with recycled content are beneficial to the environment because they reduce virgin material use and solid waste volumes. Success breeds future success: as the number of building products containing recycled content grows, the marketplace for recycled materials develops.

Economic Issues

Many commonly used products are now available with recycled content, including metals, concrete, masonry, acoustic tile, carpet, ceramic tile and insulation. Most recycled content products exhibit per-

Example 1: Sample Supplementary Cementitious Materials Calculation

Mix #	Mass of Portland cement* [lbs]	Mass of recycled SCMs [lbs]	Mass of total cementitious materials [lbs]	SCMs as a percentage of total cementitious materials [%]	Dollar value of all cementitious materials (from concrete supplier)	Recycled content value per yard [(SCM/2) x dollar value]
2	200	50	250	20%	$35	$3.50
3	300	100	400	25%	$45	$5.63

**This column also includes any other cementitious ingredients that are not recycled.*

formance similar to products containing only virgin materials and can be incorporated into building projects with ease and minimal to no cost premium.

Resources

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

Web Sites

Recycled Content Product Directory

California Integrated Waste Management Board

www.ciwmb.ca.gov/rcp

(916) 341-6606

A searchable database for recycled content products, developed by the California Integrated Waste Management Board.

Government Resources

Check with the solid waste and natural resources departments in your city or county. Many local governments provide information on recyclers and recycled content product manufacturers within their region.

GreenSpec

BuildingGreen, Inc.

www.buildinggreen.com/menus/index.cfm

(802) 257-7300

Detailed listings for more than 1,900 green building products, including environmental data, manufacturer information and links to additional resources.

Guide to Resource-Efficient Building Elements

www.crbt.org/index.html

The Center for Resourceful Building Technology Directory of environmentally responsible building products. This resource provides introductory discussions per topic and contact information for specific products, including salvaged materials. (The CRBT project is no longer active, and the CRBT Web site is no longer updated. The National Center for Appropriate Technology is providing this Web site for archival purposes only).

Oikos

www.oikos.com

A searchable directory of resource-efficient building products and sustainable design educational resources.

"Recycled Content: What is it and What is it Worth?"

Environmental Building News, February 2005.

www.buildinggreen.com/auth/article.cfm?filename=140201a.xml

U.S. EPA Comprehensive Procurement Guidelines Program

www.epa.gov/cpg/products.htm

Contains EPA information on recycled content materials with guidelines for recycled percentages. Includes a searchable database of suppliers.

Definitions

Assembly Recycled Content includes the percentages of post-consumer and pre-consumer content. The determination is made by dividing the weight of the recycled content by the overall weight of the assembly.

Post-Consumer Waste is material generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for its intended purpose. This includes returns of materials from the distribution chain (Source: ISO 14021). Examples of this category include construction and demolition debris, materials collected through curbside and drop-off recycling programs, broken pallets (if from a pallet refurbishing company, not a pallet mak-

ing company), discarded products (e.g. furniture, cabinetry and decking) and urban maintenance waste (leaves, grass clippings, tree trimmings, etc.).

Pre-Consumer Content, previously referred to as Post-Industrial Content, is defined as material diverted from the waste stream during the manufacturing process. Excluded is reutilization of materials such as rework, regrind or scrap generated in a process and capable of being reclaimed within the same process that generated it (Source ISO 14021). Examples in the pre-consumer category include planer shavings, plytrim, sawdust, chips, bagasse, sunflower seed hulls, walnut shells, culls, trimmed materials, print overruns, over-issue publications, and obsolete inventories.

SS | WE | EA | MR | EQ | ID

Credit 4

Regional Materials

SS | WE | EA | MR | EQ | ID

Credit 5.1

1 point

10% Extracted, Processed & Manufactured Regionally

Intent

Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.

Requirements

Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500 miles of the project site for a minimum of 10% (based on cost) of the total materials value. If only a fraction of a product or material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value.

Mechanical, electrical and plumbing components and specialty items such as elevators and equipment shall not be included in this calculation. Only include materials permanently installed in the project. Furniture may be included, providing it is included consistently in MR Credits 3–7.

Potential Technologies & Strategies

Establish a project goal for locally sourced materials, and identify materials and material suppliers that can achieve this goal. During construction, ensure that the specified local materials are installed and quantify the total percentage of local materials installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.

GREENING OPPORTUNITY

Can assist in certification under LEED for Existing Buildings

SS | WE | EA | MR | EQ | ID

Credit 5.2

1 Point
in addition to
MR Credit 5.1

Regional Materials

20% Extracted, Processed & Manufactured Regionally

Intent

Increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.

Requirements

Use building materials or products that have been extracted, harvested or recovered, as well as manufactured, within 500 miles of the project site for an additional 10% beyond MR Credit 5.1 (total of 20%, based on cost) of the total materials value. If only a fraction of the material is extracted/harvested/recovered and manufactured locally, then only that percentage (by weight) shall contribute to the regional value.

Potential Technologies & Strategies

Establish a project goal for locally sourced materials and identify materials and material suppliers that can achieve this goal. During construction, ensure that the specified local materials are installed. Consider a range of environmental, economic and performance attributes when selecting products and materials.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

Careful research may be required to determine what products can be sourced locally and can realistically be expected to be purchased for the project. As a result, it may be beneficial to evaluate this credit early in the design process, despite the appearance of it being exclusively a construction consideration. Project teams are encouraged to run a preliminary calculation during the design phase, as soon as a project budget is available, in order to set appropriate regional materials targets. For example, if the project has a $10 million budget, the materials cost (and subsequently 10% of that cost) can be estimated using the 45% default rate. The team would calculate that the project would need to use at least $450,000 of materials meeting the requirements of this credit to achieve MR Credit 5.1 ($450,000 is 10% of $4.5 million, which is 45% of the $10 million project cost). This estimate will likely be high, since the final calculation is based on Divisions 2–10, but it is still useful as a conservative estimate.

