LEED Green Associate Study Guide

LEADING GREEN

v4 Edition

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Introduction:

The LEED Green Associate Study Guide:

This Guide is an introduction to the basics of green building, a foundation for a more sustainable future and a resource to help you pass the LEED Green Associate exam. It is to be used to reinforce your in-class learning and cement the knowledge in your head. It presents concepts and strategies of green building using best practices that are environmentally responsible and resource efficient.
The guide is divided into chapters, starting with an overview of Green building and sustainability, then information about the USGBC, GBCI, LEED and its evolution and
finally, a review of the seven categories in LEED as follows:

1. Location and Transportation
2. Sustainable Sites
3. Water Efficiency
4. Energy and Atmosphere
5. Materials and Resources
6. Indoor Environmental Quality
7. Innovation in Design
8. Regional Priorities

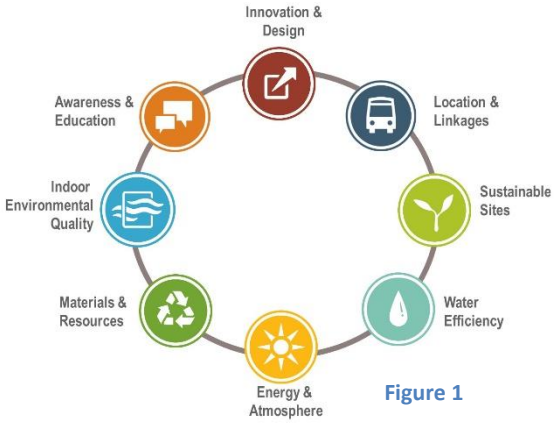


Figure 1

This guide includes most of the information you need to pass the LEED Green Associate exam but it is recommended that you download the LEED Green Associate candidate handbook and the excerpt from:

1. Introduction and Overview - LEED BDC V4 Reference Guide - http://leadinggreen.ca/?p=3051
2. LEED v4 Green Associate Candidate Handbook - http://leadinggreen.ca/?p=3052

LEED Discussion:

Now and before you get more involved with LEED, are you sure it is really worthwhile?
As a professional pursuing a **credential** it will cost you money and time, as a building owner pursuing a **certificate** for your building, it will probably raise the initial costs of your project.
To know the answer, we need to look at the following facts: since early in the 21st century we have been facing environmental crises from global warming, climate change, species extinction, droughts, floods and hurricanes. In addition we are running out of fossil fuels, thus we might not be able to meet our needs in the near future. There is no other choice but to lead a more sustainable lifestyle in all aspects including the built environment (the largest consumer of energy). LEED is a **legitimate**, **marketable** green building rating system which encourages environmental **commitment** from all stakeholders. Professionals from every sector should be well educated and equipped with the 'know how" to face these challenges, and this is exactly what makes LEED Credential important and worthy. It provides you with the knowledge of the best practices in the industry and it is based on stringent codes and standards. The credential simply certifies that you are qualified for your role. Importance of a LEED Certificate is different from an owner's perspective, it doesn't matter how green your building is unless you can prove it. A LEED Certified building needs no more proof than the certificate. It is a third party verified green building, and that means that you built an efficient building that provides the healthiest environment to its users and has a lower impact on the natural environment and resources. Add that to the *Thank You* from your community, building users and generations to come, the owner will earn marketability for his/her building, possible incentives from the government, more productive employees, and lower operations and maintenance costs. Owners worry about the higher initial costs of green buildings, but studies prove that through good design and construction they only cost slightly higher or are on par with traditional buildings costs. Looking at the financial return of a green building and its aforementioned benefits, Green Buildings are not only environmentally responsible, they are also be more profitable in the short and long term. LEED certification is the standard for defining a green building and it is the only respected designation in sustainability which is tailored to accrediting industry professionals.

CHAPTER 1

GREEN BUILDINGS

Green Buildings

According to EPA (the US Environmental Protection Agency) sustainability is based on a simple principle: 'Everything that we need for our survival and well-being depends either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations.
Sustainability is important for making sure that we have and will continue to have, the water, materials, and resources to protect human health and our environment'. (Sustainability basic information http://www.epa.gov/sustainability/basicinfo.htm)
Sustainable construction or Green Building emerged to limit the impacts of the built environment. The built environment is the human made surroundings including buildings and transportation systems that form neighborhoods that form the urban system. It is the largest consumer of energy and producer of GhGs.

Commercial construction in the United States accounts for:

- 14% of potable water consumption
- 30% of waste output
- 38% of carbon dioxide (CO2) emissions
- 40% of raw material use
- 24% - 50% of energy use
- 72% of electricity consumption

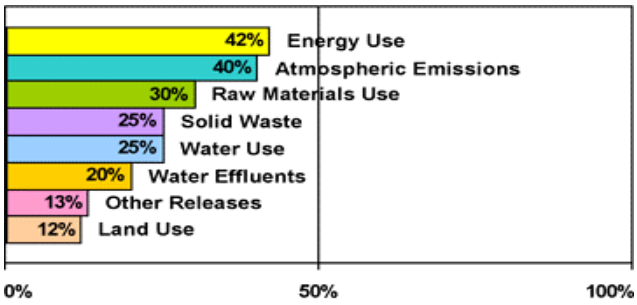


Figure 2

These impacts are directly or indirectly caused by traditional construction practices and operations. The Green building movement's target is changing traditional practices towards a more sustainable future.

Traditional practices vs. Sustainable practices:

Features of Traditional construction practices:

- Site selection only considers a project's budget and ignores the environmental impacts of clearing land for development. Development results in the destruction of wildlife, adds a burden to our natural resource supply, requires more services, parking lots and transportation systems to be built. Conventional site selection does not pay attention to the accessibility to mass transit, shared parking and existing services or the location of prime farmlands.
- No **preventive actions** are considered to limit air pollution, water pollution, greenhouse gases and toxic chemicals during construction.
- Team members don't communicate, coordinate or integrate their efforts. The building is **divided** into landscape, structure, architecture, mechanical equipment and the owner who controls the budget and major decisions. Professionals from each discipline work individually and consult only with the owner most of the time and not one another.
- Best practices in water and energy **consumption** are **ignored**.
- No waste management plan is defined to be applied during or after **construction**.

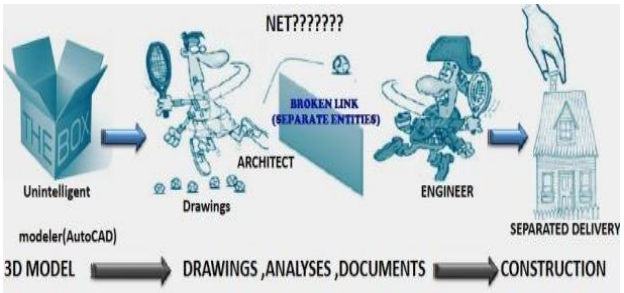


Figure 3

According to the EPA, in 2008 commercial buildings energy usage was:

- **38%** space heating
- **20%** lighting
- **8%** water heating
- **14%** cooling and ventilation

Features of Sustainable Practices:

- Site selection analysis considers factors like community connectivity, accessibility to mass transit, opportunities to share parking and avoid building on sensitive land.
- Waste and pollution reduction from construction activities and ongoing operations.
- The design and implementation of energy and water efficient systems as well as monitoring the system.
- Team members work in coordination through a holistic integrative approach to make environmentally responsible decisions.
- Operation and maintenance cost reduction due to more efficient utilities and high quality buildings.

The US General Services Administration Green Building benefits are quantified as:

- 13% lower maintenance costs
- 26% less energy usage
- 27% higher level of occupant satisfaction
- 33% lower CO2 emissions

Triple Bottom Line:

Social, Environmental and Economic benefits of Green buildings are also known to as the Triple Bottom Line (TBL), Green building evaluation is based on their impacts on **People** (Social benefits), **Planet** (Environmental benefits) and **Profit** (Economic benefits).
LEED certified projects achieve these three goals of sustainability and is how we define a green building.

Figure 4

Social, Environmental and Economic Benefits of Green Buildings:

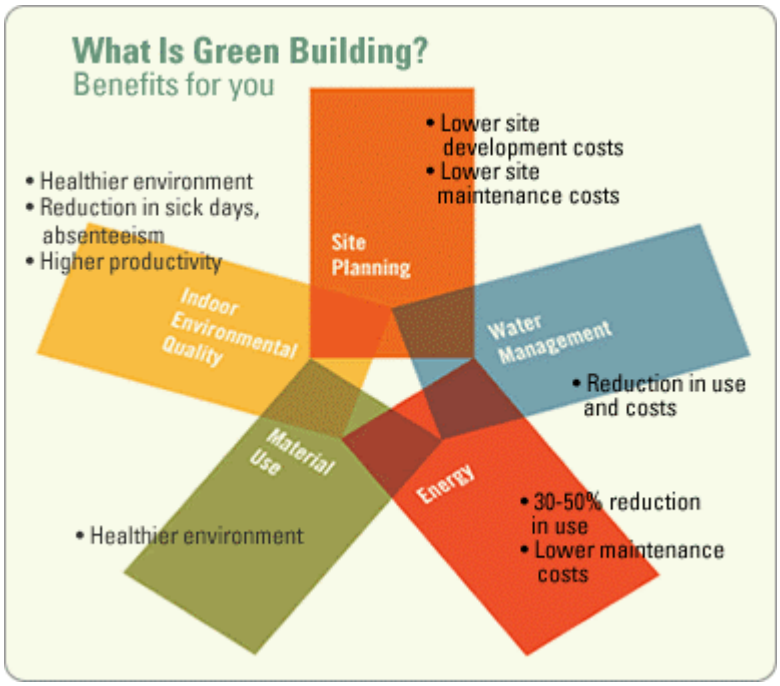


Figure 5

Social Benefits

- Better indoor environmental quality
- Healthier environment
- No extra burdens on local infra-structure

Environmental Benefits

- Protect wild life
- No air or water pollution
- No extra waste production
- Prevent natural resources depletion

Economic Benefits

- Lower operating and maintenance costs
- Higher property value
- Higher employee productivity
- Lower life cycle costs

Green Building Design Principles

Life Cycle Approach

Traditional building practices have a narrow perspective that only considers the initial construction costs. Sustainable practices use **Life Cycle Assessment (LCA)** to achieve measure sustainability.

Life Cycle Assessment (LCA) analyzes the environmental impacts of a service, material or product through its entire life cycle. Life cycle assessment evaluates a material's life cycle with respect to:

- Energy
- Emissions
- Waste

Life Cycle Cost (LCC)
Assessment of building costs from "cradle to grave", life cycle costs considers all factors from initial costs, health issues, productivity to potential building reuse after demolition. Sustainable buildings aspire to turn the term "cradle to grave" to "cradle to cradle" as a closed loop as opposed to a destructive open loop which produces waste.

Embodied energy is the energy consumed during the different stages of a material's life cycle and is included in its cycle assessment.

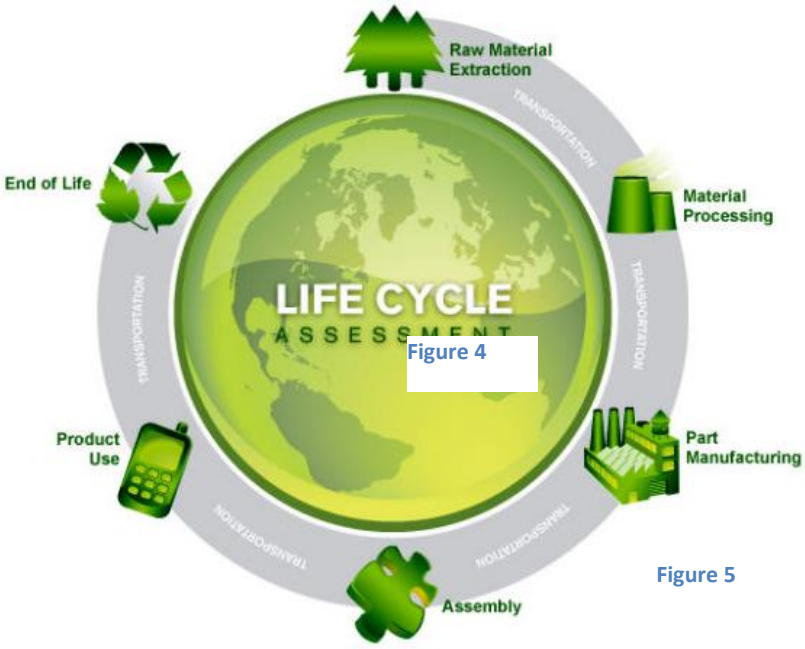


Figure 4

Figure 5

Hard Costs: Costs related to construction phases like concrete, roofing, finishing materials, site work, etc. which are paid to the contractor and material suppliers.

Soft Costs: Costs outside the construction site like architectural fees, engineering fees, permits and legal fees

Value Engineering: Value engineering is cutting project costs, often during construction phases affecting the actual value of the project. Many times green technologies and features are 'value engineered' out of the design because **the most important aspect of the building is to meet the local building code.**

Building Program / Owner's Program Requirements (OPR):

It is the set of goals and requirements defined by the owner or client. This program includes the information needed for the project team to start the pre design phase. It describes project goals, environmental vision, budget, schedule and physical properties of a project's internal and external spaces.
LEED refers to building program as Owner's Program Requirements (OPR).

Basis of Design (BOD) – the information included in the OPR such as systems descriptions, Environmental Quality (EQ) criteria, design assumptions and applicable codes **in technical terms.**

Flexible Design:

Sustainable design promotes flexible design that can support future building occupancy. Team members need to look beyond the owner's current needs to include future expected needs and occupancies. LEED encourages retrofitting existing buildings because of the economic and environmental costs of a new build. Reusing buildings for a different purpose other than the first one they were built for is called **Adaptive Reuse**.

Regenerative projects:

USGBC predicts green buildings and communities will create **Regenerative Projects** that will:

- Support the health of the local community and regional ecosystems.
- Generate electricity and send back to the grid.
- Return water to the hydrologic system cleaner than it was before use.
- Serve as locations for food production and community networking.
- Regenerate biodiversity.
- Promote many other relationships that link projects to the whole system of life around them.

A Regenerative project will be **Net Zero Energy =** use no more electricity than it generates onsite
- **Net Zero Carbon Footprint -** net zero carbon emissions
- **Water Balance -** uses only water received by precipitation
- Zero Waste - reuses, recycles or composts all wastes

Project Location:

Site selection can have major effects on the building performance. Team members must analyze site options in terms of factors such as:

- The availability of infrastructure.
- Accessibility to mass transit.
- Existing natural factors such as climate, water, soils and habitat.
- The availability of community services and its connection to the project.

Credit Synergies:

When making decisions regarding a strategy that would comply with credit requirements, a project team must analyze this decision with respect to other possible interacting credits. These credit interactions can have synergies or tradeoffs between them. An example of these interactions is the relationship between storm water management credit and the water use reduction or between the day lighting and views credit and optimizing energy use.

Commissioning:

The Commissioning Agent or Authority (Cx) ensures that the owner's program requirements (OPR) are included in the design process and that the building systems are installed and designed properly. LEED describes who can be the project's commissioning agent and their responsibilities through design phases. As a minimum, LEED requires the commissioning of energy systems of the project and results in reduced energy use, reduced contractor callbacks, better building documentation and system verification.

Operations & Maintenance Program:

O&M includes training the facility manager, project owner and building occupants on how to operate the building and to optimize its performance while avoiding system degradation. The operation and maintenance program ensures that the building operates as designed and that maintenance personnel provide quality and regular maintenance to the building ensuring economic payback goals are met over time.

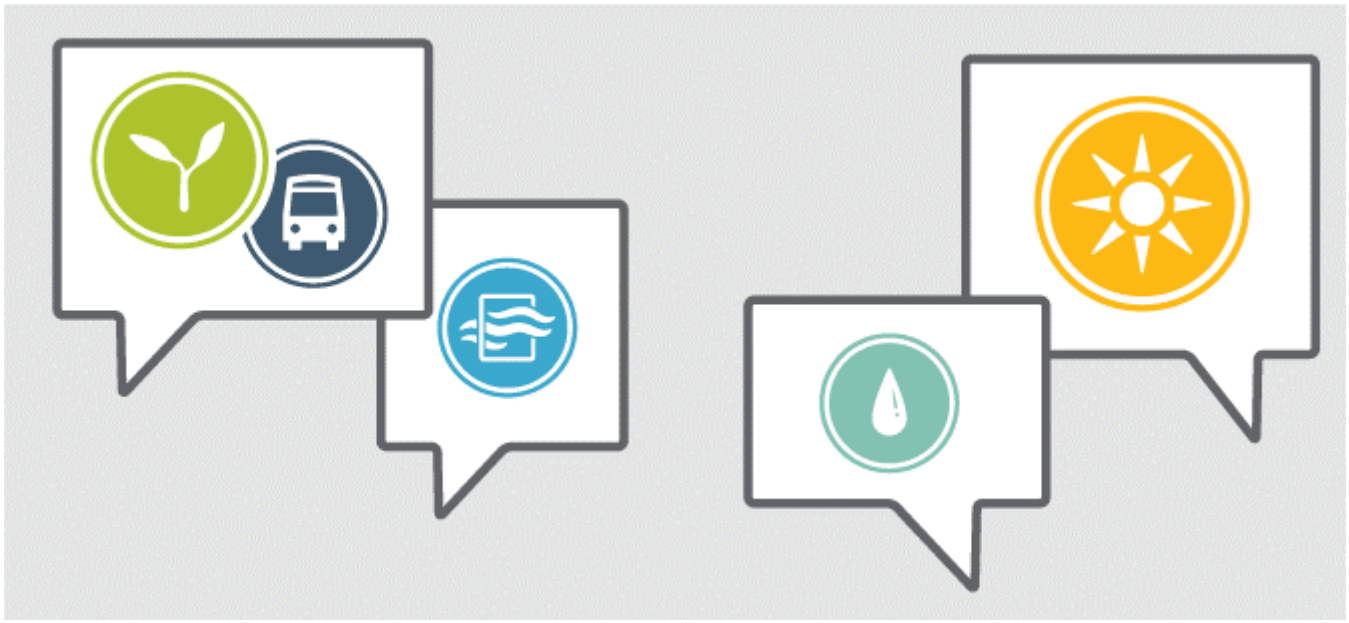
Energy Star and LEED:

Energy star is developed by the EPA to allow a building owner or manager to evaluate the building's performance through free technical tools and resources. Energy Star Labeled buildings use about 35% less energy than traditional buildings. Electronics, home appliances, heating and cooling equipment can be Energy Star Labeled after they achieve certain energy efficiencies. EPA's Portfolio manager is an online tool which benchmarks your building against other and tracks consumption. LEED on the other hand provides only building certification, addressing a wide range of green building features through its categories: sustainable sites, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, and innovation.

Figure 6

CHAPTER 2

The Governing Bodies of LEED – USGBC + GBCI



U.S. Green Building Council (USGBC)

The U.S. Green Building Council (USGBC) is a 501(c) (3) nonprofit organization. It was formed in 1993 and based in Washington D.C. Members of USGBC include building owners and users; real estate developers; facility managers; architects, designers, engineers, general contractors, subcontractors; product and building system manufacturers; government agencies and nonprofits. They represent companies and organizations from across the building industry.

USGBC's Mission: "To transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy and prosperous environment that improves the quality of life."

USGBC's Vision - Buildings and communities will regenerate and sustain the health and vitality of all life within a generation.

USGBC is **a Voluntary, Market driven and Consensus based** organization that provides:

- Educational opportunities for both public and industry professionals through workshops and online or live seminars. USGBC helps industry professionals pursue accreditation as LEED professionals from the Green Building Certification Institute (GBCI).
- Green building resources, strategies and tools for project teams and organizations interested in executing green buildings.
- Networking through forums to support green building dialogue and communication.
- Tracks the status of all LEED professionals including Green Associates and AP+.

There are only **2 formally acceptable ways** to refer to the USGBC:

1. U.S. Green Building Council
2. USGBC

In 2002, USGBC launched Green Build the world's largest green building conference.

Green Building Certification Institute (GBCI)

The Green Building Certification (GBCI) is a separate entity that manages LEED professional accreditation program and the LEED project certification process. The GBCI was established in 2008 with the support of the U.S. Green Building Council and administered LEED project certification through third party certification bodies accredited by the American National Standards Institute (ANSI). GBCI complies with ISO standard 17024.