The general contractor should work with subcontractors and suppliers to verify availability of materials which are extracted/harvested/recovered and manufactured locally (within 500 miles of the project site). The contractor should run preliminary calculations based on the construction budget or schedule of values during the preconstruction phase whenever possible. This will allow the construction team to focus on those materials with the greatest contribution to this credit during the buy-out phase.

The general contractor is typically responsible for documenting the amounts and values of regionally harvested and manufactured materials used on the project. The general contractor must track the materials cost of each locally harvested and manufactured product that will be applied to the LEED credit.

Calculations

List those products that are believed to be extracted/harvested/recovered and manufactured within 500 miles of the project site.

Indicate the name of the manufacturer, the product cost, the distance between the project site and the manufacturer, and the distance between the project site and the extraction site for each raw material contained within each product.

Determine the Total Materials Cost for the project.

The Total Materials Cost may be derived by multiplying the total construction cost (hard costs for CSI MasterFormat 1995 divisions 2–10 only) by 0.45. Alternately, the Total Materials Cost may be a tally of actual materials cost (CSI MasterFormat 1995 divisions 2–10 only) from the project Schedule of Values or similar document. The benefit to using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost would find it easier to achieve the 10% and 20% credit thresholds, since total materials cost is in the denominator of the equation below. The purpose of the default value is to streamline the documentation process, as it is often challenging to break out the materials costs from labor and equipment costs for all materials on the project.

Calculate the Percent Local Materials according to Equation 1.

Furniture and furnishings (CSI Division 12 components) are excluded from the calculations for this credit, unless they are considered consistently across MR

Equation 1

$$\text{Percent Local Materials} = \frac{\text{Total Cost of Local Materials (\$)}}{\text{Total Materials Cost (\$)}}$$

Credits 3–7. This credit applies primarily to CSI MasterFormat 1995 divisions 2–10. Mechanical, electrical and plumbing components, along with appliances and equipment cannot be included in this credit for reasons of fairness and simplification: limited manufacturing locations, skewed results due to relatively high cost compared to the actual mass of materials in the product, and the complexity of some systems is not conducive to gathering the data needed for LEED credits (the exclusion also applies to credits 3 and 4).

Reused and Salvaged Materials

Reused and salvaged materials that satisfy the requirements of MR Credits 3.1 and 3.2, may also contribute to MR Credits 5.1 and 5.2. The location from which they were salvaged is to be used as the point of extraction, and the location of the salvaged goods vendor is to be used as the point of manufacture. On-site salvaged materials automatically qualify.

For a material with more than one point of manufacture or extraction, all within the 500-mile radius, list a single item with the greatest distance. If a portion of the material was either manufactured or extracted beyond the 500-mile radius, list only that portion and associated cost satisfying the credit requirement.

For assemblies or products manufactured within the 500-mile radius but containing only some components that also were extracted within the 500-mile radius, use multiple lines in your list. Base the proportionality of such products' costs on the weight of their various components. (See the example for concrete shown in **Table 1** and **Table 2**.)

Exemplary Performance

An Innovation in Design point for exemplary performance may be available when the next incremental percentage threshold is achieved. For regionally harvested, extracted and manufactured materials, the credit calculation must be 40% or greater.

Submittal Documentation

These credits are submitted as part of the **Construction Submittal**.

Table 1: Sample Assembly Percent Regionally Extracted Calculation for Concrete

Components	Weight [lbs]	Distance between Project & Extraction Site [miles]	Weight Contributing to Regional Extraction [lbs]
Cement	282	1,250	0
Fly Ash	282	125	282
Water	275	1	275
Slag	750	370	750
Recycled Concrete & Aggregate	1,000	8	1,000
Sand	1,200	18	1,200
Component Totals	3,789		3,507
Percent Regionally Extracted Materials [3,507 / 3,789]			92.6%

Table 2: Sample MR Credit 5 Calculation

Product	Manufacturer	Distance Between Project & Manufacturer [mi]	Distance Between Project & Extraction/ Harvest [mi]	Product Cost [$]	Value Qualifying as Regional	Information Source
Plant material	Green's Landscape	5	5	$6,770	$6,770	contractor submittal
Concrete aggregate	Joe's Concrete	15	15	$21,000	$21,000	contractor submittal
Insulation	UR Warm	105	1,080	$9,250	-	product cut sheet
Gypsum board	Gypsum R Us	75	288	$8,550	$8,550	letter from manufacturer
Carpet	Fiber Good	355	721	$15,333	-	letter from manufacturer
Casework	Top Counter	18	320	$12,200	$12,200	contractor submittal
Lumber	My Mill	110	320	$38,990	$38,990	contractor submittal
Wood Doors	Closeby	71	320	$7,000	$7,000	contractor submittal
Total Cost of Regional Materials					**$94,510**	
Total Materials Cost (Divisions 2–10)					**$751,000**	
Percent Regional Materials					**13%**	
Points Earned					**1**	

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

- ❑ Provide the project's total project cost (for application of 45% default factor) or total materials cost. Note this reported value must be consistent across all MR credits.
- ❑ Complete the regional materials calculation table in the Submittal Template. The following information will be required to fill in this table: product name for each tracked material; material manufacturer; total product cost for each tracked material; percentage of product, by weight, that meets both the extraction and manufacture criteria; distance between the project site and extraction/harvest/recovery site; distance between the project site and the final manufacturing location.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's credit approach.

Considerations

Environmental Issues

By purchasing regionally manufactured building materials, the local economy is supported, transportation costs and environmental impacts are reduced, and money paid for these materials is retained in the region, supporting the regional economy. The availability of regionally manufactured building materials is dependent on the project location. In some areas, the majority of products needed for the project can be obtained within a 500-mile radius. In other areas, only a small portion or none of the building materials can be sourced locally. It also is important to address the

source of raw materials used to manufacture building products. Raw materials for some building products are harvested or extracted far from the point of manufacture, contributing to air and water pollution due to environmental impacts associated with transportation between point of extraction and point of manufacture.

The use of regional building materials reduces transportation activities and the accompanying pollution associated with delivering materials to the job site. Trucks, trains, ships and other vehicles deplete finite reserves of fossil fuels and generate air pollution. By selecting building materials that are produced from regional materials, transportation impacts are further reduced.

Economic Issues

Regional building materials are more cost effective for projects due to reduced transportation costs. Also, the support of regional manufacturers and labor forces retains capital for the community, contributing to a more stable tax base and a healthier local economy.

Resources

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

Government Resources

Check with your local Chamber of Commerce and regional and state economic development agencies for building materials manufacturers in your area.

Definitions

Regionally Manufactured Materials, for use in this credit, must be assembled as a finished product within a 500-mile radius of the project site. Assembly, as used for this credit definition, does not include on-site assembly, erection or installation of finished components, as in structural steel, miscellaneous iron or systems furniture.

Regionally Extracted Materials, for use in this credit, must have their source as a raw material from within a 500-mile radius of the project site.

Rapidly Renewable Materials

SS | WE | EA | MR | EQ | ID

Credit 6

1 point

GREENING OPPORTUNITY

Can assist in certification under LEED for Existing Buildings

Intent

Reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials.

Requirements

Use rapidly renewable building materials and products (made from plants that are typically harvested within a ten-year cycle or shorter) for 2.5% of the total value of all building materials and products used in the project, based on cost.

Potential Technologies & Strategies

Establish a project goal for rapidly renewable materials and identify products and suppliers that can support achievement of this goal. Consider materials such as bamboo, wool, cotton insulation, agrifiber, linoleum, wheatboard, strawboard and cork. During construction, ensure that the specified renewable materials are installed.

Summary of Referenced Standard

There is no standard referenced for this credit.

Approach and Implementation

After the project goal has been established for the use of rapidly renewable materials, identify the materials and suppliers that meet the stated criteria and that can achieve this goal, and incorporate products into the project specifications and plans. Project teams are encouraged to run a preliminary calculation during the design phase, as soon as a project budget is available, in order to determine the feasibility of this credit. For example, if the project has a $10 million budget, the materials cost (and subsequently 2.5% of that cost) can be estimated using the 45% default rate. The team would calculate that the project would need to use at least $112,500 of materials meeting the requirements of this credit ($112,500 is 2.5% of $4.5 million, which is 45% of the $10 million project cost). This estimate will likely be high, since the final calculation is based on Divisions 2–10, but it is still useful as a conservative estimate.

Table 1: Examples of Rapidly Renewable Materials

Examples of Rapidly Renewable Materials
Bamboo Flooring
Cotton Batt Insulation
Linoleum Flooring
Sunflower Seed Board Panels
Wheatboard Cabinetry
Wool Carpeting
Cork Flooring

See examples of rapidly renewable materials in **Table 1.** During construction, ensure that the specified rapidly renewable materials are installed.

Calculations

Identify those products that are considered rapidly renewable and their material costs to the project.

Determine the Total Materials Cost for the project.

The Total Materials Cost may derived by multiplying the total construction cost (hard costs for CSI MasterFormat 1995 divisions 2–10 only) by 0.45. Alternately, the Total Materials Cost may be a tally of actual materials cost (CSI MasterFormat 1995 divisions 2–10 only) from the project Schedule of Values or similar document. The benefit to using actual materials costs, as opposed to the default 45%, is that projects with less than 45% materials cost would find it easier to achieve the credit thresholds, since total materials cost is in the denominator of the equation below. The purpose of the default value is to streamline the documentation process, as it is often challenging to break out the materials costs from labor and equipment costs for all materials on the project.

Calculate the Percent of Rapidly Renewable Materials using Equation 1.

Assembly Rapidly Renewable Content

Assemblies include all products that are made of multiple materials, either in reaching a formulation for a material (i.e., particle board), or of all the subcomponents (i.e., a work surface). For assembly rapidly renewable content, the fraction of the assembly that is considered rapidly

Equation 1

$$\text{Percent of Rapidly Renewable Materials} = \frac{\text{Total Cost of Rapidly Renewable Materials (\$)}}{\text{Total Materials Cost (\$)}}$$

renewable is determined by weight. That fraction is then applied to the material cost to determine the rapidly renewable material cost for that assembly.

Exemplary Performance

An Innovation in Design point for exemplary performance may be available when the next incremental percentage threshold is achieved. For rapidly renewable materials, the percentage must be 5% or greater.

Submittal Documentation

This credit 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 project's total project cost (for application of 45% default factor) or total materials cost. Note this reported value must be consistent across all MR credits.
- ❑ Complete the rapidly renewable materials calculation table in the Submittal Template. The following information will be required to fill in this table: product name for each tracked material; material manufacrurer; total product cost for each tracked material; percentage of product, by weight, for each material that meets the rapidly renewable criteria.
- ❑ Provide an optional narrative describing any special circumstances or considerations regarding the project's credit approach.