GBCI responsibilities:

- GBCI manages the LEED professional accreditation program that includes examination development, registration and delivery.
- GBCI manages the development and implementation credential maintenance program (CMP), it determines the continuing education requirements for LEED accredited professionals.
- GBCI administers the LEED project certification process, evaluates a project's application and provides certification

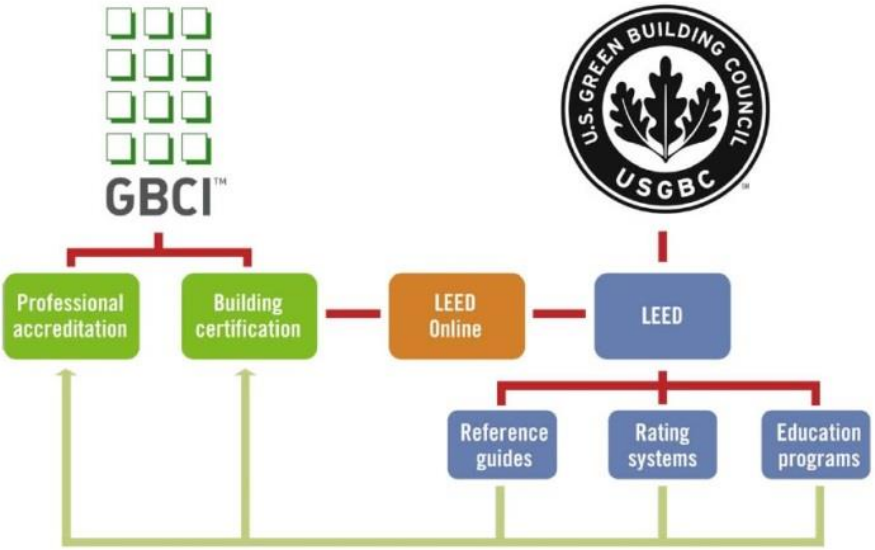


Figure 7

Leadership in Energy and Environmental Design (LEED)

Leadership in Energy and Environmental Design (LEED) is an internationally recognized third party certification program. In 1998, The USGBC launched the first LEED pilot program which is known as LEED version 1.0. It was developed to define and measure green buildings.

LEED refers to:

LEED certification of projects- A project must earn a minimum number of points in a single rating system to achieve a certain level of certification. Buildings can be certified to one of the following levels:

- **Certified**, 40-49 points
- **Silver**, 50-59 points
- **Gold**, 60-79 points
- **Platinum**, 80+ points

Figure 8

'LEED Certified 'project with the uppercase 'c' is a project that achieved 40-49 points and was awarded the basic certification level.

LEED accreditation of individuals- this is the accreditation of professionals who demonstrate certain degree of knowledge in the field of sustainability and LEED.

Accreditation is available in three levels or tiers:

Figure 9

- Tier 1- LEED Green Associate
- Tier 2- LEED Accredited Professional +
- Tier 3- LEED Fellow

Individuals earn the LEED Green Associate (basic knowledge) and LEED Accredited Professional (technical knowledge of the LEED Rating system) credentials by passing their respective exams. LEED Fellows must be **nominated after 10 years** of green building experience.

LEED Rating Systems

LEED rating systems are developed by the USGBC to act as the framework for project teams who are interested in pursuing LEED certification for their projects. The rating systems are revised and updated regularly to respond to new technologies and policies. LEED certification can be applied to a building in any stage of its life cycle and the different rating systems address various project types and scopes. The different rating systems are harmonized to ensure it is easy to switch between them and satisfy the triple bottom line.

LEED for New Construction addresses design and construction activities for new buildings and major renovations of existing buildings. Major renovations can be major HVAC or large envelope renovations.

LEED for Core & Shell is used when a project owner or developer only controls the design and construction of the building's core and shell such as mechanical, electrical and plumbing systems as well as its envelope. LEED for Core & Shell is appropriate to use if more than 40% of the gross floor area is incomplete when the project is certified.

LEED for Commercial Interiors addresses only interior design and tenant fit outs. It includes everything out of the scope of the LEED Core & Shell rating system. The two systems work together for full certification.

LEED for Schools, LEED for Healthcare, Data Centers, Hospitality, Warehouses and Distribution centers and LEED for Retail are derivatives of LEED for New Construction and LEED for Commercial Interiors to address unique features of building type ***(just know they exist).***

LEED for Schools focuses on school specific requirements such as classroom acoustics, mold prevention, environmental site assessment and master planning. Academic buildings that serve educational purposes and non-academic buildings on school campuses are eligible for LEED for schools certification.

LEED for Healthcare is applied to buildings of medically related uses such as clinics, medical and dental offices and medical education and research centers.

LEED for Retail addresses buildings or spaces used by retailers such as banks and restaurants.

LEED for Data Centers is applied to buildings which have high density computing equipment that are used for data storage and processing. It is only used when data centers take up 60%+ of the building

LEED for Warehouses and Distribution Centers is used for storage facilities

LEED for Hospitality is used for buildings dedicated to hotels, motels or service industry lodging.

LEED for Existing Buildings: Operations & Maintenance rating system focuses on operation and maintenance activities including limited construction activities. It is applied to existing buildings to improve building operation and maintenance. It usually involves retrofitting or renovating the property.

LEED for Homes rating system is used for low- rise (1-3 stories) residential buildings. Projects that are 4-8 stories should select Multi-family midrise. LEED for Homes is explained in more detail below

LEED for Neighborhood Development rating system addresses the land use planning of a neighborhood through addressing its components; **building design, infrastructure, street design** and **open spaces**. LEED for Neighborhood Development promotes smart growth and urbanism principles. There are 2 paths:

- **LEED ND Plan**
  - Project is still in planning phase of up to 75% constructed
- **LEED ND Built Development**
  - For projects which are near completion or were developed within the last 3 years

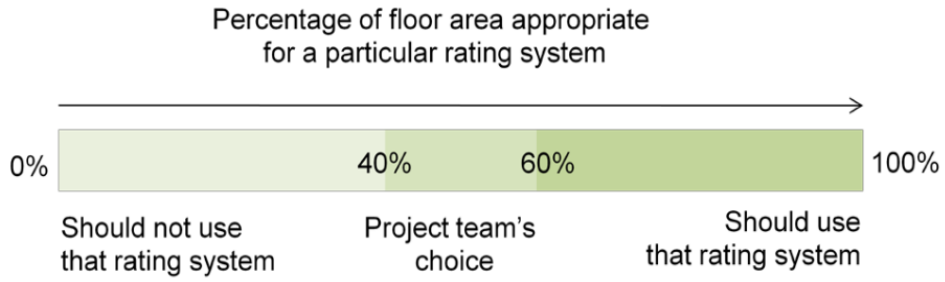
- **<u>LEED for ND contains 5 credit categories</u>**:
  1. **Smart Location & Linkage**
  2. **Neighborhood Pattern & Design**
  3. **Green Infrastructure & Buildings**
  4. **Innovation & Design Process**
  5. **Regional Priority Credits**

LEED Campus is used for multiple buildings on a site under control of a single entity

LEED Volume is used for 25 or more identical projects under BD+C or O+M (Ex. Walmart)

<u>Rating System Guidance Selection</u>

THE 40/60 RULE: If a rating system is appropriate for **more than 60% of the gross floor area** of a LEED project building or space, then that rating system should be used.



- **Multiple Certifications:** A building can earn multiple certifications using different rating systems**.** For example**,** an office building which is certified under LEED for Core & Shell rating system can earn LEED for Commercial Interiors and then the same building can pursue LEED for Existing Buildings Operation & Maintenance certification. Other examples are buildings certified under NC, CS or Schools may be certified under EB: O&M

If the 40/60 rule fails to determine which rating system to select – **The project team ultimately decides**

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

LEED Green Building Reference Guides

A LEED reference guide is a written guide to assist project teams through the certification process. For each rating system there is a relevant reference guide, for example, the Reference Guide for Green Building Design and Construction (BD+C) is the guide for New Construction, Schools and C&S rating systems. It explains each

credit intentions, requirements, implementation strategies, references, etc. LEED Reference Guides provide project teams with all the information they need to achieve certification. **It is essentially the LEED code.**

LEED version 4, also known as **LEED v4** is organized so that the Reference Guide for Green Building Design and Construction **(BD&C)** is the reference for projects pursuing certification under **LEED-NC, LEED-Schools** or **LEED-CS** rating systems and the Reference Guide for Interior Design and Construction **(ID&C)** is the reference for projects pursuing certification under **LEED-CI**, etc.

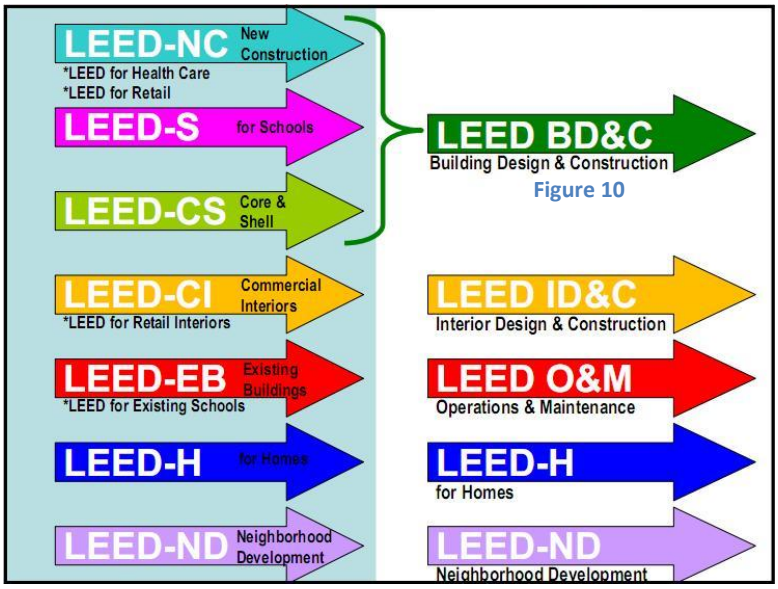


Figure 10

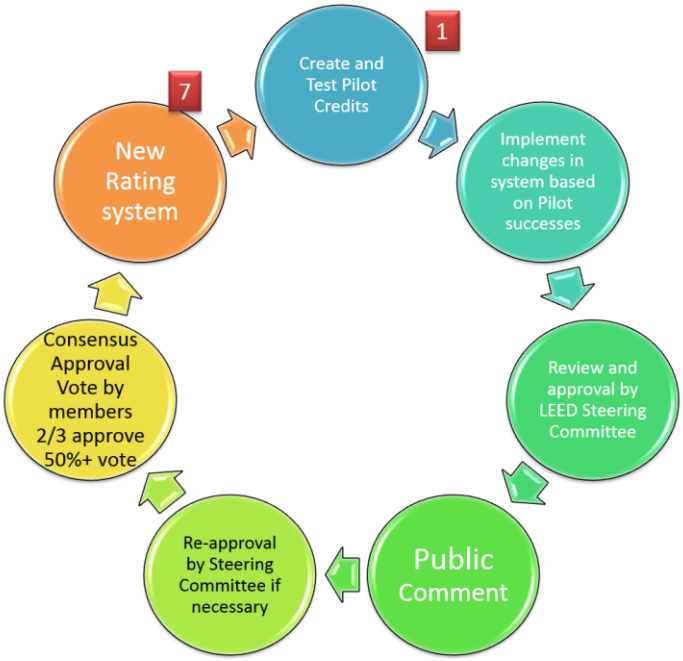
Rating System Credit Categories

All the LEED rating systems - excluding LEED for Neighborhood Development - follow a structure that divides green building strategies into the following categories:

- Location and Transportation **(LT)**
- Sustainable Sites **(SS)**
- Water Efficiency **(WE)**
- Energy and Atmosphere **(EA)**
- Materials and Resources **(MR)**
- Indoor Environmental Quality **(EQ)**
- Innovation in Design **(ID)**
- Regional Priority **(RP)**

LEED V4 rating System Development

The LEED rating system must raise the bar every few years to continue pushing the market to greater sustainable heights. As a result they use a 7 step process which ensures the new LEED rating system adheres more stringently to the triple bottom line through a realistic approach.



LEED V4 Impact Categories– The Basis of Point Allocation (Credit Weightings)

There are 7 impact categories which are used to determine how LEED can best address the triple bottom line and properly weigh credits. There are 7 categories displayed in clockwise decreasing order of importance.

- All LEED credits are worth a minimum of 1 point.
- All LEED credits are positive, whole numbers; there are no fractions or negative values.
- All LEED credits receive a single, static weight in each rating system; there are no individualized scorecards based on project location.

Rating System Prerequisites and Credits-Explained

Each credit category in a LEED rating system consists of **prerequisites** which are mandatory and **credits** which are chosen by the project team based on cost, environmental benefit and organizational goals.

Prerequisites: Mandatory elements of the LEED rating systems. A LEED project team must satisfy all prerequisites. If a project fails to meet any prerequisite then it will NOT be eligible for certification. No points are awarded for achieving prerequisites.

Credits: credits are non-mandatory optional elements of LEED rating systems. Project teams choose a combination of credits to earn points towards certification. Each credit has a certain number of points; if a project meets the requirements of a credit then it earns the points associated with this credit. Different credits are worth different points and the point allocation also depends on the degree in which you achieve the credit. There are two types of credits: Design and Construction which signify when they need to be documented.

To earn LEED certification, the project must satisfy all the prerequisites and earn a minimum number of points.

Each LEED prerequisite or credit has an intent, requirements and strategies to achieve the credit/prerequisite. For the LEED Green Associate exam, the intent is very important and many questions relate back to the reason behind the credit's existence, while the LEED AP exams focus on a credit's requirements and subsequent point allocation.

These sections are mentioned in the LEED rating systems.

1. **Intents**: this section mentions the sustainability goals and environmental benefits of the credit/prerequisite. Essentially "Why the credit exists."
2. **Behind the Intent**: describes how the credit fits into the overall sustainability picture
3. **Requirements:** this section outlines the options or paths to achieve the credit/prerequisite requirements and specifies the number of points associated with the credit.
4. **Step by Step Guidance**: General tips and examples of how to implement and document credits
5. **Further Explanation**: Calculations, special project considerations and international compliance
6. **Related Credits**: credits/prerequisites may have synergies or tradeoffs between them, this section lists the other credits/prerequisites which are affected by achieving this credit/prerequisite.
7. **Referenced Standards**: a list of standards, such as ASHRAE, ASTM and EPA that are used as a requirement to achieve the credit/prerequisite. **Federal, state, local laws and codes** are used if more stringent than these standards
8. **Changes from LEED 2009**: explanation of how the credit has changed
9. **Required Documentation:** this section explains and lists the required documents to be uploaded to LEED Online and specifies the declarant responsible for signing off on the credit/prerequisite.
10. **Examples:** some credits/prerequisites have examples to show how they were achieved.
11. **Exemplary Performance:** additional points that can be earned from some credits for a project that greatly exceed or double performance requirements. No prerequisite offers exemplary performance points and not all the credits have exemplary performance points.
12. **Definitions:** definitions for terminology specific to this credit/prerequisite.

Minimum Program Requirements (MPRs)

A LEED project must satisfy Project Minimum Requirements (MPRs). MPRs are mandatory; they define the minimum characteristics that a project must possess in order to be eligible for certification. Even before Prerequisites, MPRs must be met. MPRs are **standard across all rating systems AND** have 3 main goals:

- Customer guidance and understanding
- Reinforce LEED's integrity
- To minimize challenges throughout the LEED certification process

<u>Each rating system has 3 identical MPRs:</u>

1. Must be in a **permanent** location on **existing** land
   - Cannot be designed to move
     - Ex. Trailers or Portables are not eligible

2. **Must use reasonable LEED boundaries**
   - Include all contiguous land associated with the project
     - Ex. Hardscapes (sidewalks and parking), stormwater treatment and landscaping
   - Must not unreasonably exclude portions of the site which makes it easier for the project to meet credits and prerequisites - NO GERRYMANDERING (adjusting the site boundary)
   - The Gross Floor Area of a LEED Project **must exceed 2%**

3. **Must comply with project size requirements (GFA)**
   - LEED BD+C and O+M - a minimum of 1,000 square feet
   - LEED ID+C - a minimum of 250 square feet
   - LEED ND at least two habitable buildings and be no larger than 1500 acres.
   - LEED for Homes - defined as a "dwelling unit" by all applicable codes.

Credit Harmonization

Credits and prerequisites of all LEED rating systems are consistent and aligned to make it easier for project teams to switch between rating systems. Credit Harmonization promotes consistency between the many LEED Rating Systems.

Regional Priority Credits

USGBC regional councils and chapters have identified **6 credits per rating system** that are of a particular importance to specific areas and address geographically specific environmental issues. LEED Online automatically determines a project's regional priority credits based on its **zip code**. Each Regional Priority credit is worth 1 point and no more than 4 points can be awarded for each project under the Regional Priority category. A searchable database of regional priority credits is available by the USGBC website.

LEED Technical Advisory Groups (TAGs)

Technical Advisory Groups (*TAGs*) provide LEED technical advice; they assess and recommend technical solutions to the superior **LEED Steering Committee (LSC)** for review and approval. TAGs are responsible for providing technical advice to LEED committees and working groups to improve credits/prerequisites and support tool development. There are 6 LEED TAGs which represent the first 6 credit categories.

Project Registration and Certification

Commercial LEED Rating Systems

GBCI is the third-party verification for LEED certification. A project pursuing LEED certification must satisfy all Minimum Program Requirements (MPRs), prerequisites and a minimum number of credits as described in the applicable rating system. In the past the GBCI used to outsource this process to LEED Reviewing consulting firms but has been slowly migrated the process back in-house to avoid discrepancies between reviewers. **Don't forget that projects must always meet local, regional and fire codes first!**

Project Certification Levels

- **Certified**: 40-49 points
- **Silver**: 50-59 points
- **Gold**: 60-79 points
- **Platinum**: 80+ points

Figure 11

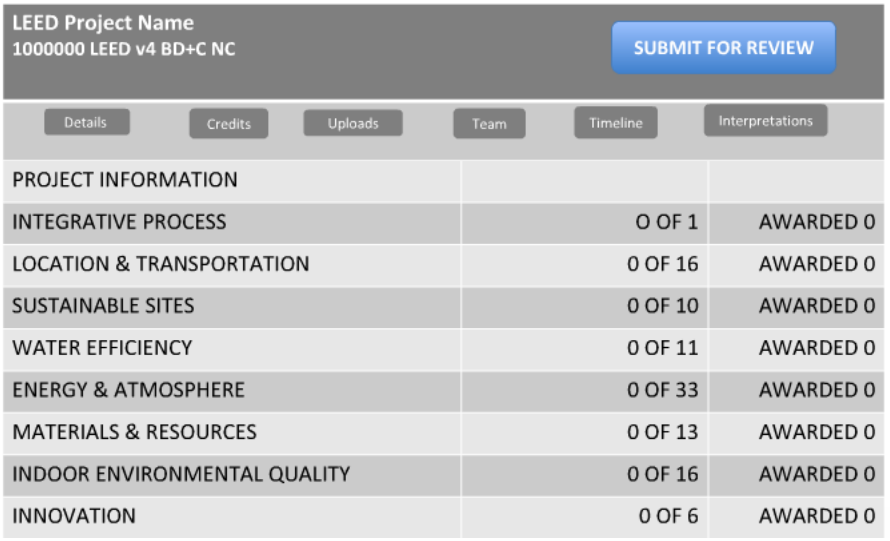
Registration

The first step in the certification process is the Project Registration. Projects can be registered on the GBCI website (www.gbci.org). The website has information on registration costs. Registration provides access via LEED online website (www.leedonline.com) communication, software tools and other important information.

LEED Online

LEED online is a web based tool which the project team uses to manage the LEED certification process. LEED online allows project teams to:

- Complete documentation requirements
- Upload required files
- Submit application for review
- Receive reviewer feedback
- Manage project details
- Earn LEED certification



Owner and Agent

The owner controls the property, has authority over its elements and accepts the certification agreement. While the agent is granted authority by the owner to register the project.

Project Administrator

This role is automatically assigned by GBCI to the person who registers the project via LEED Online. The project administrator can be changed after registration. Project Administrator responsibilities are to:

- Invite team members to the project on LEED online
- Assign credits to team members and give them responsibility to upload/sign credit forms
- Submit the application for review
- Accept the reviewer feedback

LEED AP

A project with a LEED AP+ who plays a principle role in the project is eligible for 1 point under the Innovation in Design category if they have the correct corresponding specialty. A maximum of 1 point can be achieved regardless of the number of LEED AP's. It is not mandatory to have a LEED AP in the project team to achieve certification but a LEED AP can do the following:

- Understand the certification process
- Assign credits to team members according to their expertise and the credit requirements
- Coordinate between team members from different disciplines
- Manage the credits documentation and uploaded files
- Coordinate between local codes and standards and LEED requirements

Eligibility

A project that meets all the required MPRs and prerequisites and can achieve the minimum number of points to earn a certification level is a candidate for LEED certification.

Project Checklist (LEED Credit Scorecard)

It is a form provided by the USGBC that includes the prerequisites and credits of the selected rating system. This form is used by the project team (often during a charrette) to determine if they can meet all the prerequisites and the certification level they can achieve.