Considerations

Environmental Issues

Many conventional building materials require large inputs of land, natural resources, capital and time. Conversely, rapidly renewable materials generally require less of these inputs and are therefore likely to be more environmentally responsible. Rapidly renewable resources are those materials that substantially replenish themselves faster than traditional extraction demand (i.e., planted and harvested in less than a 10-year cycle).

Rapidly renewable resources sometimes provide the opportunity to displace raw materials that have greater environmental impacts. Common examples include composite panels that are made from agricultural fiber such as wheat, substituting for composite wood panels. Irresponsible forestry practices cause ecosystem and habitat destruction, soil erosion and stream sedimentation. Rapidly renewable crops require significantly less land—often due to higher density and shorter growing cycles—to produce the same amount of end product, and are often by-products that are otherwise considered waste. Bio-based plastics (e.g., from corn starch) and other rapidly renewable resources are beginning to provide alternatives to some petroleum-based plastics.

Economic Issues

Because rapidly renewable resources may be harvested more quickly, they tend to give a faster payback on investment for manufacturers. As demand increases, they are expected to become cost-competitive with conventional materials.

The land saved from the production requirements of rapidly renewable resources may be used for a variety of other uses, including open space and other agricultural products. Rapidly renewable materials, by virtue of a more consistent harvesting cycle, may sustain a community over a longer period than the steady and eventual depletion of finite resources or the degradation of a productive ecosystem.

SS | WE | EA | MR | EQ | ID

Credit 6

Resources

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

Web Sites

Environmental Building News

BuildingGreen, Inc.

www.buildinggreen.com/products/bamboo.html

(802) 257-7300

An article in Environmental Building News on bamboo flooring, including a listing of bamboo flooring suppliers.

Environmental Design + Construction

www.edcmag.com

(search for Highlights of Environmental Flooring)

An Environmental Design + Construction article providing information on bamboo flooring, linoleum and wool carpeting.

GreenSpec

BuildingGreen, Inc.

www.buildinggreen.com/menus/index.cfm

(802) 257-7300

Detailed listings for more than 1,900 green building products, including environmental data, manufacturer information, and links to additional resources.

Oikos

www.oikos.com

A searchable directory of resource-efficient building products and sustainable design educational resources.

Definitions

Rapidly Renewable materials are considered to be an agricultural product, both fiber and animal, that takes 10 years or less to grow or raise, and to harvest in an ongoing and sustainable fashion.

Certified Wood

SS | WE | EA | MR | EQ | ID

Credit 7

1 point

GREENING OPPORTUNITY

Can assist in certification under LEED for Existing Buildings

Intent

Encourage environmentally responsible forest management.

Requirements

Use a minimum of 50% of wood-based materials and products, which are certified in accordance with the Forest Stewardship Council's (FSC) Principles and Criteria, for wood building components. These components include, but are not limited to, structural framing and general dimensional framing, flooring, sub-flooring, wood doors and finishes.

Include materials permanently installed in the project. Wood products purchased for temporary use on the project (e.g., formwork, bracing, scaffolding, sidewalk protection, and guard rails) may be included in the calculation at the project team's discretion. If any such materials are included, all such materials must be included in the calculation. If such materials are purchased for use on multiple projects, the applicant may include these materials for only one project, at its discretion. Furniture may be included, providing it is included consistently in MR Credits 3–7.

Potential Technologies & Strategies

Establish a project goal for FSC-certified wood products and identify suppliers that can achieve this goal. During construction, ensure that the FSC-certified wood products are installed and quantify the total percentage of FSC-certified wood products installed.

Summary of Referenced Standard

Forest Stewardship Council's Principles and Criteria

www.fscus.org

(877) 372-5646

Certification is a "seal of approval" awarded to forest managers who adopt environmentally and socially responsible forest management practices, and to companies that manufacture and sell products made from certified wood. This seal enables consumers, including architects and specifiers, to identify and procure wood products from well-managed sources and thereby use their purchasing power to influence and reward improved forest management activities around the world.

LEED accepts certification according to the comprehensive system established by the internationally recognized Forest Stewardship Council (FSC). FSC was created in 1993 to establish international forest management standards (known as the FSC Principles and Criteria) to assure that forestry practices are environmentally responsible, socially beneficial and economically viable. These Principles and Criteria have been established to ensure the long-term health and productivity of forests for timber production, wildlife habitat, clean air and water supplies, climate stabilization, spiritual renewal, and social benefit, such as lasting community employment derived from stable forestry operations. These global Principles and Criteria are translated into meaningful standards at a local level through region-specific standards setting processes.

FSC also accredits and monitors certification organizations. These "certifiers" are independent, third-party auditors that are qualified to annually evaluate compliance with FSC standards on the ground and to award certifications. There are two types of certification:

- **Forest Management Certification** is awarded to responsible forest managers after their operations successfully complete audits of forestry practices and plans.
- **Chain-of-Custody (COC) Certification** is awarded to companies that process, manufacture and/or sell products made of certified wood after audits verify proper accounting of material flows and proper use of the FSC name and logo.

Approach and Implementation

Establish a project goal for FSC-certified wood products and identify suppliers that can achieve this goal. Research the availability of the wood species and products that you wish to use to ensure that they are available from FSC-certified sources. Another method for lowering the impact of wood resources is to research and specify quality grades that are most readily available from well-managed forests. Using lower grades of wood can dramatically reduce pressure on forests, which produce only limited quantities of top-grade timber (i.e., Architectural Woodwork Institute [AWI] Grades 2 or 3 for lumber or veneer rather than Grade 1).

At the earliest opportunity make contact with local vendors, suppliers and manufacturers that provide FSC-certified products. Provide project bidders with a list of certified vendors and encourage them to make contact early in the project to establish product availability and pricing. See the Resources section for information on product databases and boilerplate forms. As the availability of certain certified wood products may vary over the life of a project, consider having the owner pre-purchase, store and supply particular items to the contractor ("Furnished by the Owner, Installed by the Contractor," or FOIC). Finding a storage location that

best mimics the final ambient moisture of the space will ensure proper installation. Because of the typically high ambient moisture present during construction, a job site is not the best location to store wood if FOIC is being implemented.

Specify in contract documents that wood products shall come from forests that are certified as well-managed according to the rules of the FSC, and require chain-of-custody documentation. Wherever possible, employ a line-item strategy based on current availability of specific products rather than a blanket approach.

Chain-of-Custody Requirements

COC certification is required to different extents based on two scenarios: products with and without the on-product FSC label. If a manufacturer places its FSC COC label on product packaging used for individual sale (generally applying to fabricated products), then subsequent entities in the supply chain are not required to have COC certification unless the product's packaging or form is changed before it reaches the end consumer. (*Note:* this instruction is meant for LEED compliance only; it varies from FSC rules). For example, a wholesaler or retailer does not need COC to market a packaged case good kit that is labeled with the manufacturer's COC number. A fabricator using a labeled product as a component of a larger assembly will need to have COC certification since it is altering the product's packaging, and possibly its form.

For products that are not individually packaged for sale to be sold as FSC-certified, the vendor to the consumer is required to have COC certification. Contractors and subcontractors are considered the end consumers; they can demonstrate with copies of invoices (if requested) the quantity purchased for the job and their suppliers' COC numbers. For example, a contractor or subcontractor that installs non-labeled FSC wood panels is not required to have COC certification; its supplier must have COC certification. A manufacturer that installs its own product (e.g. custom cabinetry) is not required to have COC certification.

Calculations

List all new wood on the project and identify which components are FSC-certified. Using **Equation 1**, tally both the new wood and the FSC-certified wood.

Assemblies

In the case of an assembly, only the percentage of FSC-certified wood can be applied toward the credit. Wood components that are labeled "FSC Pure" or "FSC Mixed" are 100% FSC (the latter is assured via volume credit accounting). Determine the amount of new wood as a percent of the total weight, volume or cost and the amount of FSC-certified wood as a percent of the total weight, volume or cost. The cost basis is expected to be useful for veneer. Enter these amounts in the MRc7 Submittal Template along with the total value of the product. The template's spreadsheet will calculate all certified wood value as a percent of all new wood materials.

Project teams should develop a separate spreadsheet to calculate the amount of new wood and amount of FSC-certified wood for complicated assemblies and enter the summary data as one line item in the Submittal Template.

Equation 1

$$\text{Certified Wood Material Percentage} = \frac{\text{FSC-certified Wood Material Value (\$)}}{\text{Total New Wood Material Value (\$)}}$$

The calculations for certified wood shall include only new wood products. The value of any recycled wood fiber content of a product that qualifies as contributing to MR Credit 4, Recycled Content Materials, shall be excluded.

Exemplary Performance

Project teams may earn an Innovation in Design point for exemplary performance when the requirements reach the next incremental step. For FSC-certified wood, the credit calculation must be 95% FSC-certified wood or greater.

Submittal Documentation

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

The following data and calculation information is required in order to complete the v2.2 Submittal Templates:

- ❑ A list of items (and/or components of products) claimed as FSC certified, including product type, manufacturer, and the appropriate entity's COC certification number. Each product name can then be cross-referenced with the manufacturer or vendor COC number during the LEED certification review.

An optional narrative can be submitted describing any special circumstances or considerations regarding the project's credit approach.

Considerations

Environmental Issues

The negative environmental impacts of irresponsible forest practices can include destruction of forests, loss of wildlife habitat, soil erosion and stream sedimentation, water and air pollution, and waste generation. The FSC Standard incorporates many criteria that contribute to the long-term health and integrity of forest ecosystems. From an environmental perspective, the elements of responsible FSC-certified forestry include sustainable timber harvesting (i.e., not removing more timber volume than replaces itself over the cutting interval or rotation), preserving wildlife habitat and biodiversity, maintaining soil and water quality, minimizing the use of harmful chemicals, and conserving high conservation value forests (e.g., endangered and old-growth forests).

Economic Issues

World trade in forest products has increased dramatically in the last 30 years, from $47 billion in 1970 to $139 billion in 1998. As more developing countries embrace world forest product markets and their growing economies encourage domestic consumption, the protection of forests will become a critical issue. Currently, the costs of FSC-certified wood products are equal to or higher than conventional wood products and availability varies by region. The price of FSC-certified wood products is expected to be more competitive with conventional wood products in future years as the world's forest resources are depleted and the forest industry embraces more widespread adoption of sustainable business principles.

Irresponsible logging practices can have negative social impacts. Thus, the socioeconomic and political components to FSC certification include respecting indigenous people's rights and adhering to all applicable laws and treaties. Certification also involves forest workers and forest-dependent communities as stakeholders and beneficiaries of responsible forest management. Through the encouragement of responsible forest practices local timber economies are stabilized and forestland is preserved for future generations.

Resources

Web Sites

Forest Stewardship Council, United States

www.fscus.org/green_building

(202) 342-0413

For information and practical tools such as databases of certified product suppliers, referral service, specification language, and the "Designing & Building with FSC" guide and forms.

Print Media

Sustainable Forestry: Philosophy, Science, and Economics by Chris Maser, DelRay Beach, St. Lucie Press, 1994.

The Business of Sustainable Forestry: Strategies for an Industry in Transition by Michael B. Jenkins and Emily T. Smith, Island Press, 1999.