LEED v4 for BD+C: New Construction and Major Renovation
Project Checklist

Project Name:
Date:

Y	?	N			
			Credit	Integrative Process	1

0	0	0	Location and Transportation		16
			Credit	LEED for Neighborhood Development Location	16
			Credit	Sensitive Land Protection	1
			Credit	High Priority Site	2
			Credit	Surrounding Density and Diverse Uses	5
			Credit	Access to Quality Transit	5
			Credit	Bicycle Facilities	1
			Credit	Reduced Parking Footprint	1
			Credit	Green Vehicles	1

0	0	0	Sustainable Sites		10
Y			Prereq	Construction Activity Pollution Prevention	Required
			Credit	Site Assessment	1
			Credit	Site Development - Protect or Restore Habitat	2
			Credit	Open Space	1
			Credit	Rainwater Management	3
			Credit	Heat Island Reduction	2
			Credit	Light Pollution Reduction	1

0	0	0	Water Efficiency		11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
			Credit	Outdoor Water Use Reduction	2
			Credit	Indoor Water Use Reduction	6
			Credit	Cooling Tower Water Use	2
			Credit	Water Metering	1

0	0	0	Energy and Atmosphere		33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
			Credit	Enhanced Commissioning	6
			Credit	Optimize Energy Performance	18
			Credit	Advanced Energy Metering	1
			Credit	Demand Response	2
			Credit	Renewable Energy Production	3
			Credit	Enhanced Refrigerant Management	1
			Credit	Green Power and Carbon Offsets	2

0	0	0	Materials and Resources		13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
			Credit	Building Life-Cycle Impact Reduction	5
			Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
			Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
			Credit	Building Product Disclosure and Optimization - Material Ingredients	2
			Credit	Construction and Demolition Waste Management	2

0	0	0	Indoor Environmental Quality		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
			Credit	Enhanced Indoor Air Quality Strategies	2
			Credit	Low-Emitting Materials	3
			Credit	Construction Indoor Air Quality Management Plan	1
			Credit	Indoor Air Quality Assessment	2
			Credit	Thermal Comfort	1
			Credit	Interior Lighting	2
			Credit	Daylight	3
			Credit	Quality Views	1
			Credit	Acoustic Performance	1

0	0	0	Innovation		6
			Credit	Innovation	5
			Credit	LEED Accredited Professional	1

0	0	0	Regional Priority		4
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1

0	0	0	TOTALS	Possible Points:	110

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Figure 12

The 3 phases of credit applications:

1. Predesign – **Discovery**
2. Schematic Design **– Design and Construction**
3. Feedback Mechanisms – **Operations and performance monitoring**

Credit Forms and Calculators

Credit forms are used to document and verify credit/prerequisite compliance. Credit forms or templates are Adobe interactive PDF forms accessible by Project Administrator and project team members via LEED online. Each credit/prerequisite has its form which lists the documentation requirements for its achievement and signed by a specified team member. Calculators are *built in* for the credits that need calculations.

Samples of Credit Templates and Forms are available on the USGBC website - http://www.usgbc.org/articles/first-look-leed-v4-online-forms

Application Process Outline

1. **Initiate Discovery Phase** – Follow steps in the Integrative Process Credit
2. **Select a Rating System –** Use the 40/60 rule to pick the appropriate LEED Rating system
3. **Check MPR compliance**
4. **Establish Project Goals** - align with the project's context and the values of the project team, owner, or organization. This is accomplished through a goal-setting workshop (see IP)
5. **Define project scope** – map the LEED Project boundary and explore any special certification programs such as Volume or Campus applications
6. **Develop LEED scorecard** (see above) – Select **Y/?/N** for each credit based on expectations
7. **Continue Discovery Phase** – additional cost and strategy analysis
8. **Continue Iterative Process** – repeat the 7 steps above until satisfaction
9. **Assign Roles and Responsibilities** – One team member leads the process and manages the application and documentation
10. **Consistent Documentation** – gather data at regular intervals to ensure ongoing progress
11. **Quality Assurance** – review all LEED documentation to avoid errors prior to submission

Certification Process - There are two options:

- **Split Review**: some of the project credits/prerequisites can be submitted during the **design phase** as outlined in the LEED reference guide. Other credits/prerequisites must be submitted during **construction phase**. Only after the construction process can these points be earned.
- **Combined Review**: all credits and prerequisites are submitted for review at one time. The project team can choose the option that best suits their project case. **Only available for LEED BD+C and ID+C.**

Review Process

Preliminary Review – After this process the project administrator will receive a preliminary rating and requests for additional information per credit. The project administrator has the option to appeal the reviewer's decision.

Final Review – Any new information is reviewed and a final rating is received by the Project administrator. The project administrator has the option to appeal the reviewer's decision, but once the decision is accepted no further appeals may be made. The project cannot reapply for LEED certification if it is denied.

Once certification is accepted the project will be included in the LEED Project Directory and a plaque will be received based on points achieved.

Project Credit Interpretation Requests/Rulings (CIRs)

If a project team needs any clarification regarding any credit or prerequisite then they may send a credit interpretation request at a cost of $220 for each request. Credit interpretation requests can be submitted by the project team at any time after the project registration. CIR requests must not exceed 600 words or 5000 characters including spaces. No attachments, cut sheets or drawings are allowed within a CIR request except for LEED ND where a site plan can be attached.

Credit interpretation rulings are the reviewers' responses to these requests, credit interpretation rulings constitute precedents. If a project team encounters unclear issues they should:

- search the reference guide for help
- contact USGBC customer services for answers
- send a credit interpretation request

LEED Interpretations

- Precedent setting version of Credit Interpretation Rulings
- A LEED Interpretation requires more time than a CIR because it can be applied to multiple projects and rating systems after a decision is made

Alternative Compliance Paths (ACPs)

Projects can comply with credits while not adhering to explicit requirement documentation in the reference guide through ACPs. If the project team believes they satisfy the credit's intent through a method outside of the existing reference guide they can submit documentation explaining credit compliance.

LEED Pilot Credit Library

The library is compiled of a number of innovative credits which have not gone through the USGBC's drafting and balloting process for approval. Projects are encouraged to test LEED pilot credits through the Innovation in Design credit category as a means of advancing LEED.

LEED Professional Credentials

The GBCI manages the LEED credentials and exams and there are 3 tiers of credentials

- **LEED Green Associate;** demonstrates a solid and current foundation in green building principles and practices.

- **LEED AP;** a credential that affirms an advanced knowledge in green building as well as expertise in a particular LEED rating system**.**

- **LEED Fellows;** a highly accomplished class of individuals nominated by their peers and distinguished by the caliber of their contributions to advancing the field of green building.

LEED Professional Exams

- LEED Green Associates earn their credential by passing a two-hour, computer-based exam comprising 100 randomly delivered multiple-choice questions.

- LEED APs earn their credential by passing a four hour, two-part computer-based test, part one is the LEED Green Associate exam. Part two consists of 100 randomly delivered multiple-choice questions and must be completed. The two parts of the exam can be taken separately on two different appointments or together. LEED Green Associates do NOT have to take the LEED AP exam.

Credential Maintenance Program (CMP)

The GBCI also developed a continuing education process known as the Credential Maintenance Program (CMP). In order to maintain a LEED credential, the LEED professional must;

- Earn continuing education (CE) hours as described in the CMP within a 2 year reporting cycle
  - LEED Green Associates must earn **15 CE hours** (3 must be LEED-specific)
  - LEED APs with Specialty must earn **30 CE hours** (6 must be LEED-specific)**, as well as 6 additional hours** for each additional specialty.
- CE hours must be earned and reported during the 2 year reporting cycle after passing.
- A $50 renewal fee must be paid by all LEED Professionals every 2 years

Summarizing USGBC, GBCI & LEED

USGBC is responsible for developing:

- LEED rating systems
- LEED Reference Guides
- LEED educational courses and research projects

GBCI provides the third party verification for LEED project certification and LEED professional credentials. **GBCI** manages and administers:

- LEED project certification process from registration to certification
- LEED professional credentials examination and accreditation
- The Credential Maintenance Program

LEED (not LEEDs)

- LEED Accredited Professionals (LEED AP+)
- LEED Green Associates
- LEED certified projects (Certified, Silver, Gold, Platinum)

Note that individuals are accredited to be LEED Green Associates or LEED APs. Buildings are certified (with lower case ‘c’) to a certification level ranging from Certified (with upper case ‘c’) to Platinum. Organizations can be members of USGBC national organization and individual can be members of USGBC regional chapters. Companies and products cannot be accredited or certified.

LEED for Homes

Overview

LEED for Homes is designed to promote the transformation of the homebuilding industry towards more sustainable practices. It is now more similar to the other rating systems versus LEED 2009.

LEED for Homes credit categories:

- Location and Transportation **(LT)**
- Sustainable Sites **(SS)**
- Water Efficiency **(WE)**
- Energy and Atmosphere **(EA)**
- Materials and Resources **(MR)**
- Indoor Environmental Quality **(EQ)**
- Innovation in Design **(ID)**
- Regional Priority **(RP)**

How to participate in LEED for Homes:

LEED for Homes depends on third party verification provided by Green Raters and LEED for Homes Providers.

Green Raters provide in-the-field verification services at each and every LEED for Homes Project. All Green Raters work with LEED for Homes Provider Organizations to complete the verification process on each LEED for Homes project. Green Raters must be involved with the project from the design and throughout the construction process. Green Raters are responsible for:

- Providing on-site verification of services
- Assembling the Project Submittal Package and submitting it for certification review
- Verifying that the home is designed and built to the requirements of the LEED for Homes rating system

LEED FOR HOMES GREEN RATER

Figure 13

LEED for Homes Providers provide quality assurance oversight for each Green Rater. LEED for Homes Providers are local organizations or companies selected by the USGBC based on their demonstrated experience to manage a team of Green Raters and support builders of high-performance homes. They can also be a Home Energy Rating System Rater (HERS Rater). A provider is responsible for the following:

- Recruitment and registration of projects
- Coordination and oversight of Green Raters
- Certification of LEED for homes
- Quality assurance

LEED™ FOR HOMES

Figure 14

Steps to participate

1. Contact a LEED for Homes Provider and join the program
2. Identify a project team
3. Build the home
4. Certify the project
5. Market and sell the LEED home

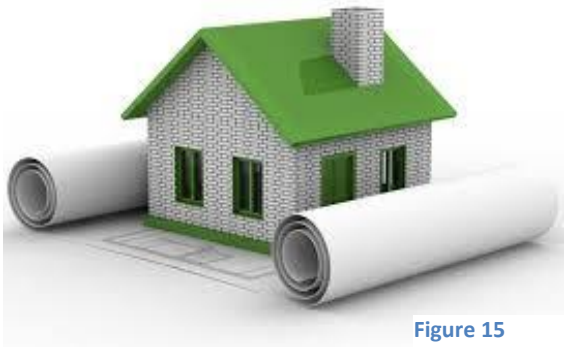


Figure 15

Eligible building types

- Single family homes
- Low-rise multi-family (1 to 3 stories)
- Mid-rise multi-family (5 to 8 stories)
    - 50%+ of Gross Floor Area residential

Important Notes:

- LEED for Homes **does not use** LEED ONLINE
- LEED for Homes uses ENERGY STAR for homes to measure energy efficiency
- LEED for Homes is the only rating system that adjusts points based on the size of the project and its effect on resource consumption
- LEED for Homes Providers are contacted by the USGBC for quality assurance
- Green Raters are contracted by the owner to inspect, document and assist the LEED process
- Documentation flows from the owner → green rater → LEED for Homes Provider → USGBC/GBCI
- The LEED project must be defined as a “dwelling unit” by all applicable codes
- LEED for Homes and Multifamily Lowrise – 1-3 stories. 3-5 story projects may choose the rating system corresponding to the ENERGY STAR program in which they are participating.

CHAPTER 3

INTEGRATIVE PROCESS (IP)

Integrative Process (IP)

Integrated Design Approach:

This is a paradigm shift from the linear planning process and is composed of all project team members including the property owner, facility manager, designers and contractors working together in the early stages of the project to set the sustainable goals of the project and promote synergies between the parties.
The Integrated Design Process (IDP) is essential in maximizing sustainable success as all members must work together in an open-ended, cohesive team. **Whole Building** or **Holistic Design** approaches result in forward- thinking sustainable designs.
Integrated Design depends on concepts such as:

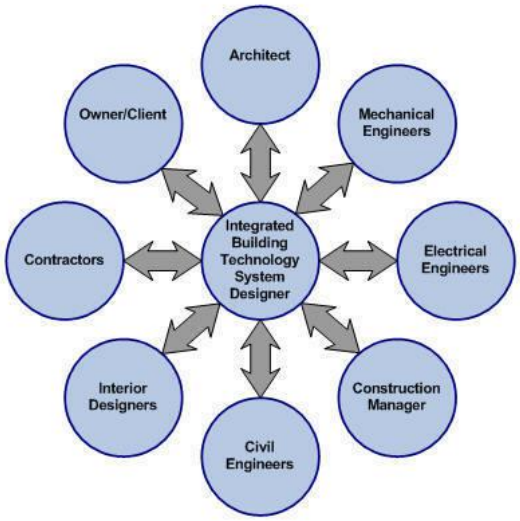


Figure 216

- **Integrated Project Delivery**
- **Integrated Project Team**
- **Systems Thinking Approach**
- **Life Cycle Approach**

Integrated Project Delivery (IPD)

Instead of the traditional design/build or design/bid/build project delivery methods, Integrated Project Delivery is used to promote the collaboration among key stakeholders and design professionals at **early stages of the design phase**. The owner, architect, general contractor, building engineers, fabricators, and subcontractors work together throughout the design and construction process. At the beginning of the process the project team members **collaboratively define the sustainable goals** of the project and during project construction process, the technologies and strategies are reviewed to verify that they meet these goals. *By looking at the graphs one can see that IP leads to greater cost control because it is expensive to make any changes late in the project construction phases. This will also help avoid green features being value engineered out of the project as costs are understood early.*

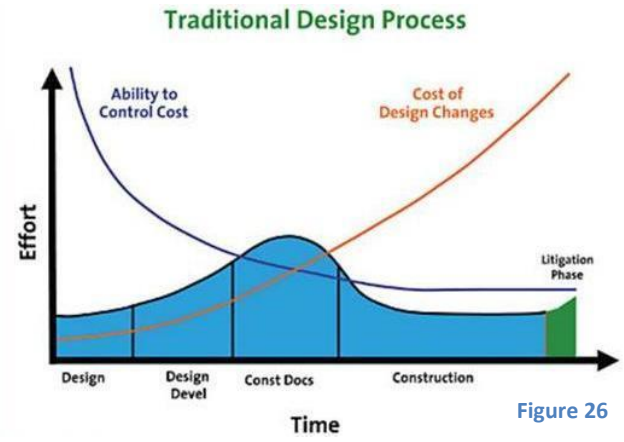


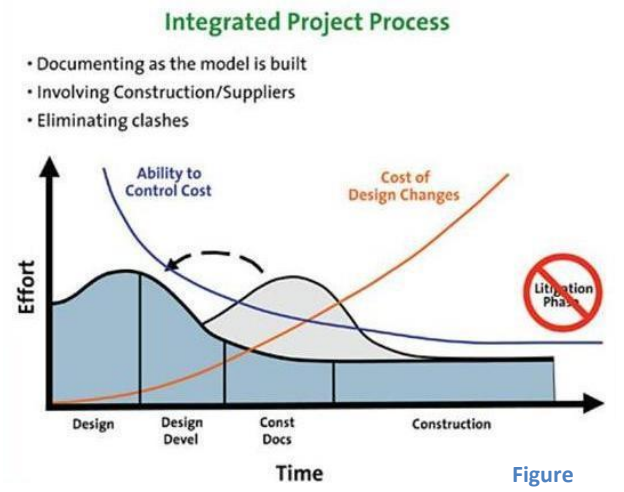
Figure 26

Design Charrette: a brainstorming session held at the beginning of a project to set project goals, exchange information and address challenges. It is essentially a pre-design meeting.

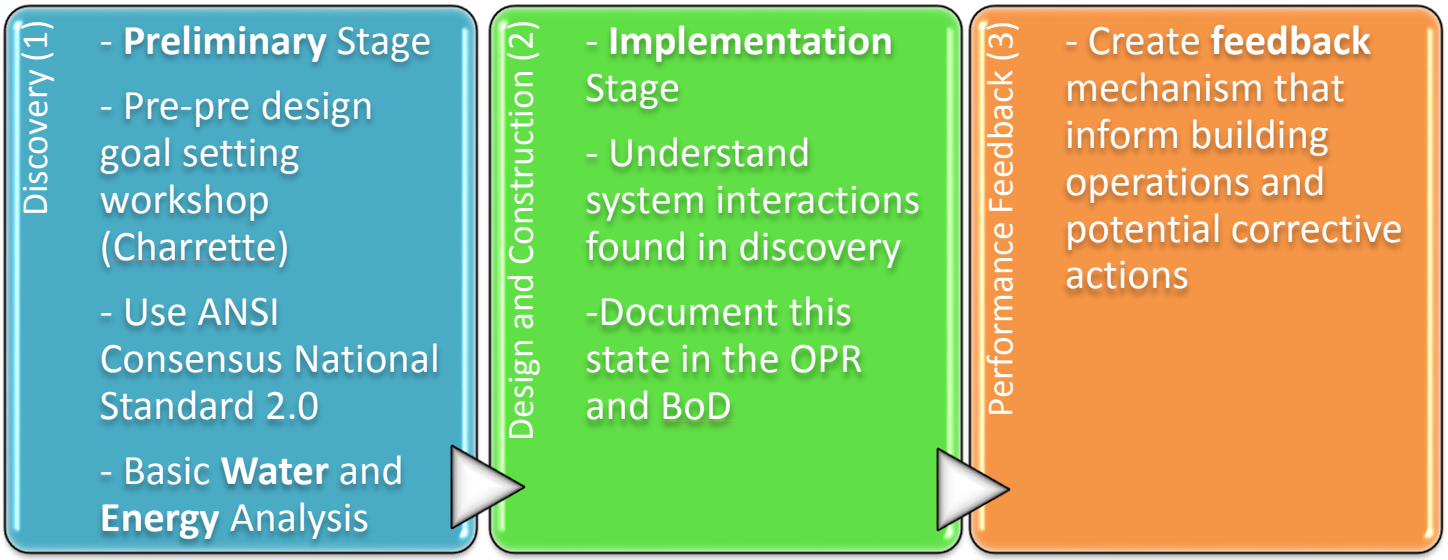
Integrative Process (IP) and LEED:

IP was only a strongly encouraged route to success in LEED in the past. However, with the onset of LEED V4 it is now worth points. IP is even a prerequisite in **healthcare** following:
Identify Team → Prepare and Convene Charrette → Goals

The IP credit is applicable to all rating systems in the building design and construction umbrella. The credit encourages the project team to find opportunities to achieve synergies throughout all building systems and focusses on energy and water related systems. There are three main phases for IP:
Discovery → Implementation → Performance Feedback
See below:



Figure



Energy Systems IP example:

1. Discovery – perform a simple box energy model analysis to understand how energy is distributed
2. Implementation – Use the analysis in the discovery to create the Owners Project Requirements (OPR)
3. Feedback – Use energy meters or a building automation system to ensure proper energy distribution

Water Systems IP example:

1. Discovery – perform a water budget analysis prior to schematic design
2. Implementation – Use the analysis in the discovery to create the Owners Project Requirements (OPR)
3. Feedback – Utilize water meters to ensure no leaks and proper adherence to the OPR

Integrated Project Delivery phases:

- **Pre-Design:** Data collection, discussions of project goals and green technologies.
- **Design**:
  1. **Schematic Design (SD):** Preparation of preliminary design options and project layout
  2. **Design Development (DD):** More detailed design of the building and its energy systems
  3. **Construction Documents (CD):** Preparation of the detailed construction documents which are needed for permissions and bidding
- **Bidding:** the process of selecting the contractor to prepare for the construction phase
- **Commissioning:** process to achieve, verify, document the facilities and systems will perform as designed and installed. This ensures building quality through on-site verification.
- **Occupancy:** the Certificate of Occupancy has been issued and the building can be occupied

Figure 18

Objectives of the holistic or integrative design process include: credit interactions, a high Cost-benefit ratios, accessibility, security, synergies, productivity, functionality and an aesthetically pleasing design.

Integrated Project Team

The integrated project team is the key factor to the success of the Integrated Design Process. The project team includes the key stakeholders and professionals from every discipline and requires:

- Good communication and coordination between the team
- Strong analysis to develop innovative solutions
- Collaboration among all members from early stages and throughout all the project phases
- Decisions based on information from all members to satisfy the project goals and prevent conflicts

Figure 19

Systems Thinking Approach

Systems thinking approach is used to recognize that the change of one part of system will affect other parts of the system. It is important to understand the relationship between all parts of a system and to consider the influence of disrupting it. The goal of the systems thinking approach is to avoid designing a solution to one problem that results in another problem. For example, using triple glazed windows instead of single glazed will require a stronger structure and a smaller HVAC system to treat the space. There are two types of systems.

- **Open loop systems**

Open loop is the linear loop in which resources are extracted, manufactured, used and turned into waste. It is known by Cradle to Grave open loop. Open loops are considered **unsustainable**.