Definitions

Chain-of-Custody (COC) is the path taken by raw materials, processed materials, and products from the forest to the consumer, including all successive stages of processing, transformation, manufacturing and distribution. The COC certificate number is listed on invoices for non-labeled products to document that an entity has followed FSC guidelines for product accounting. COC is not required by distributors of a product that is individually labeled with the FSC logo and manufacturer's COC number.

Sustainable Forestry is the practice of managing forest resources to meet the long-term forest product needs of humans while maintaining the biodiversity of forested landscapes. The primary goal is to restore, enhance and sustain a full range of forest values—economic, social and ecological.

A **Vendor** is defined as the company that supplies wood products to building project contractors or subcontractors for on-site installation.

SS | WE | EA | **MR** | EQ | ID

Credit 7

Indoor Environmental Quality

Americans spend on average 90% of their time indoors where the U.S. Environmental Protection Agency reports that levels of pollutants may run two to five times—and occasionally more than 100 times—higher than outdoor levels[1]. Similarly, the World Health Organization reported in its Air Quality Guidelines for Europe, Second Edition[2] that most of an individual's exposure to many air pollutants comes through inhalation of indoor air. Many of these pollutants can cause health reactions in the estimated 17 million Americans who suffer from asthma and 40 million who have allergies, thus contributing to millions of days absent from school and work. Outbreaks of Legionnaires' disease and sick building syndrome confirm the relationship of indoor air quality to the occupant health.

Over the past twenty years, research and experience has improved our understanding of what is involved in attaining high Indoor Environmental Quality (IEQ), and revealed manufacturing and construction practices that can prevent many IEQ problems from arising. The use of better products and practices has reduced potential liability for design team members and building owners. The results are increased market value for buildings with exemplary IEQ and greater productivity for the occupants. In a case study included in the 1994 publication Greening the Building and the Bottom Line, the Rocky Mountain Institute cites how improved indoor environmental quality improved worker productivity by 16%, netting a rapid payback on the increased capital investment.

Preventing IEQ problems is generally much less expensive than identifying and solving them after they occur. One practical way to prevent IEQ problems from arising is to specify materials that release fewer and less harmful chemical compounds. Evaluation of the properties of the adhesives, paints, carpets, composite wood products and furniture and specifying those materials with low levels of potentially irritating off-gassing can reduce occupant exposure. Scheduling of deliveries and sequencing construction activities can reduce material exposure to moisture and absorption of off-gassed contaminants. Protection of air handling systems during construction and a building flush-out prior to occupancy further reduces potential for problems arising during the operational life of a building.

Using higher ratios of filtered outside air, increasing ventilation rates, managing moisture, and controlling the level of contaminants in the cleaning substances used can provide optimal air quality for building occupants. Installation of automatic sensors and controls to maintain proper temperature, humidity, and rates of outdoor air introduced to occupied spaces also plays a key role in maintaining optimal air quality. Use of sensors to alert building maintenance staff to potential Indoor Air Quality (IAQ) problems such as carbon dioxide (CO_2) build-up in an occupied space can also effectively balance energy and IEQ issues.

Occupant well-being can be improved by providing views to the exterior and by providing daylighting. In addition, providing occupants with the ability to control their personal thermal environment can reduce hot/cold complaint calls and generally raise occupant satisfaction levels which can lead to increases in productivity.

The joint efforts of the owner, building design team, contractors, subcontractors and suppliers are integral to providing a quality indoor environment.

Overview of LEED® Prerequisites and Credits

EQ Prerequisite 1
Minimum IAQ Performance

EQ Prerequisite 2
Environmental Tobacco Smoke (ETS) Control

EQ Credit 1
Outdoor Air Delivery Monitoring

EQ Credit 2
Increased Ventilation

EQ Credit 3.1
Construction IAQ Management Plan—During Construction

EQ Credit 3.2
Construction IAQ Management Plan—Before Occupancy

EQ Credit 4.1
Low-Emitting Materials—Adhesives & Sealants

EQ Credit 4.2
Low-Emitting Materials—Paints & Coatings

EQ Credit 4.3
Low-Emitting Materials—Carpet Systems

EQ Credit 4.4
Low-Emitting Materials—Composite Wood & Agrifiber

EQ Credit 5
Indoor Chemical & Pollutant Source Control

EQ Credit 6.1
Controllability of Systems—Lighting

EQ Credit 6.2
Controllability of Systems—Thermal Comfort

EQ Credit 7.1
Thermal Comfort—Design

EQ Credit 7.2
Thermal Comfort—Verification

Overview of LEED® Prerequisites and Credits (continued)

EQ Credit 8.1
Daylighting & Views—Daylight 75% of Spaces

EQ Credit 8.2
Daylighting & Views—Views for 90% of Spaces

Indoor Environmental Quality Credit Characteristics

Table 1 shows which credits were substantially revised for LEED for New Construction 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.

Table 1: EQ Credit Characteristics

Credit	Significant Change from Version 2.1	Design Submittal	Construction Submittal	Owner Decision-Making	Design Team Decision-Making	Contractor Decision-Making
EQp1: Minimum IAQ Performance	*	*			*	
EQp2: Environmental Tobacco Smoke (ETS) Control		*		*	*	
EQc1: Outdoor Air Delivery Monitoring	*	*			*	
EQc2: Increased Ventilation	*	*			*	
EQc3.1: Construction IAQ Management Plan, During Construction	*		*			*
EQc3.2: Construction IAQ Management Plan, Before Occupancy	*		*			*
EQc4.1: Low-Emitting Materials, Adhesives & Sealants			*		*	*
EQc4.2: Low-Emitting Materials, Paints & Coatings			*		*	*
EQc4.3: Low-Emitting Materials, Carpet Systems	*		*		*	
EQc4.4: Low-Emitting Materials, Composite Wood & Agrifiber			*		*	*
EQc5: Indoor Chemical & Pollutant Source Control	*	*			*	
EQc6.1: Controllability of Systems, Lighting	*	*			*	
EQc6.2: Controllability of Systems, Thermal Comfort	*	*			*	
EQc7.1: Thermal Comfort, Design	*	*			*	
EQc7.2: Thermal Comfort, Verification	*	*		*	*	
EQc8.1: Daylighting & Views, Daylight 75% of Spaces	*	*			*	
EQc8.2: Daylighting & Views, Views for 90% of Spaces	*	*			*	

Prerequisite 1

Required

Minimum IAQ Performance

Intent

Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

Requirements

Meet the minimum requirements of Sections 4 through 7 of ASHRAE 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Mechanical ventilation systems shall be designed using the Ventilation Rate Procedure or the applicable local code, whichever is more stringent.

Naturally ventilated buildings shall comply with ASHRAE 62.1-2004, paragraph 5.1.

Potential Technologies & Strategies

Design ventilation systems to meet or exceed the minimum outdoor air ventilation rates as described in the ASHRAE standard. Balance the impacts of ventilation rates on energy use and indoor air quality to optimize for energy efficiency and occupant health. Use the ASHRAE 62 Users Manual for detailed guidance on meeting the referenced requirements.

SS | WE | EA | MR | EQ | ID

Prerequisite 1

Summary of Referenced Standard

ASHRAE Standard 62.1-2004: Ventilation For Acceptable Indoor Air Quality

American Society of Heating, Refrigerating and Air-Conditioning Engineers

www.ashrae.org

(800) 527-4723

"The purpose of this standard is to specify minimum ventilation rates and indoor air quality that will be acceptable to human occupants and are intended to minimize the potential for adverse health effects. This standard is intended for regulatory application to new buildings, additions to existing buildings and those changes to existing buildings that are identified in the body of the standard. This standard applies to all indoor or enclosed spaces that people may occupy, except where other applicable standards and requirements dictate larger amounts of ventilation than this standard. Release of moisture in residential kitchens and bathrooms, locker rooms, and swimming pools is included in the scope of this standard. Additional requirements for laboratory, industrial, and other spaces may be dictated by workplace and other standards, as well as by the processes occurring within the space. This standard considers chemical, physical, and biological contaminants that can affect air quality. Thermal comfort requirements are not included in this standard." (ASHRAE 62.1-2004)

Note that although ASHRAE Standard 62.1-2004 will be the relevant standard for the vast majority of projects, certain low-rise residential projects pursuing certification under LEED for New Construction may use ASHRAE Standard 62.2-2004 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings to comply with this prerequisite.

Approach and Implementation

Building mechanical and passive ventilation systems seek to ensure that adequate fresh air is available for occupants in the space. Under-ventilated buildings may be stuffy, odorous, uncomfortable and/or unhealthy for occupants. ASHRAE Standard 62.1-2004 establishes minimum requirements for the ventilation air rates in various types of occupied zones and building ventilation systems. The standard takes into account the density of people within an area, the type of activity that is expected to occur in the space, and the nature of the ventilation air delivery system.

Strategies

There are three basic methods for ventilating buildings:

- ❑ Active Ventilation (i.e., mechanical ventilation)
- ❑ Passive Ventilation (i.e., natural ventilation)
- ❑ Mixed-mode Ventilation (i.e., both mechanical and natural ventilation)

Mechanically Ventilated Spaces—Ventilation Rate Procedure

For mechanical ventilation systems, ASHRAE Standard 62.1-2004, Section 6, presents procedures for determining the minimum required ventilation rates for various applications, using either the Ventilation Rate Procedure or the Indoor Air Quality Procedure. The Ventilation Rate Procedure is more straightforward to apply and much more common in practice and is the prescribed approach required by EQ Prerequisite 1.

The Ventilation Rate Procedure methodology is found in Section 6.2 of ASHRAE 62.1-2004. The breathing zone outdoor airflow is equal to the sum of the outdoor airflow rate required per person times the zone population, plus the outdoor air-

flow rate required per unit area times the zone floor area. The standard's Table 6-1 "Minimum Ventilation Rates in Breathing Zone" provides information by occupancy category to determine both the amount of outdoor air needed to ventilate people-related source contaminants and area-related source contaminants. The people-related sources portion of the outdoor air rate addresses actual occupancy density and activity. The area-related sources portion accounts for background off-gassing from building materials, furniture and materials typically found in that particular occupancy. Finally, the required zone outdoor airflow is the breathing zone outdoor airflow adjusted to reflect the "zone air distribution effectiveness" using adjustment factors in Table 6-2 of the standard. For multiple-zone systems, outdoor air intake flow is adjusted to reflect the "system ventilation efficiency" of the air distribution configuration, using adjustment factors in Table 6-3 of the standard.

This prerequisite requires that applicants demonstrate that the delivered minimum zone outdoor airflow for each zone and the outdoor air intake flow for the system meets or exceeds that required by ASHRAE Standard 62.1-2004 for each zone.

Naturally Ventilated Spaces

ASHRAE Standard 62.1-2004 Section 5.1 provides requirements on the location and size of ventilation openings for naturally ventilated buildings. The standard requires that all naturally ventilated spaces shall be permanently open to and within 25 feet of operable wall or roof openings and that the openable area be at least 4% of the net occupiable floor area. As appropriate, all other non-ventilation-related requirements (i.e., exhaust for combustion appliances, outdoor air assessment, and outdoor air intakes) in the standard must be met to comply with this prerequisite.