- **Closed loop systems:**

Closed loop is the circular loop in which resources are extracted, manufactured, used and then reused or recycled. It is known by Cradle to Cradle closed loop. It is **more sustainable** and environmentally responsible

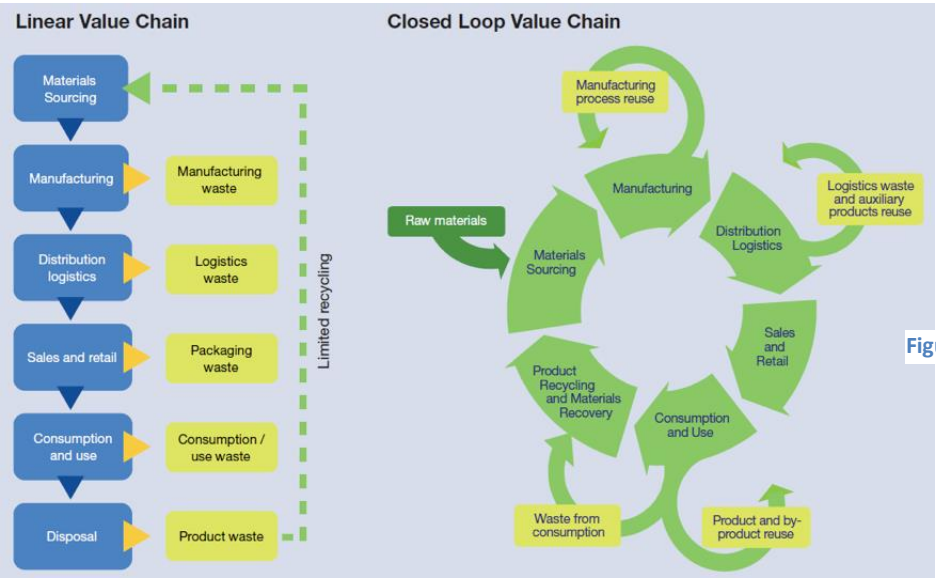


Figure 20

The systems thinking approach also involves system feedback in the form of two possible loops:

- **Positive Loop** (amplifies) – climate change melts ice → reducing ability to reflect the sun's heat using its albedo → more warming of our atmosphere

- **Negative Loop** (controls/regulates) – Thermostat set to 72°F in winter → room cools → thermostat tells heater to provide heat up to 72°F → Thermostat tells heater to shut off until needed

CHAPTER 4

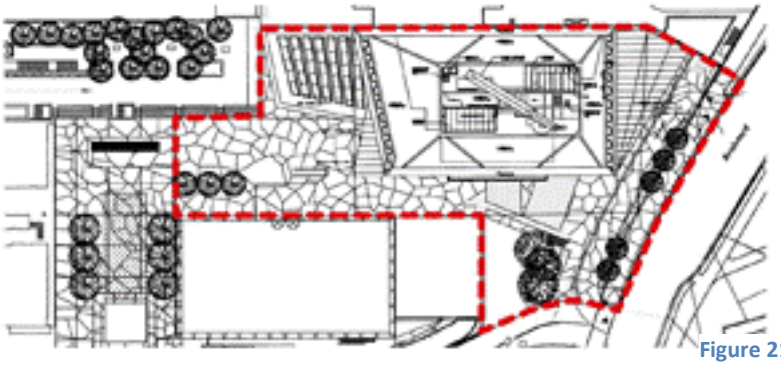
Location and Transportation (LT)

LTc1 LEED for Neighborhood Development Location (D)				LTc2 Sensitive Land Protection (D)				LTc3 High Priority Site (D)				LTc4 Surrounding Density and Diverse Uses (D)				LTc5 Access to Quality Transit (D)				LTc6 Bicycle Facilities (D)				LTc7 Reduced Parking Footprint (D)				LTc8 Green Vehicles (D)			
8	8	8		1	1	2		1	1	1	Y	1	1	1		1	1	1	Y	1	1	1		1	1	1	Y	1	1	1	
16	15	20						2	2	3		5	5	6		5	4	6													
NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS	

Location and Transportation (LT) Introduction

It is estimated that in 2030 60% of the global population will live in an urban area, and currently transportation emissions are the second largest contributor of greenhouse gases (next to buildings) as 33% of our GhG emissions are due to getting from point A to point B. This credit category focusses on reducing our transportation emissions by encouraging alternative transportation, building on previously developed land equipped with existing infrastructure and compact planning. A major goal of LT is to discourage the use of private driven gas automobiles. Before delving into how to earn points in this credit category we must understand a few terms:

LEED Project Boundary is the portion of the project site submitted for LEED certification. It must remain consistent for all required credit calculations. If a piece of land supports day to day building operations and is off-site, that piece of land must also be included in the LEED boundary. For multiple building developments, the LEED project boundary may be a reasonable portion of the development as determined by the project team. For example in a campus project or an industrial complex, 100 percent of gross land on campus must be included in LEED boundaries if all the buildings on campus are LEED certified.



Recommended LEED Site Boundary

Figure 21

Gerrymandering of a LEED project boundary is prohibited; the boundary may not unreasonably exclude sections of land to create boundaries for the sole purpose of complying with credits.

Building footprint is the area defined by the perimeter of the building plan. Non-building facilities such as pavements and landscaping are not included.

Development footprint is the area of the site including pavements, parking, landscaping, roads and other facilities as well as the building. It is essentially all alterations done to the site.

Property boundary is the total area within the legal boundaries of the site.

LEED for Neighborhood Development and Smart Locations:

LEED promotes the development of vibrant, equitable communities that are healthy, walkable and mixed uses. It encourages the developing near existing communities and public transportation to reduce vehicle trips. LEED ND includes credits for smart locations, green buildings infrastructure and neighborhood design and pattern

Full Time Equivalent (FTE)

Many prerequisites and credits require an estimated occupancy count and LEED accomplishes this through FTE calculations. One FTE is equal to a 40-hour work week. Thus if the sum of all ‘people-hours’ spent in the building over a week is 4000, we divide this be 40 to equal an estimated 100 FTEs in this building.

Location

Site selection must consider the natural and social characteristics of the site as well as the existing infrastructure. One must examine how the site is connected to its surroundings and what services are available to the building users. A good site can affect energy conservation strategies, landscaping and vegetation, and the access to public transportation. All LEED rating systems address principles of Smart Growth.

Smart Growth is an urban planning theory that encourages:

- The protection of undeveloped land
- Transit-oriented and bicycle-friendly land use to reduce automobile use
- Mixed use development
- Development of compact urban centers
- Design of walkable neighborhoods

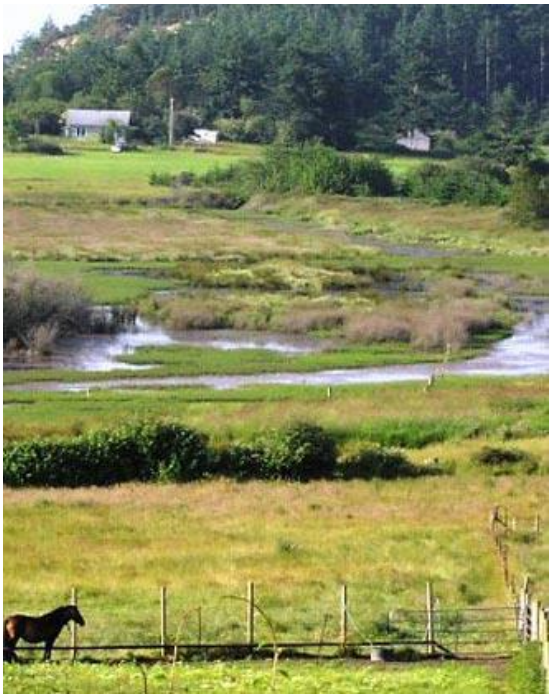


Figure 22

LEED for Neighborhood Development Location – LTc1

A project can earn all the points available in the entire LT credit category by selecting a site that is located within the LEED boundary of an existing LEED for ND certified property. Different points are awarded depending on the level of certification and no other LT credits can be pursued if this credit is achieved. By building in a LEED ND location you guarantee reduced automobile dependence, walkability, existing green infrastructure and the enhancement of overall health.

Selecting a Site:

Site selection is the first step in development and can result in many LEED points. LEED encourages the development of previously developed sites to protect the natural environment, trees, streams, and native plants or species.

Sensitive Land Protection – LTc2

A project team can satisfy this credit by locating the development on a **previously developed site** – or –

A project team seeking LEED certification must prevent developing on the following land types:

1. **Prime farmland** defined by the Natural Resources Conservation Service (NRCS) Soil survey
2. Lands Within **100 feet of water bodies** as defined by the US Army Corps' of Engineers' Wetlands
3. Lands within 500 feet of wetlands as regulated by the US Army Corps' of Engineers' Wetlands
4. Areas that are a **habitat for threatened or endangered species** as defined by US Endangered Species Act or NatureServe
5. **Floodplains** as defined by the General Emergency Management Agency (FEMA)

Important Terms:

Brownfield – A brownfield site is a previously used or developed land that may be contaminated with hazardous waste or pollution and has the potential to be reused once any hazardous substances, pollutants, or contaminants are remediated
Historic District – A group of buildings/structures that have been deemed significant to the area

Infill site – a previously developed site that was built on, has been graded or a site in-between existing structures. It is essentially a gap in the built environment. Building on infill sites protects undeveloped land and can benefit from the existing infrastructure such as roads, utilities and other services. 75% of site must be previously developed

High Priority Site – LTc3

This credit includes 3 Options to promote the redevelopment of sites/areas deemed undesirable through decontamination, gentrification or preservation:

1. **Historic District –** Locate project within a historic district or infill site
2. **Priority Designation –** Locate project within a site identified by a government agency as for priority redevelopment
3. **Brownfield Remediation -** Select a site which contains soil or water contamination and deemed by federal, regional or local authority. Land remediation is costly and time consuming but a project can also take advantage of existing amenities and infrastructure

Figure 23

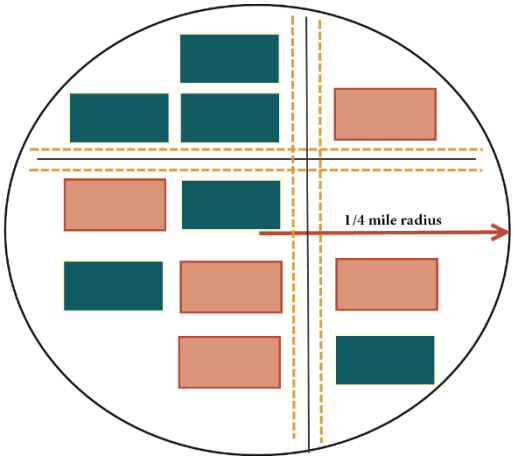
Surrounding Density and Diverse Uses – LTc4

The intent here is to conserve land and habitats by developing in areas with existing infrastructure. Encouraging pedestrian walkability significantly reduces automobile trips by developing in a dense area with a lot of diversity. Again we are trying to discourage the use of private driven gas operated automobiles. There are 2 options to show compliance with this credit which look at density and diverse uses.

Important Terms:

Buildable Land – land where construction can occur and excludes public right of way (IE. Roads)
Density– A measure of floor area (Sf) or units per buildable land (acre)
Floor-Area Ratio (FAR) – Density of non-residential land-use

$$\text{FAR} = \frac{\text{Building Floor Area (SF)}}{\text{buildable land area}}$$



1. **Surrounding Density in <u>quarter mile radius</u> exceeds:**
    a. Residential Density = Dwelling Units / Acre
    b. Non-Residential Density = 0.5 FAR+
        i. Ensure these spaces are separated
    c. Combined = SF/Acre of buildable land

2. **Diverse Uses**

   a. Select a site that is within ½ mile walking distance (entrance to entrance) of existing and publicly available diverse uses including:

1. **Category:** Food Retail
   Type - Supermarket
2. **Category:** Services
   Type – Bank, theatre
3. **Category:** Community Retail
   Type - Convenience Store, Pharmacy
4. **Category:** Civic & Community Uses
   Type – Senior or Child-care
5. **Category:** Education Facility
   Type - University

A project may only count 2 types per category and 3 categories must be represented for a minimum of 4 diverse space uses.

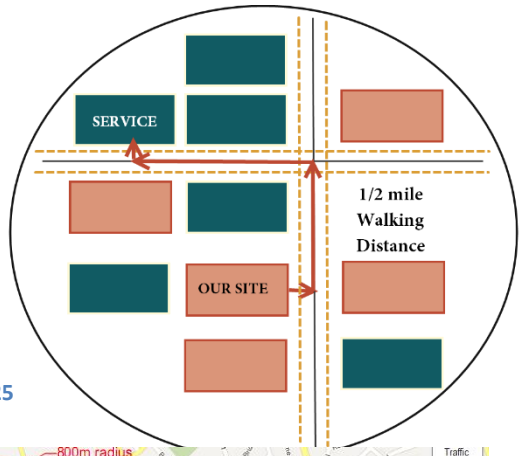
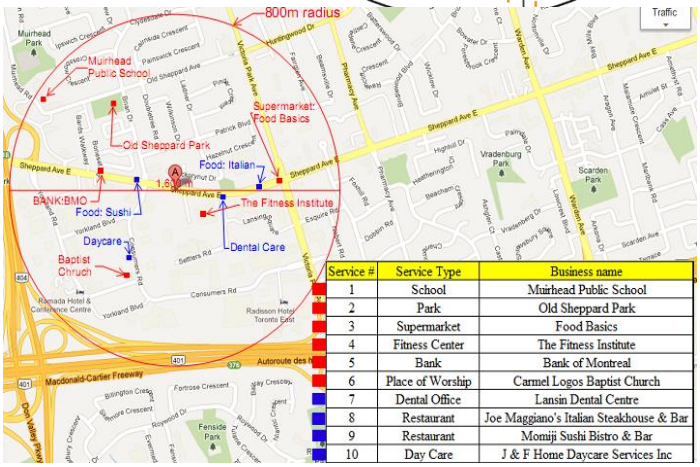


Figure 24-25



Service #	Service Type	Business name
1	School	Muirhead Public School
2	Park	Old Sheppard Park
3	Supermarket	Food Basics
4	Fitness Center	The Fitness Institute
5	Bank	Bank of Montreal
6	Place of Worship	Carmel Logos Baptist Church
7	Dental Office	Lansin Dental Centre
8	Restaurant	Joe Maggiano's Italian Steakhouse & Bar
9	Restaurant	Momiji Sushi Bistro & Bar
10	Day Care	J & F Home Daycare Services Inc

Transportation

More new buildings mean more demand on transportation, LEED promotes the development of sites near mass transit and encourages more efficient means of transportation. The goal of transportation related credits in LEED is the reduction of vehicle trips and the promotion of sustainable alternatives.

Access to Quality Transit – LTc5

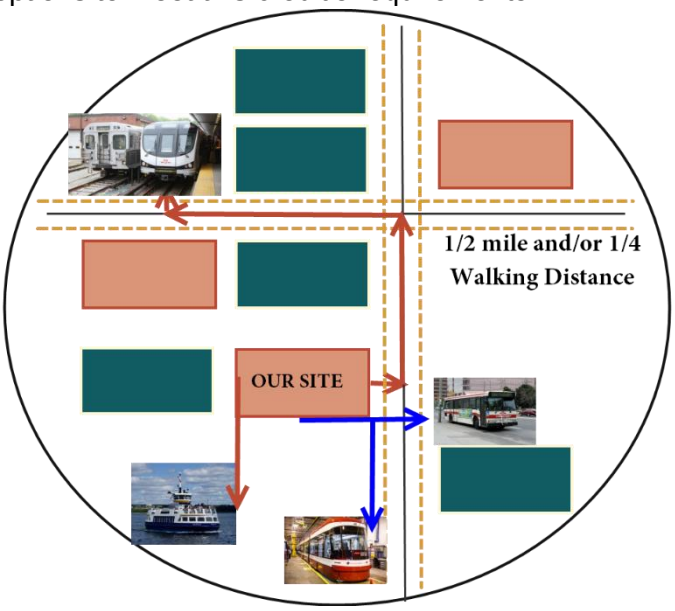
The intent of this credit is to encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use. There are two options to meet this credit's requirements:

1. **Ensure that any functional entry is within ¼ mile walking distance of either:**
    a. A bus stop
    b. Streetcar Stop **or**
    c. Rideshare Location

Minimum trip count: 72 weekday and 40 Weekend trips

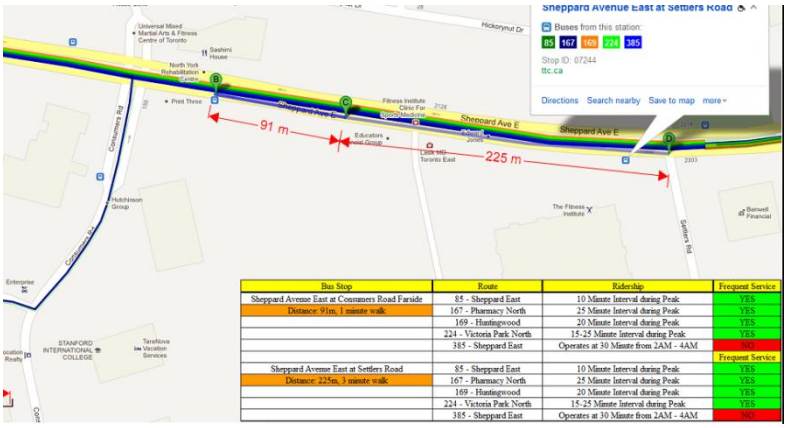
2. **Ensure that any functional entry is within ½ mile walking distance of either:**
    a. Bus Rapid Transit stop
    b. Light or Heavy Rail Station **or**
    c. Commuter rail or ferry terminals

Minimum trip count: 24 weekday and 6 Weekend trips



Schools Specific Option

Ensure that a certain percentage of students live within ¾ mile walking distance (Grade 8 and below) and/or 1.5 miles (Grade 9 and above) of a functional entry.



Bicycle Facilities – LTc6

Cycling significantly reduces CO_2 levels, lowers risk of disease and reduces road congestion. This credit requires that adequate bicycle storage be provided for short-term and long-term visitors as well as a connection to a bicycle network.

1. A network consists of **off-street** bicycle paths or **on-street** bicycle lanes
2. The **bicycle network** must be within **3 miles** of one of the following:
    a. 10 diverse uses
    b. A **school or employment** center (If residential project)
    c. **Bus Rapid Transit**, Light or Heavy Rail Station or a Commuter rail or ferry terminals
3. Provide short and/or long term **parking for occupants**
    a. **Long-term** = Covered parking that is easily accessible to residents and employees
    b. **Short-term** = Uncovered Parking used by visitors
4. Provide **Showers for occupants** in commercial spaces

Reduced Parking Footprint – LTc7

The US has twice as many parking spots as people! Most of these spaces are impervious and above ground. The intent of this credit is to reduce automobile dependance and reduce impervious pavement which is detrimental to our environment due to rainwater runoff and contribution to the heat island effect (To be discussed in Sustainable Sites). This credit has 3 requierments:

1. **Do not exceed local zoning code requirement**
2. **Reduce Parking capacity from Baseline (ITE Handbook Standard)**
    a. If LTc4 – Surrounding Density & Diverse Uses **IS NOT ACHIEVED**
        • **20% Reduction**
    b. If LTc4 – Surrounding Density & Diverse Uses **IS ACHIEVED**
        • **40% Reduction**
3. **Provide 5% preferred carpool parking**
    a. Parking closest to the entrance

Green Vehicles – LTc8

Gasoline powered automobiles are not the only option for car ownership as hybrids, electric vehicles and alternatively fueled vehicles are gaining popularity. There are two requirements for this credit:

1. **Provide 5% preferred parking or 20%+ discount for green vehicles**
    a. American Council for an Energy Efficient Economy (ACEEE) score of 45+

    - **AND ONE OF** -

2. Provide **Electric Vehicle Charging Stations**

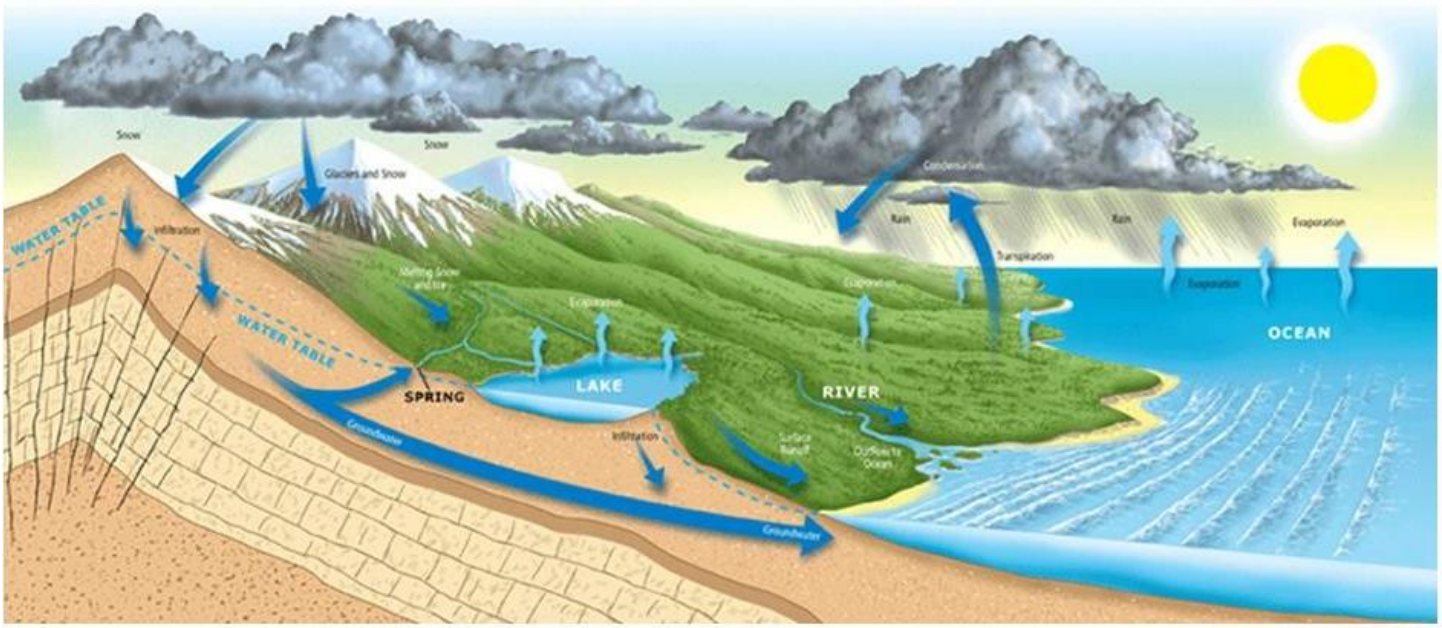
    - OR -

2. Provide alternative refueling / **battery switching stations**

Schools Only – All buses must meet prescribed emissions standards and all other school-owned vehicles must be green.

CHAPTER 3

SUSTAINABLE SITES (SS)



Sustainable Sites				
10	11	12		
NC	S	CS		

SSp1 Construction Activity Pollution Prevention (C)			
R	R	R	
NC	S	CS	

SSp2 Environmental Site Assessment (D)			
NA	R	NA	
NC	S	CS	

SSc1 Site Assessment (D)			
1	1	1	
NC	S	CS	

SSc2 Site Dvlpment—Protect or Restore Habitat (D)			
1 2	1 2	1 2	Y
NC	S	CS	

SSc3 Open Space (D)			
1	1	1	
NC	S	CS	

SSc4 Rainwater Management (D)			
2 3	2 3	2 3	Y
NC	S	CS	

SSc5 Heat Island Reduction (D)			
1 2	1 2	1 2	Y
NC	S	CS	

SSc6 Light Pollution Reduction (D)			
1	1	1	
NC	S	CS	

Sustainable Sites (SS)

Overview

The site selection is the first step towards any project. A project's site is considered sustainable if it reduces construction impacts, restores degraded or contaminated areas, protects water quality and mitigates rainwater runoff and light pollution. This chapter will discuss the Sustainable Sites category and the strategies to achieve it.

Sustainable Sites interacts with the Location and Transportation credit category as SS also depends on the chosen location but focuses on the existing site conditions rather than its surroundings. Developers are encourages to design and construct with the natural elements provided by the site as opposed to disturbing it and fighting nature.

Sustainable Site Design

A sustainable site design considers the whole development footprint including landscaping and hardscapes. The goal of the site design is to determine the site's ability to support the building while minimizing its environmental impacts.

Construction Activity Pollution Prevention – SSp1

It is essential to minimize environmental impacts during construction process. Construction activities result in:

- The loss of the topsoil
- Loss of nutrients, soil compaction and decreased biodiversity
- Water pollution due to water runoff which carries pollutants and sediments to receiving water
- Airborne dust which causes environmental and health issues
- The degradation of water bodies and aquatic habitats

-The project team must develop and implement an Erosion and Sedimentation Control Plan (ESC) to reduce construction pollution; the ESC plan must comply with the **2012 EPA General Construction Permit or local codes,** whichever is more stringent.

Strategies to control Erosion and Sedimentation:

- Temporary or permanent **Seeding** to stabilize the soil
- **Mulching** using hay, grass or gravel to hold the soil
- **Earth dike** to divert runoff into sediment traps
- **Straw bales**
- **Silt fence**
- **Erosion control blankets**

Silt fence

Erosion control blankets

Mulching

Note that Schools and Healthcare projects are required to conduct a phase 1 Environmental Site Assessment If contamination is suspected then a phase 2 Environmental Site Assessment must be performed (SSp2)

Site Assessment – SSc1

The first credit is part of the integrative process and logically deals with determining existing site conditions. This credit requires that the natural conditions be evaluated and include:

1. **Topography** - Contour mapping and slope stability risks.
2. **Hydrology** - Flood hazard areas, delineated wetlands and other bodies of water
3. **Climate** - Solar exposure, heat island effect potential, sun angles, winds, precipitation and temperature
4. **Vegetation** - Plant types, tree mapping, threatened or endangered species, and unique habitat
5. **Soils** - prime farmland, healthy soils, previous development, disturbed soils
6. **Human use** - Views, transportation infrastructure, adjacent properties and materials effects
7. **Human health effects** Proximity of vulnerable populations, and proximity to sources of air pollution

Figure 26

Site Development: Protect and Restore Habitat – SSc2

The intent of this credit is to conserve the existing natural features and attempt to restore what was originally on the site.
This credit has two options:

1. **Protect** 40% of greenfield area (if greenfield exists)

- AND -

1. **Restore** 30% of developed land (including building footprint) with native/adaptive vegetation

- OR -

2. Provide financial support ($0.40/sf) for total site area to a **Land Trust Alliance organization within the same EPA ecoregion**
    - Land Trust – non-profit organization that actively works to conserve land through conservation easement or acquisition

Site Development: Maximize Open Space – SSc3

Open Space is equal to the property area **subtract** the development hardscape footprint and is essentially the vegetated land on site. Open space provides a habitat for vegetation and wildlife; while reducing the urban heat island effect, increasing storm water infiltration and connecting humans to the outdoors. A compact high-rise building with the same square footage as a low-rise building reduces the building footprint and minimizes the disturbance of the existing ecosystem. This credit has requirements based on open space set aside:

1. **30%** of site area (including building footprint) must be open space
    - **25%** of that open space must be vegetated or have a **tree canopy**
    - Outdoor space must be **accessible and useab**le for building occupants

These spaces can be used for many purposes such as social and physical activities and community gardens.

A Note on vegetative roofs for SSc2 and SSc3:

Extensive Green Roof – vegetative roof not designed for human access and minimal maintenance
Intensive Green Roof – vegetative roof with a variety of plants and human uses. Native and adaptive plants are encouraged

Projects that achieve a density of 1.5+ floor-area ratio (FAR), **vegetated roofs** can be used toward the minimum 25% vegetation requirement

Rainwater Management – SSc4

Conventional new developments have detrimental effects on the natural environmental systems. New developments reduce the natural permeability of sites and increase rain water runoff. Increased runoff rates can result in erosion and sedimentation of waterways. The water quality is reduced due to pollutants carried by runoff water and can be harmful to aquatic life in receiving waters. It is useful to note the amount of tax dollars and energy required to pump and treat storm water that runs off into our municipal water systems. A storm Water Management plan (SWP) often includes strategies to collect and reuse storm water to reduce the water runoff from the site. Strategies to manage storm water addresses both water **quality and quantity**. LEED encourages practices that reduce storm water runoff and protect the quality of both surface and ground water. This accomplished by reducing the impervious surface area and adding structural or nonstructural features that retain water onsite to allow infiltration and reuse.

1. **Use Low Impact Development and Green Infrastructure**
   - Capture and treat 95th percentile rainfall events (IE (95% of all rainfall events do not exceed the 95th percentile runoff volume)

2. **Natural Land Cover Condition management**
   - **Amount to manage = (**Post Development Runoff - natural land cover condition runoff**)**

Green Infrastructure - management approaches and technologies that help water infiltrate, evapotranspire, capture and reuse stormwater to maintain or restore natural hydrologies

Low Impact Development - emphasizes on-site natural features to protect water quality, by replicating the natural land cover hydrologic regime of watersheds, and addressing runoff close to its source (IE. maintain vegetative swales, rain gardens and minimize impervious cover**.**

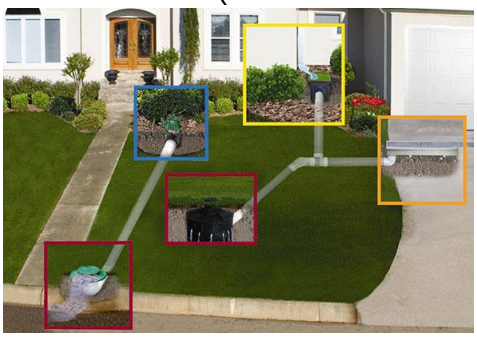
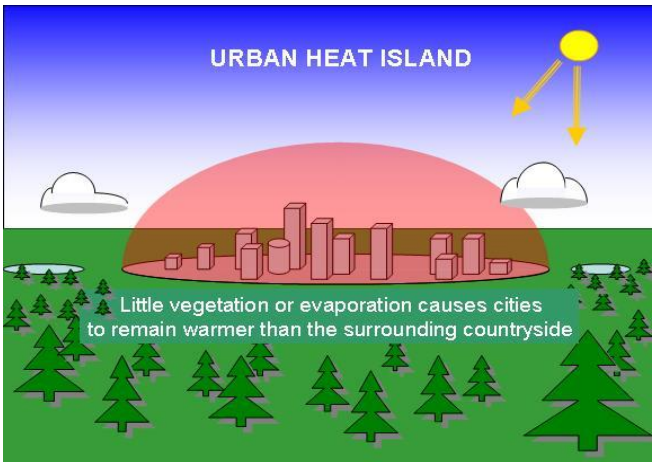


Figure 27

Heat Island Reduction – SSc5

A heat island is defined as the thermal differences between developed and undeveloped areas.
Urban areas experience higher temperatures as compared to their surrounding rural counterparts due to:

- The abundance of dark hardscapes such as asphalt and concrete which absorb and store heat during day and release it at night.
- Insufficient ventilation due to narrow streets, high buildings, vehicles exhaust
- The lack of evapotranspiration which increases the heat island effect and contributes to urban smog.



LEED refers to Heat island as the rise in temperatures from 2 to 10 degrees in urban areas higher than surrounding rural areas, addressing both roof and non-roof components in two different credits under the sustainable sites category. Cool pavements and cool roofs are terms referring to materials with lower emissivity and higher albedo and subsequently higher Solar Reflectance Index (SRI).

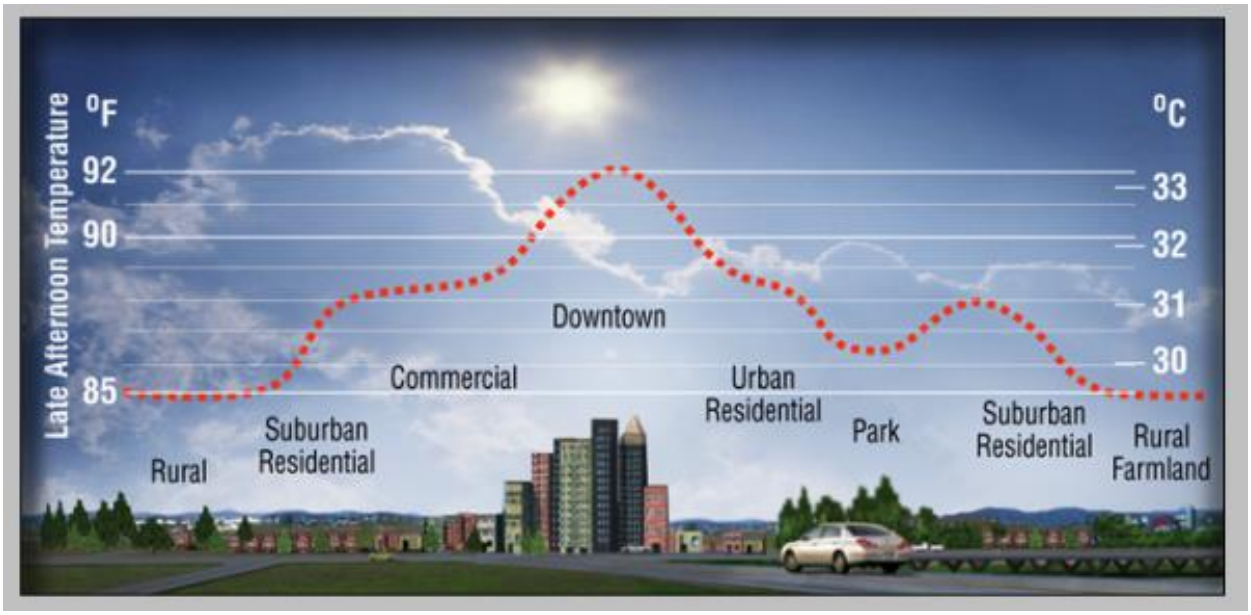
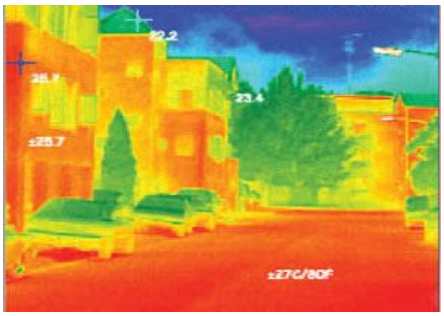


Figure 28

Emittance or emissivity is the ability of a material to emit heat by radiation.
Solar reflectance or albedo is the fraction of the solar energy reflected by a surface defined as a number between 0 and 1. The higher the number the better the roof reflects energy.
Solar reflectance index (SRI) is the measure of the constructed surface ability to reject solar heat, a combined value of reflectivity and emissivity. It is defined so that standard black is zero (reflectance 0.05, emittance 0.90) and standard white is 100 (reflectance 0.80, emittance 0.90). **This is used for roof surfaces.**
Solar Reflectance (SR) – the fraction of solar energy that is reflected by a surface on a scale of 0 to 1. Black paint is 0 and white paint is 1. **This is used for non-roof surfaces**

Strategies for reducing heat island effect:



- **Non roof**

Hardscapes*:* Decrease areas of impervious hardscape and use higher solar reflectance materials. Use cool pavements with three year aged SR of .28 (or Initial SR of 0.33) or higher, or open grid systems which are 50% or more pervious.

Shading*:* provide shading for 50% of the hardscape area by taking advantage of existing tree canopies **OR** new trees anticipating their size and shade within 10 years of installation

OR add shading structures covered by solar panels **OR** architectural features with SR .28 or higher.

Parking*:* locate 75%+ of parking spaces under roofs or shades with Initial SRI > 39 - or - 3 year aged SRI > 32, or a vegetative root or energy generation systems.

- **Roofs**

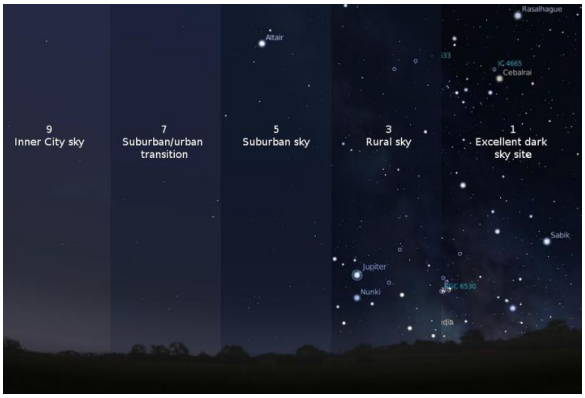
Install roofs using one of the following strategies:
Use roof materials with the following SRI requirements:

	Slope	Initial SRI	3-year aged SRI
Low-sloped roof	≤ 2:12	82	64
Steep-sloped roof	> 2:12	39	32

OR provide vegetated roof for at least 50% of roof area,
OR use a combination of vegetated roof and high SRI roof that comply with this equation:

$$\frac{\text{Area of NonRoof (SF)}}{0.5} + \frac{Area\ of\ High\ SRI\ Roof (SF)}{0.75} + \frac{Area\ of\ Vegetative\ Roof (SF)}{0.75} \geq Total\ paved + Total\ Roof$$

Light Pollution Reduction – SSc6



Excessive or intrusive artificial night lights cause light pollution. Light pollution disrupts ecosystems, affects health and reduces night sky observation. LEED promotes well designed lighting systems that reduce light pollution. The light pollution reduction credit's intent is to minimize light trespass from the building and its site, reduce sky glow to increase night sky access, improve nighttime visibility through glare reduction and reduce development impact on nocturnal environments.

Lighting Zones created by the Model Lighting Ordinance:
Determine the project's lighting zone according to the requirements of IESNA RP-33 as follows:

1. LZ0 – No Ambient Lighting
2. LZ1 - Dark (park and rural settings)
3. LZ2 - Low (residential areas and neighborhood business districts)
4. LZ3 - Medium (commercial/industrial and high density residential)
5. LZ4 - High (major city centers and entertainment districts)

There are two options to achieve this credit and both deal with restricting uplight and light trespass off the site.

1. **Backlight-Uplight-Glare (BUG) Method**

Based on the Illuminating Engineering Society (IES) TM standard – do not exceed luminaire ratings per zone

2. **Calculation Zone**

Do not exceed the maximum allowed percentage of total luminaire lumens emitted above horizontal/vertical

Light Pollution Reduction Strategies
Interior Lighting

- Reduce power to all non-emergency lighting with a direct line of sight to building envelope openings, such as windows and doors during off-schedule hours or curfew times.
- Provide automatic shielding, for all non-emergency lighting with a direct line of sight to building envelope openings, such as windows and doors.
- Develop a computer model for more accurate design and selection of lighting systems and fixtures
- Comply with ASHRAE 90.1 lighting densities
- Use low angle lights and full cutoff light fixtures

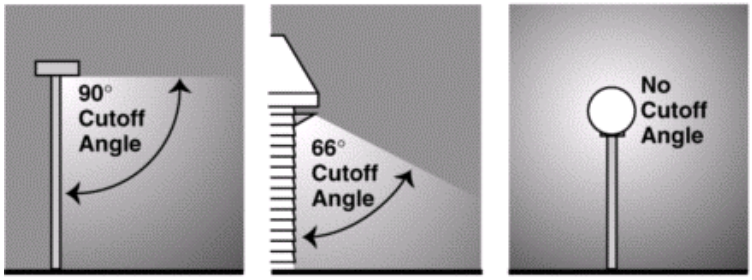


Figure 29

Schools Only – Site Master Plan – SSc7

Achieve 4 of the following 6 credits:

· LT Credit: High Priority Site
· SS Credit: Site Development Protect or Restore Habitat
· SS Credit: Open Space
· SS Credit: Rainwater Management
· SS Credit: Heat Island Reduction
· SS Credit: Light Pollution Reduction

Schools Only – Joint Use Facilities – SSc8

Ensure the school's facilities are optimally utilized through sharing them with the general public or specific services such as a police office or health clinic. Alternatively share a space owned by another organization such as an offsite gymnasium. Ensure that there is direct pedestrian access and toilet access afterhours.

Core and Shell Only - Tenant Design and Construction Guidelines– SSc7

The project team must create an easily understandable document to ensure tenants understand the sustainable features and utilize them in case they fit it out in the future.

Healthcare Only – Places of Respite and Direct Exterior Access – SSc7 + SSc8

Human health is directly linked to healthcare facilities and as a result the built-environment should do as much as it can to promote occupant wellbeing. These credits deal with mimicking the outdoor environment indoors (places of respite) or creating an accessible outdoor space such as courtyards or terraces (Direct Exterior Access).

CHAPTER 5

WATER EFFICIENCY (WE)

Water Efficiency				WEp1 Outdoor Water Use Reduction (D)				WEp2 Indoor Water Use Reduction (D)				WEp3 Building-Level Water Metering (D)				WEc1 Outdoor Water Use Reduction (D)				WEc2 Indoor Water Use Reduction (D)				WEc3 Cooling Tower Water Use (D)				WEc4 Water Metering (D)			
11	12	11		R	R	R		R	R	R		R	R	R		12	12	12		16	16	15	Y	12	12	12		1	1	12	
NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS	

Water Efficiency (WE)

Overview

Water is an essential resource on earth. Over 400 billion gallons of water are used each day in U.S. representing almost 25% of the nation's fresh water supply. EPA estimates that 1/3 of streams, rivers and lakes are now unsafe for swimming and fishing, where nearly 86% of the water we use is discharged. According to the United Nations Environment Program, if our present patterns continue, two out of every three people will live in water-stressed conditions by the year 2025. Toilets account for 25% of daily water use in the U.S. and 1.6 billion gallons of water are wasted in the U.S. every year because of inefficient toilets. LEED encourages the use of strategies and technologies that reduce the amount of potable water consumed in buildings, while meeting the needs of the systems and occupants. Many strategies are no cost or provide a rapid payback. Water use reduction can reduce the burden on wastewater treatment facilities.

The water efficiency category addresses potable water usage associated within buildings, the site's landscaping and proper metering of water usage. This credit category focusses on efficiency first as the prerequisites attempt to reduce waste, and credits look at the integration of alternative sources of water such as graywater.

Water Efficiency versus Conservation- Conservation focusses on policies and activities to manage the use of water whilst efficiency is the reduction of water needed for a specific purpose. **Conservation** is defined as trying to reduce water use entirely and **efficiency** aims to reduce waste by using less for the same task

Full Time Equivalents (FTEs)- the FTE of a project must be consistent across all credits. FTE is a regular building occupant who spends 40 hours per week in the project building. Part time or overtime occupants have FTE values based on their hours inside the building per week divided by 40. FTEs are based on an 8 hour occupancy period per day. An 8 hour (5 days a week) full time occupant has an FTE value of 1.0. FTEs are needed to calculate the baseline, and design case water usage of a building.

FTE identifies the total number of building occupants according to their occupany types:

- Full time staff
- Part time staff
- Peak Transients (students, volunteers, visitors, customers, etc.)
- Residents

Potable water- water that meets or exceeds EPAs drinking water quality standards, and is approved for human consumption by state or local authorities having jurisdiction.

Graywater (or greywater)- domestic wastewater from bathroom and laundry sinks, tubs, showers and washers. The Uniform Plumbing Code (UPC) defines gray water as untreated household wastewater that has not come in contact with toilet waste; the International Plumbing Code (IPC) defines graywater as wastewater discharged from lavatories, bathtubs, showers, clothes washers and laundry sinks. Most states will not allow kitchen sinks or dishwashers to be included with graywater.