Mixed-Mode Ventilated Spaces

For mixed-mode ventilated spaces, project teams need to meet the minimum ventilation rates required by Chapter 6 of ASHRAE 62.1-2004 regardless of ventilation mode (natural ventilation, mechanical ventilation or both mechanical and natural ventilation).

Calculations

Exemplary Performance

This prerequisite is not eligible for exemplary performance under the **Innovation in Design** section.

Table 1: Sample Summary Calculations Used to Determine Outdoor Air Ventilation Rates – Mechanically Ventilated

Zone Identification			Standard Cases ASHRAE Std 62.1-2004 Verification Rate Procedure									Design Case		
Zone	Occupancy Category	Area (sf)	People Outdoor Air Rate (cfm/person)	Area Outdoor Air Rate (cfm/sf)	Occupant Density (#/1000 sf)	Breathing Zone Outdoor Air Flow Vbz/ (CFM)	Table 6-2 Zone Air Distribution Effectiveness Ez	Zone Outdoor Air Flow Voz/ (CFM)	Table 6-3 System Ventilation Efficiency Ev	Outdoor Air Intake Flow Vot/ (CFM)	Outdoor Air Intake Flow (CFM)	Zone Primary Air Flow Fraction Vpz/ (CFM)	Primary Outdoor Air Fraction Zp = Voz/ Vpz	Meets Standard?
General Office	Office Space	8000	5	0.06	5	680	1.0	680	1.0	680	800	8000	0.09	Y
Training Room	Lecture Classroom	750	7.5	0.06	65	411	1.2	342	0.9	360	400	1400	0.24	Y
Break Room	Conference Meeting	250	5	0.06	50	63	1.0	63	1.0	68	75	500	0.13	Y
Total		9000				1154		1085		1129	1275	9900		Y

Notes: For the general office space air distribution is overhead, hence Ez = 1. Outdoor air fraction, Zp, < 0.16, hence System Ventilation Efficiency is 1.0. For the training room, air distribution is underfloor, hence Ez = 1.2. Outdoor air fraction, Zp < 0.25, hence System Ventilation Efficiency is 0.9. For the break room, air distribution is overhead, hence Ez = 1. Outdoor air fraction, Zp, < 0.15, hence System Ventilation Efficiency is 1.0.

Table 2: Sample Summary Calculations Used to Determine Outdoor Air Ventilation Rates – Naturally Ventilated

Zone Identification		ASHRAE Std 62.1-2004 Section 5.1 Natural Ventilation				
Zone	Net Occupiable Area (sf)	Description of Operable Openings	Operable Area (sf)	Operable Area/ Occupiable Area (%)	Ratio > 4%?	Operable Openings within 25'?
Bedroom 1	150	(1) 5'x5' slider window	12.5	8.3%	Y	Y
Bedroom 2	180	(1) 5' x 5' slider window	12.5	6.9%	Y	Y
Living Room	275	(1) 6' x 5' slider window & (2) 3' x 1' transome windows	21	7.6%	Y	Y
Total	605		46	8%	Y	Y

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:

❑ Design narrative describing the project's ventilation design. Include specific information regarding fresh air intake volumes and any special conditions that affected the project's ventilation design.

AND

❑ For Mechanically Ventilated Buildings: confirmation that the project has been designed to meet the minimum requirements of ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality, using the Ventilation Rate Procedure.

OR

❑ For Naturally Ventilated Buildings: confirmation that the project has been designed to comply with the requirements for location and size of window openings per ASHRAE Standard 62.1-2004, Section 5.1.

AND

❑ For Naturally Ventilated Buildings: provide applicable project drawings to show the naturally ventilated building zones and the operable window areas.

Considerations

Good indoor air quality in buildings may yield improved occupant comfort, well-being and productivity. A key component of maintaining indoor air quality in a green building is providing adequate ventilation. ASHRAE Standard 62.1-2004 describes procedures for avoiding the introduction of contaminants; the criterion includes location of air intakes as they relate to potential outdoor sources of contamination. The standard also outlines general ventilation rates for a variety of building types and occupancy categories.

Because ASHRAE Standard 62.1-2004 has become standard ventilation design practice for many areas, generally no additional design effort or capital cost will be required to meet this prerequisite. Its successful implementation reduces potential liability regarding indoor air quality issues for architects, builders, owners, building operators and occupants.

Resources

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

Web Sites

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

www.ashrae.org

(404) 636-8400

Advances the science of heating, ventilation, air conditioning and refrigeration for the public's benefit through research, standards writing, continuing education and publications.

U.S. Environmental Protection Agency's Indoor Air Quality Web site

www.epa.gov/iaq

(800) 438-4318

Includes a wide variety of tools, publications and links to address IAQ concerns in schools and large buildings.

Definitions

Indoor Air Quality is the nature of air inside the space that affects the health and well-being of building occupants.

Mechanical Ventilation is provided by mechanical powered equipment, such as motor-driven fans and blowers, but not by devices such as wind-driven turbine ventilators and mechanically operated windows. (ASHRAE 62.1-2004)

Natural Ventilation is provided by thermal, wind or diffusion effects through doors, windows or other intentional openings in the building. (ASHRAE 62.1-2004)

Ventilation is the process of supplying and removing air to and from a space for the purpose of controlling air contaminant levels, humidity or temperature within the space.

Mixed-mode Ventilation is a ventilation strategy that combines natural ventilation with mechanical ventilation allowing the building to be ventilated either mechanically or naturally and at times both mechanically and naturally simultaneously.

SS	WE	EA	MR	EQ	ID
Prerequisite 1					