Blackwater- wastewater from toilets and urinals. Most jurisdictions consider water from kitchen sinks and dishwashers to be blackwater and it cannot be reused

Process water- water used for industrial processes and building systems such as boilers, cooling towers and chillers

Stormwater runoff- runoff water resulting from precipitation that flows over surfaces, and conventionally into storm sewers or waterways

WaterSense- is an EPA sponsored program that promotes and certifies water-efficient products, programs, and practices. WaterSense helps consumers identify water efficient products, and programs that meet WaterSense water efficiency and performance criteria. Watersense fixtures must use some amount of water (IE. Waterless urinals do not comply)

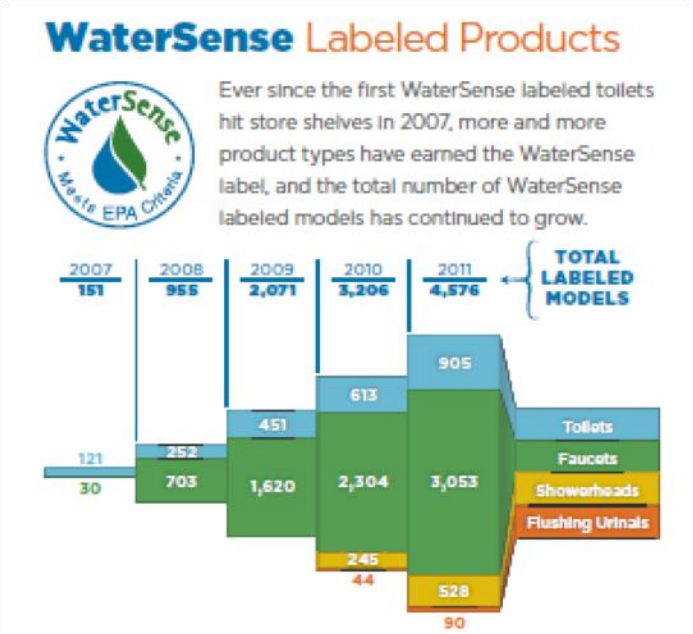


Figure 30

Gallons per flush (gpf)- the flow rate measurement unit for flush fixtures such as water closets and urinals.

Gallons per minute (gpm)- the flow rate measurement unit for flow fixtures such as faucets,showerheads, aerators, sprinkler heads

Waterless urinals- works completely without water or flush valves by passing urine through a liquid seal. There are two varieties of waterless urinal: cartridge based and non cartridge based units.

Dual flush- water closets use a full flush for solid waste and a half flush for liquid waste, Dual flush toilets can save around 2/3rd of water used for flushes.

Outdoor Water Use Reduction – WEp1 + WEc1

Outdoor water usage, mostly for irrigation, account for 30% of the 26 billion gallons of potable water used daily. Outdoor water use reduction can be achieved by using effective practices such as using native/adaptive plants or using gray water for irrigation.

A project pursuing LEED must comply with the **prerequisite** for outdoor water use reduction of 30%

Outdoor Water Use Reduction	
Percentage Reduction	Points (BD+C)
30%	Prerequisite
50%	1
100%	2

Points are incrementally awarded based on the amount of potable water offset by your choice of strategies

Water efficient landscaping strategies:

- Use EPA's WaterSense budget to establish a baseline based on the site's average rainfall and evapotranspiration rate
- Install native or adaptive landscaping to reduce or eliminate irrigation demands.
- Xeriscape the landscaping which is a thorough process that requires little or no irrigation
- Use mulching to retain moisture and prevent evaporation of the plant's water
- Reduce or eliminate turf grasses that need to be irrigated continuously
- Use efficient irrigation systems such as Drip irrigation systems or micro-misters
- Use nonpotable water for irrigation such as captured rainwater, graywater or municipally claimed wastewater

Indoor Water Use Reduction – WEp2 + WEc2

Indoor Water Use Reduction	
Percentage Reduction	Points (BD+C)
20%	Prerequisite
25%	1
30%	2
35%	3
40%	4
45%	5
50%	6
55% (EP)	7

LEED requires the project to reduce indoor water usage by 20% over the building's baseline in the prerequisite, and awards up to 6 points for further reduction. The Energy Policy Act of 1992/2005 (EPAct) established water conservation standards for water closets, shower heads, faucets, and other plumbing fixtures. Water use reduction calculations depend on the number of FTEs, not the number of fixtures, and the default ratio between male and female occupants is 1:1. Calculations are used to compare actual efficient specified fixtures versus the baseline conventional **flush** and **flow** fixtures. All newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled (or a local equivalent for projects outside the U.S.).

- Conventional toilets: 1.6 gpf
- Conventional urinals 1.0 gpf
- Private lavatory (bathroom) faucets: 2.2 gpm
- Public faucets: 0.5 gpm (private or public distinction is based on location and use)
- Conventional kitchen faucets: 2.2 gpm
- Conventional showerheads: 2.5 gpm

Standards for specific appliances are as follows:

- Residential clothes washer - ENERGY STAR or performance equivalent
- Commercial clothes washer - CEE Tier 3A
- Residential dishwasher - ENERGY STAR or performance equivalent
- Prerinse spray valve - consumption ≤1.3 gpm (4.9 lpm)
- Ice machine - ENERGY STAR or performance equivalent, and use either air-cooled or closed-loop cooling

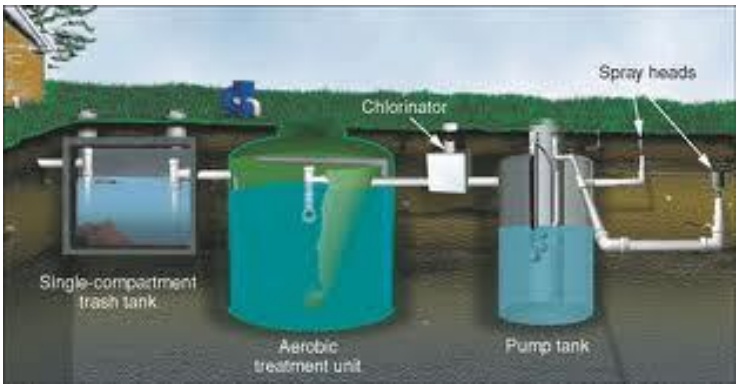
Water use reduction strategies:

- Install water efficient plumbing fixtures such as:
  - Efficient flow fixtures: lavatories, sinks, showerheads with lower gpm rates
  - Efficient flush type fixtures: dual flush toilets, waterless toilets/urinals, composting toilets, high efficient toilets HET

- Use nonpotable water such as captured rainwater, graywater or municipally claimed wastewater for toilets and urinals

Figure 31

- Use water efficient fixtures, nonpotable water, or municipally treated wastewater
- Treat on-site wastewater to tertiary standards



Exclude water reuse from: raw naturally occurring water bodies, rivers, groundwater, well water, sea water and discharge from open-loop geothermal

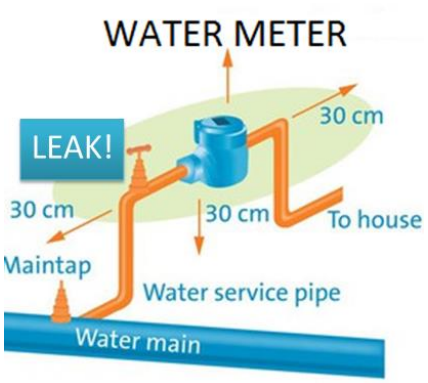
Percent Improvement calculations = {(Baseline – Actual) / Baseline)} x 100

Figure 34

Figure 33

Figure 32

Water Metering – Building Level (WEp3) / Submetering (WEc4)



An integral path to ongoing sustainability is the requirement to know exactly the volume of water used over time. Modern water distribution systems have many components in the project and on its site which results in ample leakage opportunities. Meters are a proactive approach to locating leaks.

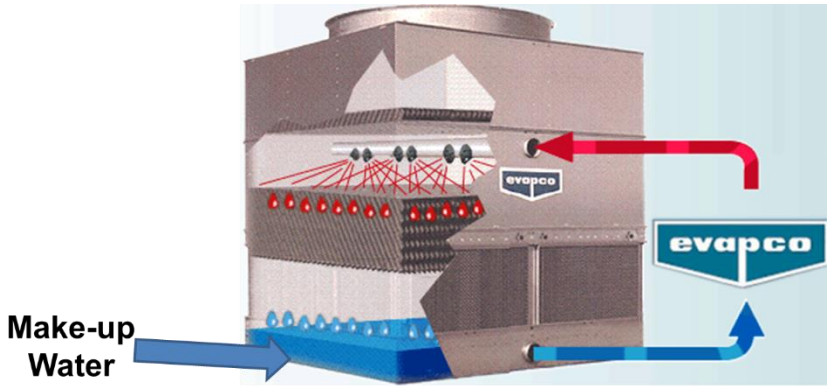
The Building level water metering prerequisite requires that all potable water sources be metered such as public supply, on-site well and on-site potable water treatment systems. If there are multiple potable sources additional meters may be required. This meter must collect data for total water use in the building and on its associated grounds as well as commit to sharing annual summaries with the USGBC for 5 years.

The water metering credit requires two or more permanently installed system-level water meters for the following subsystems:

1. Irrigation water (80% of area)
2. Indoor plumbing fixtures and fittings (80%+)
3. Domestic hot water (80%+)
4. Boilers that use 100 000g+ / year
5. Reclaimed water (100%)
6. Process water (80%+)
    - Humidification systems
    - Dishwashers
    - Clothes washers
    - Pools

Cooling Tower Water Use - WEc3

Cooling towers are part of a building's HVAC system, and assist with the air conditioning process by cooling water in a closed loop system through evaporative cooling and heat extraction. Process water is the water used in building equipment such as cooling towers. However, this water evaporates and unwanted dissolved solids build up and results in removal of this unwanted concentrated water (blowdown) to prevent inefficient scaling in the equipment. Makeup water must then be added to compensate for blowdown and evaporation. This credit attempts to maximize the amount of times the water can cycle through the system before being removed by blowdown. This credit requires a one-time potable water analysis to determine the concentration of at least five dissolved solids and ensure maximums are not surpassed. For additional points a project can reduce the concentration levels in makeup water to achieve at least 10 cycles prior to blowdown or use 20% recycled nonpotable water to achieve the minimum of 10 cycles



CHAPTER 6

ENERGY AND ATMOSPHERE (EA)

Energy & Atmosphere				
	33	31	33	
	NC	S	CS	

EAp1 Fundamental Commissioning and Verification (C)				
	R	R	R	
	NC	S	CS	

EAp2 Minimum Energy Performance (D)				
	R	R	R	
	NC	S	CS	

EAp3 Building-Level Energy Metering (D)				
	R	R	R	
	NC	S	CS	

EAp4 Fundamental Refrigerant Management (D)				
	R	R	R	
	NC	S	CS	

EAc1 Enhanced Commissioning (C)				
	3 6	3 6	3 6	
	NC	S	CS	

EAc2 Optimize Energy Performance (D)				
	1 18	1 16	1 18	Y
	NC	S	CS	

EAc3 Advanced Energy Metering (D)				
	1	1	1	
	NC	S	CS	

EAc4 Demand Response (C)				
	1 2	1 2	1 2	
	NC	S	CS	

EAc5 Renewable Energy Production (D)				
	1 3	1 3	1 3	Y
	NC	S	CS	

EAc6 Enhanced Refrigerant Management (D)				
	1	1	1	
	NC	S	CS	

EAc7 Green Power and Carbon Offsets (C)				
	1 2	1 2	1 2	
	NC	S	CS	

Energy and Atmosphere (EA)

Overview

According to the U.S. Department of Energy generating electricity from fossil fuel such as natural gas, oil and coal negatively affects the environment throughout its life cycle. The damage begins with extraction and transportation, followed by refining and distribution and concluding with consumption (burning). Buildings in the U.S. consume 39% of the energy and 68% of the electricity produced annually. This is also responsible for 38% of the global carbon dioxide emissions through greenhouse gases. The Energy and Atmosphere category has the most points available within the LEED rating systems and promotes efficiently designed buildings and sourcing energy from renewables.
This category addresses both energy and refrigerant usage in the building. The core of the Energy and Atmosphere category addresses the following topics:

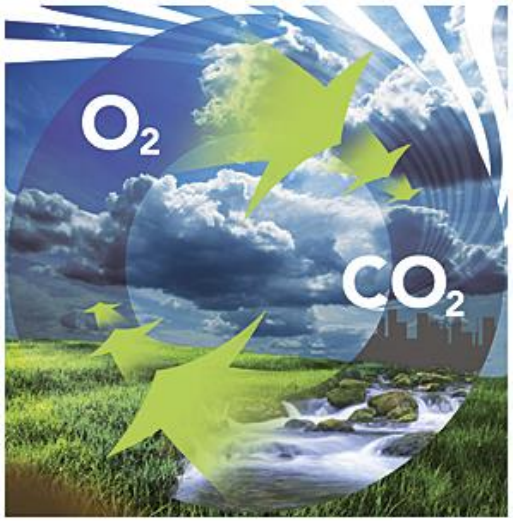


Figure 35

- Energy demand
- Energy efficiency
- Renewable energy
- Ongoing energy performance

Figure 36

Commissioning – EAp1 + EAc1

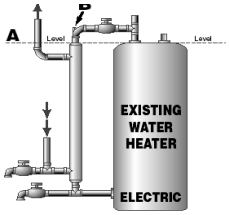
Commissioning is a process used to verify that the project's energy-related systems were installed, calibrated and are performing according to the owner's project requirements, basis of design and construction documents. Comissioning ensures that the building owner gets the performance out of the efficient systems. Fundamental commissioning of building energy systems is required in a prerequisite while enhanced commissioning is addressed in another credit.

Benefits of commissioning

- Reduced energy use
- Lower operating costs
- Fewer contractor callbacks
- Better building documentation
- Improved occupant productivity
- Verification that the commissioned systems perform in accordance with the owner's project requirements

Commissioning process activities

- Designate an individual as the commissioning authority **(CxA)** to lead, review and oversee the completion of the commissioning process
- The owner's project requirements **(OPR)** must be documented
- Develop the basis of design **(BOD)** to include the OPR



- The CxA must review OPR and BOD to verify that owner's requirements are included
- Develop and incorporate commissioning requirements into the construction documents
- Develop and implement a commissioning plan
- Verify the installation and performance of the systems to be commissioned
- Complete a summery commissioning report

Mandatory Commissioned Systems (MEP) – EAp1

Verify and Document that the following systems are planned, designed, installed, tested and maintained:

- **Mechanical** - HVAC&R systems
- **Electrical** - Lighting and day lighting controls
- **Plumbing** - Domestic hot water systems
- **Renewable** energy systems

Enhanced commissioning – EAc1

The Enhanced Commissioning credit has multiple paths to compliance:

1 – Enhanced Systems Commissioning - Path 1 (3 points):

- Review contractor submittals.
- Verify inclusion of systems manual, occupant training requirements in construction documents and seasonal testing.
- Review building operations **10 months** after substantial completion.
- Develop an **on-going** commissioning plan.
-

Path 2 (4 points):

- Achieve **path 1** AND
- Include procedures in Commissioning plan

- AND/OR -

2 – Envelope Commissioning **(2 points):**

- Follow EAp1's requirements as they apply to the building envelope:

Figure 39

Figure 38

Figure 37

Energy Performance – EAp2 + EAc2

LEED addresses the building's energy performance through a prerequisite that establishes a minimum level of energy efficiency for the proposed building in order to reduce environmental and economic impacts associated with inefficient energy use. Optimized energy performance and higher percentages of energy efficiency are needed to earn points. The number of points depends on the percentage of energy **cost** savings. The energy performance of a building depends on the reduction of energy demand by the building and the efficiency of the building systems installed as **compared to a baseline.**
LEED offers three options to achieve the energy performance related credit/prerequisite:

1 - Whole Building Energy Simulation (1-18 points):
To determine the improvement in a new building performance, it is compared to a baseline (reference building) which meets Appendix G of ASHRAE Standard 90.1-2010. Energy models include all energy end uses including lighting, HVAC and domestic hot water and process energy which includes office equipment, computers, elevators, escalators, kitchen cooking and refrigeration, laundry washing and drying machines, lighting that is exempt from the lighting power allowance. Various energy modeling software include EE4, eQuest, IES and EnergyPlus.

Energy simulation allows the project team to make better decisions based on the results of the simulation analysis. The model takes into account all mechanical and passive building features including its location and orientation. The final design reports are then submitted via LEED online to show percentage improvements.

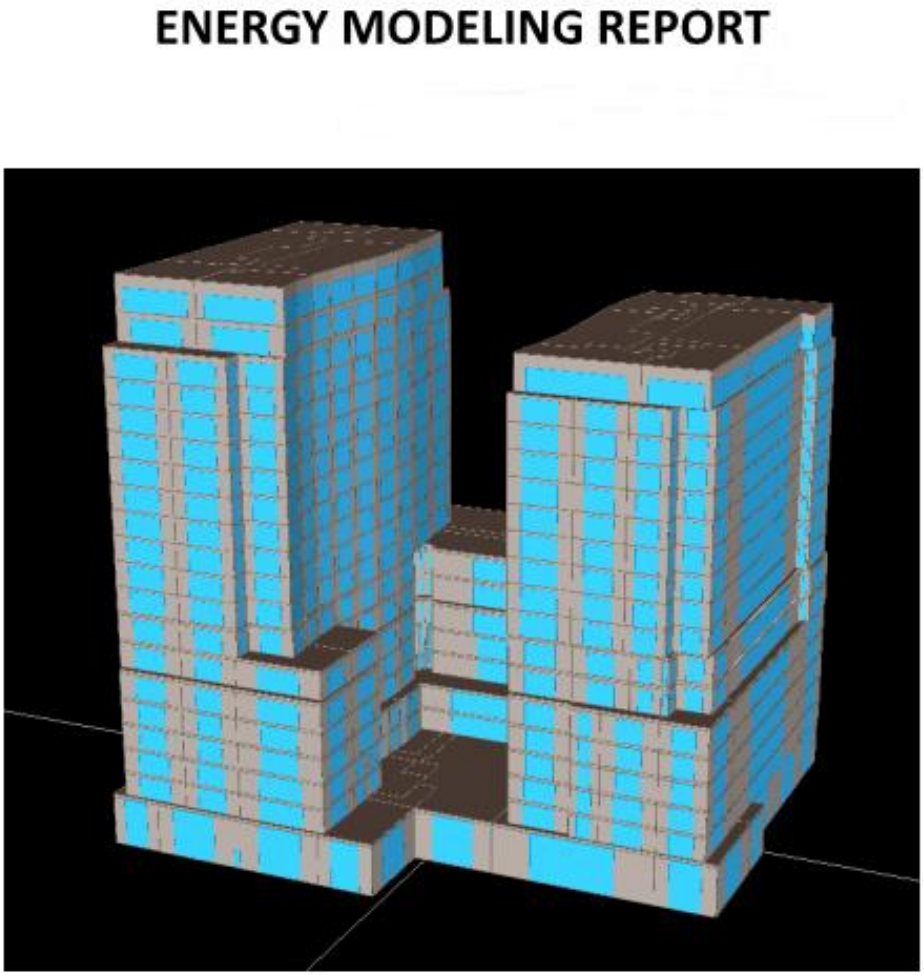


Figure 40

End Use	Modelled Annual Energy Consumption (GJ)		
	Baseline Design	Package 1	Package 2
Lighting	1,994	1,994	1,994
Misc. Equip.	928	928	928
Heating	10,907	9,977	6,881
Cooling	469	436	461
Heat Rejection	723	723	723
Pumps	520	517	509
Fans	1,733	1,099	1,099
Domestic HW	3,048	2,119	2,119
Total	**20,322**	**17,792**	**14,714**
% Better than ASHRAE 90.1-2010	**0**	**1.0%**	**18.1%**

2 - Prescriptive Compliance Path - ASHRAE 50% Advanced Energy Design Guide

3 - Prescriptive Compliance Path - Advanced Buildings Core Performance Guide

Energy Demand

Energy savings are calculated based on the amount of energy demand that a building can reduce as compared to a baseline. During the charrette the owner program requirements **(OPR)** are established and the project team must set goals regarding the project's energy demand and energy savings they can achieve.

EPA's Target Finder: is an online tool that allows the project team to set an energy target, and then compare their project's design energy and cost to pre-determined goal. The target can then be measured against a variety of design strategies. The program outputs how much energy the average building in the area (by type and zip code) consumes and how much a high-performance building in the area would consume. Target Finder is mandatory compliance for the **LEED for Schools prerequisite**.

Energy Star Portfolio Manager: is an interactive energy management tool that allows tracking and assessing energy and water consumption as well as GhG emissions across an entire portfolio of buildings in a secure online environment. It uses consumption data, cost and operational use to track 100+ metrics.

Strategies for reducing energy demand:

- **Energy goals:** set energy saving targets early on in the project and verify their achievement.
- **Building size:** a larger facility demands greater amounts of energy and more resources, so the building area should equal exactly what is needed.

- **Building orientation:** a building well oriented can benefit from natural ventilation, solar energy, passive heating and day lighting. Computer simulated 3D models help designers and architects predict how the building will perform before it is built and design accordingly.
- **Building envelope:** insulate the building envelope efficiently against heating and cooling losses.
- **Energy monitoring:** feedback and monitoring systems help occupants recognize and reduce the building's energy demand.
- **Building Systems:** Ensure that the HVAC and DHW (domestic hot water) systems are sized properly and operating at their rated efficiency.

Energy Efficiency

Strategies implemented to reduce energy demand are the basis of increasing energy efficiency.

Energy efficiency strategies:

- **Passive design and thermal energy storage:** determine the best building orientation and massing to benefit from the passive design opportunities such as day lighting, natural ventilation and passive heating and cooling from the sun and the wind.
- **High performance building envelope:** installing high-performance glazing systems and efficiently insulating the building envelope will prevent heating and cooling losses. The less treated (heat/cool) air that escapes translates into less untreated outdoor air that needs to be heated or cooled.
- **High performance building systems:** select energy efficient HVAC, plumbing, electrical and lighting systems, and perform life cycle analysis to evaluate their complete impact.
- **Verify and monitor performance:** verify that the systems are installed as per owner requirements and monitor their performance after occupancy to ensure that the building systems are functioning as designed.

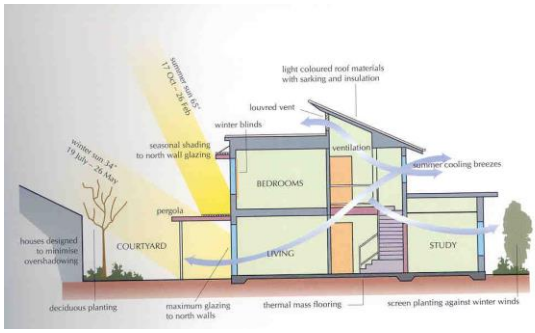


Figure 41

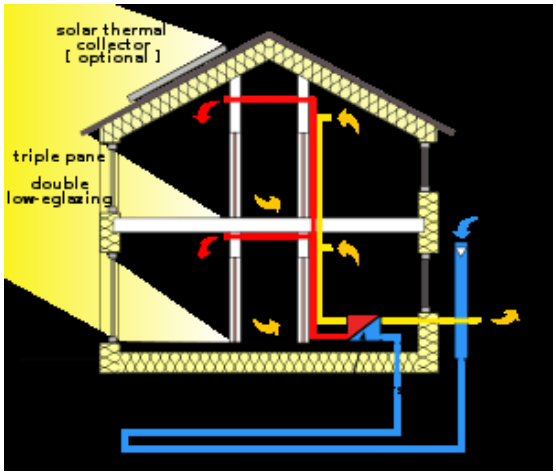
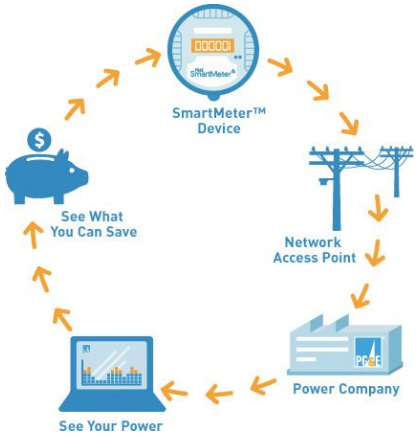


Figure 42

Energy Metering – EAp3 + EAc3

Just as buildings must meter water consumption, energy metering is even more important as energy is the most expensive aspect of a building's operations. Metering can identify opportunities for additional energy savings on a building of system level scale.

The **Prerequisite** requires permanently installed meters which can aggregately provide total building energy consumption which can be compiled into monthly/annual summaries and shared with the USGBC for 5 years.



The **Credit** requires a more advanced system for all individual energy end uses that represent 10% or more of the total annual consumption of the building. They must be:

- Record at hour intervals
- Record Demand and Consumption
- Transmit data to Remote Location

Building Automation System (BAS) Software which is used to control as well as monitor building energy demand and consumption. The automation system is used to maintain occupant comfort while meeting energy consumption goals and identifying mechanical, electrical and plumbing system woes.

Refrigerant Management – EAp4 + EAc6

Refrigerants are fluids used to transfer thermal energy in air conditioning and refrigerating systems. Chlorofluorocarbons (CFCs) used in refrigerant equipment cause damage to the ozone layer and reduce its ability to absorb the sun's ultraviolet radiation. The most common example of a CFC is called Freon. The **Montreal Protocol** bans the production of chlorofluorocarbons **CFCs** and establishes a phase out date for the use of hydrochlorofluoro-carbons (**HCFCs**) in 2030. CFCs and HCFCs are categorized as ozone depleting substances because of their high Ozone Depletion Potential **(ODP).** The dilemma when selecting refrigerants is that refrigerants with low ODP tend to have high Global Warming Potential **(GWP)** such as Hydroflourocarbons (HFC) so trade-offs among efficiency, ODP and GWP must be considered when you choose the refrigerant equipment. **Refrigerants include:**

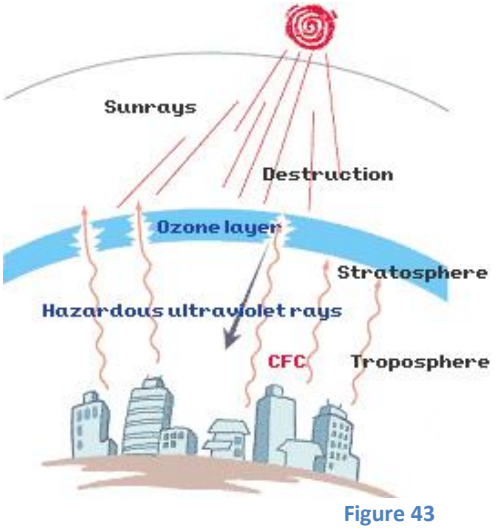


Figure 43

- ChloroFluorCarbons (CFC)
- HydoChloroFluorCarbons (HCFC)
- HydoFluorCarbons (HFC)
- Halocarbons

Natural Refrigerants

- Carbon Dioxide (CO2)
- Water (H2O)
- Ammonia (NH3)
- Hydrocarbons (HC)
- Air

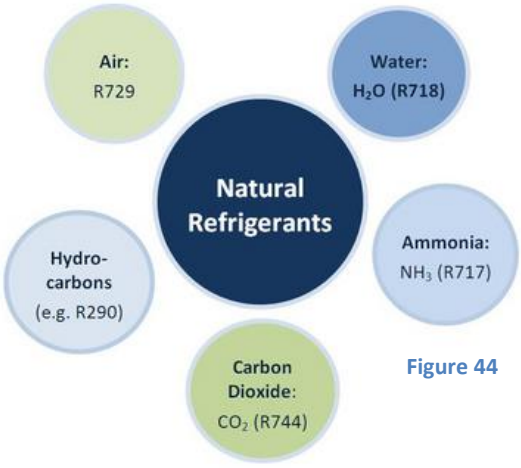


Figure 44

LEED Fundamental Refrigerant Management requires zero use of CFC based refrigerants in new buildings HVAC & R systems whereas the Enhanced credit required ODP+GWP to be under a specified value.

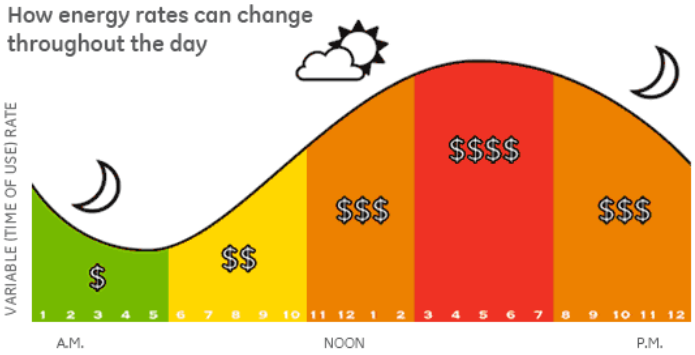
Strategies to achieve this credit/prerequisite:

- Install HVAC&R systems using no refrigerants

- Install HVAC&R systems using non CFC refrigerants
- Choose fire suppression systems and equipment that use no CFCs, HCFCs or halons
- If an existing building is undergoing a major renovation and currently uses CFCs, the building must phase out the CFCs within 5 years and reduce annual leakage to 5% or less.

PLEASE REFER TO APPENDIX (1) FOR A REQUIRED READING ON REFRIGERANTS

Demand Response – EAc4



Just like any commodity, energy is most expensive when there is not enough supply and too much demand. This is due to the requirement of peaker plants at peak periods of consumption which are expensive to operate and produce many harmful emissions. A demand response program enables the energy provider (utility company) to cut energy from demand response participants during the peak. The utility automatically sends a message and avoids the necessity of peaker plants.

Building owners must agree to participate in a Demand Response program for 10%+ of estimated peak electricity demand. Strategies to adapt to a demand response event include dimming lights, cutting the chiller, reducing ventilation and minimizing leakage through doors and operable windows.

Renewable Energy Production – EAc5

Figure 45

Energy that is naturally replenished and generated from natural resources is called renewable energy. This energy is more sustainable and environmentally beneficial than fossil fuels because there is not a finite amount of it. LEED distinguishes between renewable energy produced onsite and purchased offsite power from renewable sources. This credit looks at on-site renewable energy.

Renewable energy sources include:

- Wind energy
- Solar thermal, active and passive
- Photovoltaic
- Wave and tidal energy
- Biofuels
- Geothermal heating
- Low impact hydroelectric

$$\%\ Renewable = \frac{\text{Equivalent \$ of usable energy}}{\text{Total building annual energy cost}}$$

Total building energy annual cost (denominator) is based on EAp1's model or US DoE's Commercial Buildings Energy Consumption Survey database (Prescriptive)

Green Power and Carbon Offsets – EAc7

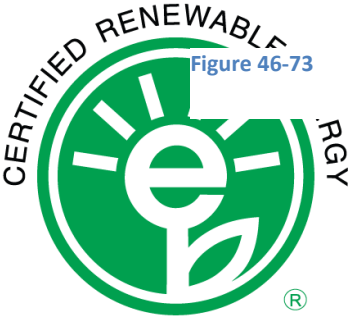


Figure 46-73

To achieve this credit the project must purchase 35% of the building's electricity consumption for at least 2 years. The percentage of the green power purchased is based on the quantity of **energy consumption**, not energy costs. Strategies to achieve this credit are as follows:

- This credit is based on the quantity of energy consumped
- Purchase power from **green-e** certified provider on closed or open electricity market to reduce Scope 1 emissions (from electricity)
- Purchase renewable energy certificates (RECs) or tradable renewable certificates (TRCs) which represent the 1 MWh of electricity was generated from a renewable source.
- The qualified resources must have come online since January 1, 2005 for a minimum of 5 years.
- Alternatively a project can purchase carbon offsets to reduce scope 2 emissions as one carbon offset is equal to one carbon dioxide equivalent of greenhouse gases

Figure 47

Scope 1 emissions – Direct emissions - natural gas burned on site (IE. Boiler) – mitigated by carbon offsets

Scope 2 emissions – Indirect emissions – greenhouse gas (IE. Purchased electricity) - mitigated by green power or RECs

Green-e is a certification program for renewable energy. LEED typically recognizes renewable energy if it's been certified by the **Center for Resource Solution** or meets Green-e's requirements.

Renewable Energy Certificates, or Tradable Renewable Certificates (TRCs), represent electricity produced from renewable energy sources sold separately from commodity. One REC represents 1 megawatt-hour (MWh) of electricity was generated from an eligible renewable energy resource. If there is not a green-e certified power supplier within feasible proximity to your project, an REC essentially purchases renewable power for a building that would otherwise be using standard electricity. RECs accomplish the ultimate goal of reducing fossil-fuel sourced electricity, albeit indirectly

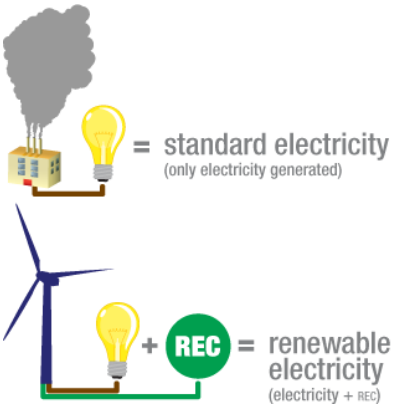


Figure 48

CHAPTER 7

MATERIALS AND RESOURCES (MR)

Materials & Resources				MRp1 Storage and Collection of Recyclables (D)				MRp2 Construction and Demolition Waste Management Planning (C)				MRc1 Building Life-Cycle Impact Reduction (C)				MRc2 BPD+O - Environmental Product Declarations (D)				MRc3 BPD+O - Sourcing of Raw Materials (C)				MRc4 BPD+O - Material Ingredients (C)				MRc5 Construction and Demolition Waste Management(C)			
13	13	14		R	R	R		R	R	R		2 5	2 5	2 6	Y	1 2	1 2	1 2	Y	1 2	1 2	1 2	Y	1 2	1 2	1 2	Y	1 2	1 2	1 2	Y
NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS		NC	S	CS	

Materials and Resources (MR)

Construction and demolition debris account for 40% of our total solid waste stream. Material selection and material disposal are the two main issues addressed in this credit category. The Materials and Resources (MR) category focuses on the life cycle impacts of materials selected for the project, and the amount of material diverted from the landfill. LEED promotes the selection of sustainable materials and the reduction of waste produced from the construction, operation and demolition of buildings. In this chapter we will discuss types of sustainable materials and strategies to reduce waste sent to landfills. It focusses on the selection of environmentally preferable materials to reduce detrimental effects on human health and environmental effects to ensure improved worker safety and health. Mechanical, electrical and plumbing (MEP) equipment are optional in most of the credit calculations. For example, including an expensive elevator would severely skew credit calculations, as points are rewarded based on cost of materials or surface area. The following are general concepts related to Materials and Resources category:

Life Cycle Impacts: This includes its extraction, processing, transportation, use and disposal. LEED promotes reusing or recycling a product at the end of its life as opposed to disposing of it, known as the cradle to cradle approach. LEED also wants to serve as a market mover and ensure all products go through and LCA.

Purchasing Policies: LEED encourages the use of sustainable materials through this category. It determines the types of materials that should be considered for a high performance building and how to reduce the life-cycle impacts of these materials. Purchasing policies should specify where items are sourced from during construction and operation of the building. Third party certification of sustainable products is essential in materials selection. Note that LEED doesn't certify products, but supports organizations that certify environmentally responsible products (Ex. FSC certified wood).

Waste reduction: The preferred waste management strategies described by the U.S. Environmental Protection Agency (EPA) are **source reduction**, **reuse**, **recycling and recovery**. Material reuse or recycling are forms of waste diversion from landfills or incineration works as well. The EPA defines the following waste management strategies:

- **Source Reduction:** the practice of designing, manufacturing, purchasing, or using materials in ways that reduce the amount of unnecessary materials in the building.
- **Reuse**: stops waste at its source because it delays or avoids that item's entry into the waste collection and disposal system.
- **Recycling**: converts materials that would otherwise become waste into valuable resources.
- **Recovery**: Either proper recycling and composting of materials or waste-to-energy plants such as incineration.

Figure 49

Credit metrics and cost calculations: Each credit is based on material area, weight or cost. A material baseline is established using the actual material cost OR 45% of the total construction costs, including labor and equipment.

Storage and Collection of Recyclables – MRp1

Figure 50

This prerequisite reduces the amount of landfill bound waste produced by the building occupants. An **easily accessible** and dedicated area for the collection and storage of materials for recycling must be provided for the entire building. It can be commingled recycling or separated on site. Materials to be recycled must include, at a **minimum, paper, corrugated cardboard, glass, plastics and metals. The project must also recycle 2 of: Batteries, electronics or mercury containing lamps.**

Construction and Demolition Waste Management – MRp2 + MRc5

Figure 81

The intent of this credit is to reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials. Requirements of this credit are to recycle and/or salvage nonhazardous construction and demolition debris through the development and implementation of a **construction waste management plan.** The construction waste management plan must:

1. Identify and establish waste diversion goals **for at least five materials** (structural and non-structural)
2. Specify whether materials will be **separated or commingled** and where they will eventually be recycled or even donated
3. Provide major **waste streams and diversion rates**

Construction Waste	
Percentage Diverted	Points (BD+C)
Plan	**Prerequisite**
50% + 3 streams	1
75% + 4 streams	2

Waste diversion rates are based on volume/weight salvaged/recycled over total waste produced. These calculations exclude excavated soil, land-clearing debris, and alternative daily cover (ADC). In some instances where the credit cannot be met waste-to-energy systems may be included.

There are 2 options to earn points:

1 – Diversion into multiple waste streams

Calculated by weight or volume as a percentage of total waste

2 – Reduction of Total waste material (Source Reduction)

- Maximum of **2.5 pounds** of construction waste / square foot of buildings floor area

Building Life-Cycle Impact Reduction – MRc1

This credit awards points for adaptive reuse of existing building resources (if it is a previously developed site) or by reducing materials use through life cycle analysis. **Adapted reuse** is the renovation of a space for a purpose different from the original. There are 4 options for credit compliance:

1 – Historic Building (5 points)

Maintain the existing building structure, envelope, and interior non-structural elements of a historic building or contributing building in a historic district. To qualify, the building or historic district must be listed or eligible for listing in the local, state, or national register of historic places.

2 - Abandoned or Blighted Building (5 points)

- Maintain 50% of **surface area** of existing building
    - 25% of damaged area may be excluded

Construction Waste	
Surface Area	Points (BD+C)
25%	**2**
50%	3
75%	4

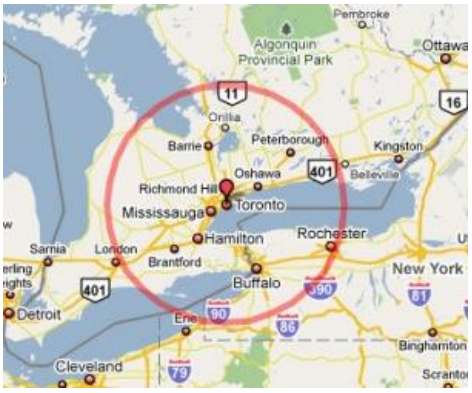
3 – Building and Material Reuse (2 - 4 points)

Reuse or salvage building materials from off site or on site as a percentage of the surface area.
Exclude window assemblies and hazardous materials + Cannot count materials in this credit to MRc2

4 – Building Life-Cycle Impact Reduction – New Construction (3 points)

- Model a baseline building (ISO 14044) and compare design case
- 10% reduction of 3 of the following **impact categories**:
    1. **Global warming potential** (greenhouse gases), in CO2e;
    2. Depletion of the **stratospheric ozone layer**, in kg CFC-11;
    3. **Acidification** of land and water sources, in moles H+ or kg SO2;
    4. **Eutrophication**, in kg nitrogen or kg phosphate;
    5. Formation of **tropospheric ozone**, in kg NOx or kg ethene; and
    6. **Depletion of non-renewable energy** resources, in MJ.

Location Valuation Factor for the following credits:



The intent of this factor is to add value to locally produced materials which reduces transportation emissions and supports the local economy. These local materials are worth **200%** of their cost for credit calculations.

To comply products must be:

1. Extracted
2. Manufactured +
3. Purchased

Within 100 miles (160km) of the project site

Building Product Disclosure and Optimization – MRc2 to MRc4

The following credits work with Life Cycle Assessment and go a step further to promote responsible material sourcing and avoidance of harmful chemicals in building products. Building Product Disclosure and Optimization awards points for selected materials manufactured with transparency in regards to all ingredients.

The following credits are based on the cost of materials as a percentage of total material cost (actual total cost of materials excluding labor or if unknown, the default denominator is 45% of total construction costs). The credits strictly deal with permanent building materials and Mechanical Electrical and Plumbing which are passive such as ducts and plumbing fixture but must consistently be reported. If furniture is to be included all products of that type must be included and kept consistent across all calculations.

BPDO - Environmental Product Declarations – MRc2

Environmental Product Declarations (EPDs) reward teams for selecting manufactured products which have verified they have improved life cycle impacts. EPDs focus on transparency and document a product's ability to mitigate impact on global warming, ozone depletion, air/water pollution and promote corporate social responsibility. Compliance with different standards result in different multiples of the product's cost (0.25-1). Points can be earned through 2 options


Figure 51

1 - Environmental Product Declarations

Use at least 20 different permanently installed products sourced from at least five different manufacturers that meet references standards

2 - Multi-Attribute Optimization

Ensure that 50% by cost of materials are third party certified products that demonstrate reduction of 3+ of the Building Life-Cycle Impact Reduction factors (see option 4 of MRc1).

BPDO - Sourcing of Raw Materials – MRc3

The achievement of this credit rewards a team for selecting products that have been extracted and sourced in a responsible manner. **Some terms to know for this credit:**

- **Pre-consumer:** excess/damaged material reused for different purpose - ISO 14021
- **Post-consumer:** material served its use and now reused - ISO 14021
- **Bio-based product:** Plant, animal or marine products (not skin)
- **Chain of Custody:** Tracks a product from extraction to end use (FSC)
- **CSRs:** Corporate Sustainability Reports based on recognized standards or 3rd parties

CSRReports

There are two options to show credit compliance:

1 – Raw material source and extraction reporting

Ensure the selected products have self-declared or third party verified corporate social responsibility reports.

2 – Leadership Extraction Practices

Use products that meet at least one of the responsible extraction criteria below for at least **25%, by cost**, of the total value of permanently installed building products in the project:

Extended Producer Responsibility (50%)

Bio-Based Materials (100%)

Certified Wood (100%)

BPDO - Material Ingredients – MRc4

The achievement of this credit rewards a team for selecting products whose ingredients are transparently reported and have verified improved life cycle impacts through mitigating the use of harmful substances.

Materials Reuse (100%)

Recycled Content
(Post = 100%)
(Pre = 50%)

1 – Material Ingredient Reporting (1 Point)

Use at least 20 different permanently installed products sourced from at least five different manufacturers that inventory 99%+ of a products ingredients through manufacturer programs →

Public (Chemical Abstract Service Registration Number)

Greenscreen for safer chemicals

Health Product Declaration Open

Cradle to Cradle

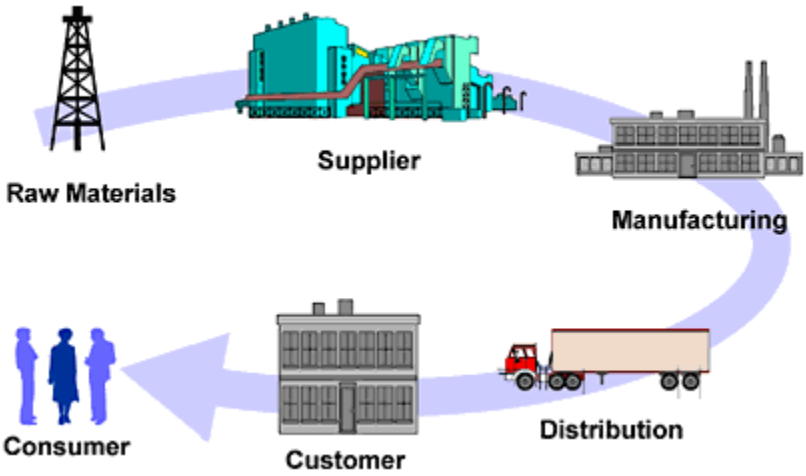
2 – Ingredient Optimization (1 Point)

Use products that document their material ingredient optimization using the paths below for at least 25%, by cost, of the total value of permanently installed products in the project

1. GreenScreen v1.2 Benchmark
2. Cradle to Cradle Certified
3. International Alternative Compliance Path – REACH Optimization
4. USGBC approved program

3 – Supply Chain Optimization (1 Point)

Use building products for at least 25%, by cost, of the total value of permanently installed products in the project that document at least **99%** (by weight) of ingredients for materials and **supply chain processes.**



MR credits for Healthcare only

MRcHealthCare – Furniture and Medical Furnishings

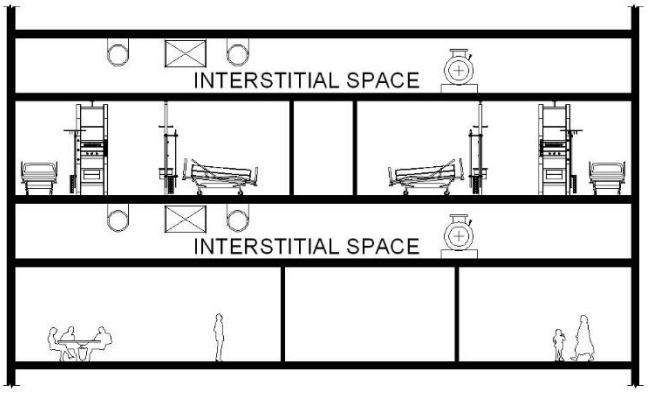
The goal of this credit is to enhance environmental and human health by ensuring materials comply with 1 of 3 options:

1. Minimal chemical content
2. Testing and modeling of chemical content
3. Multi-attribute assessment of products

MRcHealthCare – Design for Flexibility

This credit's intent is to conserve resources associated with the construction and management of buildings by designing for flexibility and ease of future adaptation, and for the service life of components and assemblies.

This credit encourages the use of **Interstitial space (essentially** an extra floor (6-9' tall) between floors to allow for easy renovation) and modular equipment and future-proofing for expansion is encouraged



MRcHealthCare – PBT Source Reduction (Healthcare Only)

Healthcare has a prerequisite as well as 2 credits which are designed to reduce PBTs (Persistent Bioaccumulative Toxins) in waste generated through all stages of a product.

The prerequisite looks at establishing maximum levels of mercury content in lamps and its corresponding credit requires the project to specify only low or no mercury containing lamps

Another credit requires projects to minimize or eliminate the use of lead, cadmium and copper.

CHAPTER 7

Indoor Environmental Quality (EQ)

Indoor Environmental Quality				
16	16	10		
NC	S	CS		

EQp1 Minimum Indoor Air Quality Performance(D)			
R	R	R	
NC	S	CS	

EQp2 Environmental Tobacco Smoke Control (D)			
R	R	R	
NC	S	CS	

EQp3 Minimum Acoustic Performance (D)			
NA	R	NA	
NC	S	CS	

EQc1 Enhanced Indoor Air Quality Strategies (D)			
1 2	1 2	1 2	Y
NC	S	CS	

EQc2 Low-Emitting Materials (C)			
1 3	1 3	1 3	Y
NC	S	CS	

EQc3 Construction IAQ Management Plan (C)			
1	1	1	
NC	S	CS	

EQc4 Indoor Air Quality Assessment (C)			
1 2	1 2	NA	
NC	S	CS	

EQc5 Thermal Comfort (D)			
1	1	NA	
NC	S	CS	

EQc6 Interior Lighting (D)			
1 2	1 2	NA	
NC	S	CS	

EQc7 Daylight (D)			
1 3	1 3	1 3	Y
NC	S	CS	

EQc8 Quality Views (D)			
1	1	1	Y
NC	S	CS	

EQc9 Acoustic Performance (D)			
1	1	NA	Y
NC	S	CS	

Indoor Environmental Quality (EQ)

Overview

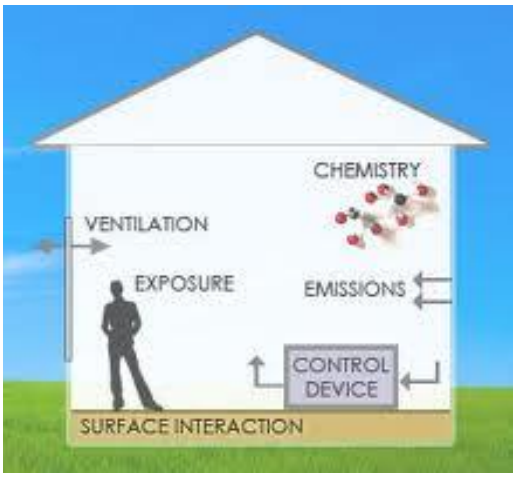


Figure 52

Maintaining a high level of indoor environmental quality requires the collaboration between the building owner, design team, contractors, building operators and occupants. The reasons LEED cares about indoor environmental quality include the following:

- According to EPA, Americans spend at least 90% of their time indoors.
- Indoor pollutants are 2 to 5 times higher than outdoor levels
- Poor indoor environmental quality has negative effects on health of occupants such as asthma and sick building syndromes (SBS).
- Good indoor environmental quality increases occupants' satisfaction, reduces employee absenteeism and therefore improves productivity.

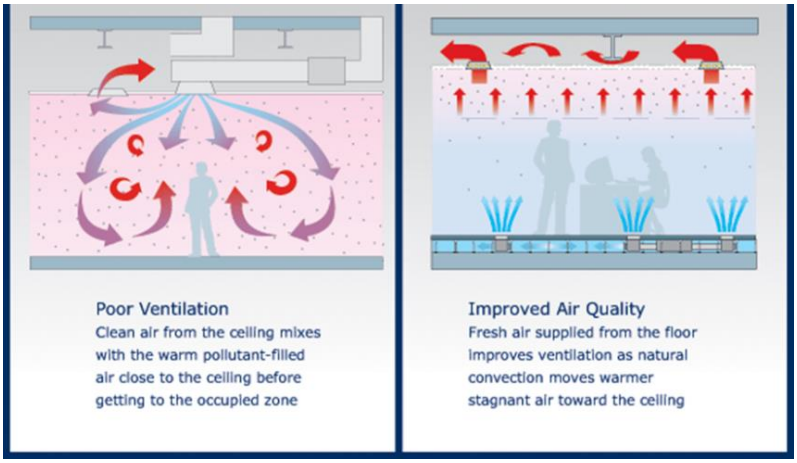
Indoor environmental quality strategies are all about improving indoor air quality and increasing occupants' comfort. The main issues addressed in this category are:

- Indoor air quality (IAQ), note the difference between IAQ and EQ
- Thermal comfort
- Lighting comfort
- Acoustics (Schools only)

Indoor Air Quality (IAQ)

Improving indoor air quality is addressed in most of the credits/prerequisites in this category; the two key strategies used in these credits/prerequisites depend on increasing ventilation rates or reducing contaminants such as tobacco smoke, carbon dioxide, volatile organic compounds (VOCs), and particulates.

Minimum Indoor Air Quality Performance – EQp1



Maintaining the minimum outdoor air intake through ventilation systems is essential in improving the indoor air quality in buildings. ASHRAE 62.1-2010 is used to achieve this prerequisite as it specifies the rates required from different ventilation modes based on size and occupant count per space. Ventilation systems vary from one project to another including:

- Mechanical ventilation (active) - ASHRAE 62.1-2010 determines minimum ventilation rates for various applications
- Natural ventilation (passive) - ASHRAE 62.1-2010 specifies requirements for the size and location of ventilation openings

- Mixed-mode ventilation (active + passive) - ASHRAE 62.1-2010 determines minimum ventilation rates and any calculation methodology can be used to meet it.

For naturally ventilated spaces the Chartered Institution of Building Services Engineers **(CIBSE)** applications manual must be followed and an analytical model may be used to confirm that the room by room airflows meet the minimum rates required by **ASHRAE 62.1-2010.**

Environmental Tobacco Smoke (ETS) Control – EQp2

Environmental tobacco smoke (ETS) is produced by cigarettes, pipes or cigars and is related to health risks such as lung disease, cancer and heart disease. The purpose of this prerequisite is to prevent the exposure of building occupants to ETS which is also known as second hand smoke. To achieve this prerequisite a project:

- Prohibit smoking in the building and on property within 25 feet from operable windows, entries and air intakes.
- Provide signage within 10 feet of all building entrances
- **Residential projects -** prohibit smoking in all common areas and within 25 feet from entries, windows and air intakes. Ensure each unit is compartmentalized by:
    - Weather-stripping all exterior and hallway doors and windows
    - Demonstrate a maximum leakage of 0.23 cubic feet per minute per square foot at 50 Pa of enclosure

Schools - Signage must be posted at the property line indicating the no-smoking policy.

Minimum Acoustical Performance - Schools ONLY – EQp3 + EQc9 (All systems)

This prerequisite is for school projects only to provide a quiet environment to facilitate the teacher-to-student and student-to-student communication. To achieve this prerequisite, classrooms and core learning spaces should include sufficient sound absorptive finishes as per ANSI/ASHRAE S12.60-2010. Projects must maintain the background noise level under **40 dBA** from HVAC systems in classrooms and other core learning spaces.

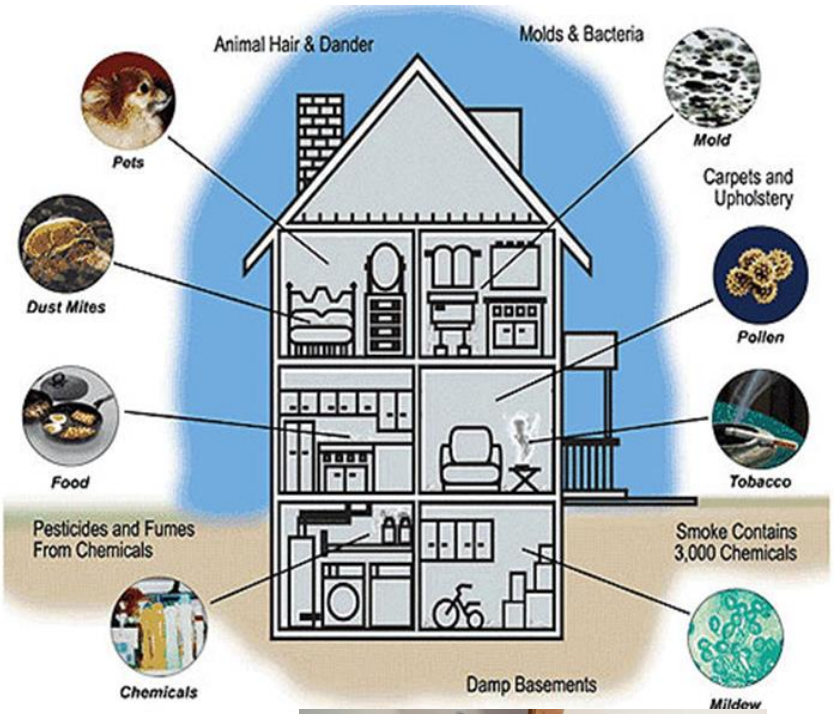
Enhanced Indoor Air Quality Strategies – EQc1

This credit protects the occupants from potentially hazardous particulates and chemical pollutants and is an extension of EQp1. It promotes strategies that minimize human contact with airborne chemicals and particles. The credit focuses on reducing chemicals entering the building as well as those being produced in the building through 2 options - firstly by:

1. Using a permanent entryway system for at least 10 feet at all regular entrances. Examples of entryway systems are installed grates and grills that capture dirt and can be cleaned underneath. Roll-out mats can be used only if they are cleaned weekly by a service organization.
2. Interior Cross-contamination Prevention (Exhaust contamination!)
3. In mechanically ventilated buildings, use new filtration media with minimum MERV of 13.

- OR -

Select one of the following strategies:



1. Exterior contamination prevention – Gaussian Model to ensure maximum concentration levels are not exceeded
2. Increased ventilation (**30% above EQp1** – ASHRAE 62.1-2010)
3. Carbon dioxide monitoring for densely occupied spaces and alarm if +/- 10% from the set point
4. Additional source control and monitoring - alarm

Low Emitting Materials – EQc2

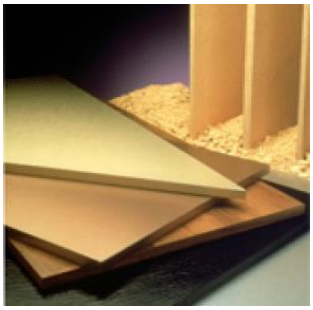
Finishing materials with high concentrations of volatile organic compounds (VOCs) or formaldehyde have negative impact on IAQ. These materials are odorous, irritating and can threaten the comfort and wellbeing of occupants due to **off-gassing.**

In LEED v4 this credit has been simplified and tests each layer of a surface even those not directly exposed to air in the interior space as defined by everything within the waterproofing membrane. This credit has requirements for 7 different categories of materials and 2 calculation based methods to show compliance.

1 – Product Category Calculations (you should be familiar with the standards and corresponding category)

Interior paints and coatings applied on site – CPDH and SCAQMD 1113
Interior adhesives and sealants applied on site – CPDH and SCAQMD 1168
Flooring - CPDH
Composite wood – California Air Resources Board (CARB) + No added Formaldehyde resins
Ceilings, walls, thermal, and acoustic insulation - CPDH
Furniture (include in calculations if part of scope of work) – ANSI/BIFMA
Healthcare and Schools Projects only: Exterior applied products – CARB 2007 + SCAQMD 1168

2 – Budget Calculation Method



If some products in a category do not meet the criteria, then a team can assess each layer of assembly – paints, coating, adhesives and sealants to earn points.

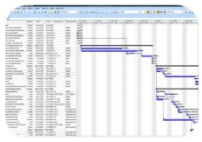
Construction Indoor Air Quality Management – EQc3

Construction and demolition practices introduce pollutants to the building indoor environment that can have effects over the lifetime of the building. To address problems that result from construction activities an IAQ management plan should be developed and implemented during construction and before occupancy. LEED awards points for managing the project's IAQ at multiple stages of the project.

This credit promotes best practices to ensure high indoor air quality during construction as outlined in the **Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines:**

- Protect absorptive materials installed or stored on site from moisture to prevent mold.
- If permanently installed air handlers are used during construction, provide filtration media with Minimum Efficiency Reporting Value **(MERV)** of 8 in all return grills as determined by **ASHRAE 52.2-1999.**
- Before occupancy, replace all filtration media with the final design filtration media
- Prohibit the use of tobacco products inside the building and within 25 feet during construction

HVAC Protection (MERV 8 Filter)



Scheduling

Source Control

Pathway Interruption

Housekeeping

Indoor Air Quality Assessment – EQc4

This credit is addressed after all construction activities are completed and all finishes are installed, but before occupancy. There are two options to achieve it:

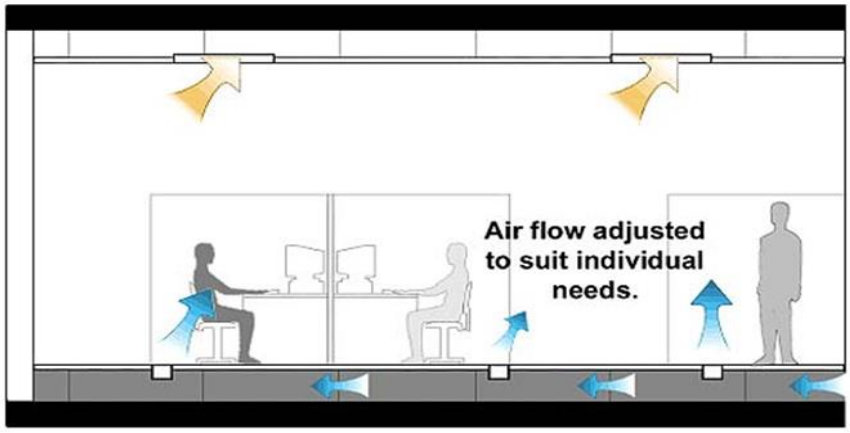
1 - Flush Out by replacing all existing air with fresh outdoor air prior to occupancy. Projects must supply a total air volume of **14,000** cubic feet of outdoor air per square foot of floor area while maintaining an indoor air temperature of at least **60°F** and relative humidity no higher than **60%.**

2 - Air Testing - Air samples are collected during normal occupied hours from areas that are between **3 and 6 feet above floor level** to demonstrate that the contaminant maximum concentrations allowed are not exceeded specifically for **Formaldehyde, ozone, VOCs and Carbon monoxide (CO).**

Thermal Comfort – EQc5

Occupants' thermal comfort should be considered for its direct influence on occupants' satisfaction and productivity. The main factors that affect thermal comfort described in **ASHRAE 55-2010** are**:**

- Occupant activity
- Occupant clothing
- Air temperature
- Radiant temperature
- Air speed
- Humidity



To meet this credit there is a comfort requirement and a control requirement:

1 – Comfort Design - HVAC systems and the building envelope must comply with **ASHRAE 55-2010**

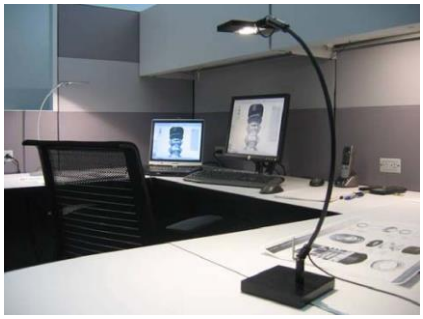
2 – Comfort Control – defined as the ability to adjust air / radiant temperature, air velocity or humidity

- Ensure 50% of individual occupant space have thermal comfort controls
- Ensure 100% of multi-occupant space have thermal comfort controls

Interior Lighting – EQc6

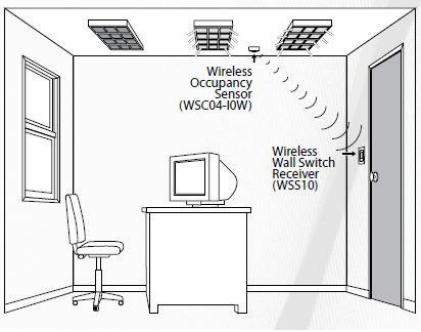
Individual controls for lighting have a significant effect on occupants' comfort. Meeting the unique needs of each occupant can be accomplished through effective design of lighting controls. There are 2 options:

1 – Lighting Control



- 90% of individual occupant spaces have lighting comfort controls with 3 modes (on/off/midlevel levels)
- 100% of multi-occupant space have lighting comfort controls with 3 modes (on/off/midlevel)
    - Lighting for presentations/projections must be separately controlled
        - Switches to control must be located in same space and operator must have direct line of sight

2 – Lighting Quality – meet 4/8 strategies:



a) Minimize objectionable glare
b) Approximate natural light
c) Maximize lamp life
d) Minimize direct-only overhead lighting
e) Specify high-reflecting surfaces for ceilings + floors
f) Specify high-reflecting surfaces for walls
g) Specify high-reflecting surfaces for furniture
h) Maintain ration of illuminance between objects

Daylight – EQc7

Natural light from the sun is the most efficient and energy-free way of illuminatimg a space. Daylighting design should consider heat gain or loss that can result from daylighting strategies. Daylighting can reduce the need for electric lighting and therefore reduce the building's energy consumption. Shading devices, light shelves, courtyards, atriums and window glazing are strategies of daylighting. This credit requires manual or automatic **glare-control** devices for all regularly occupied spaces and one of the three following options:

1 – Simulation: Spatial Daylight Autonomy

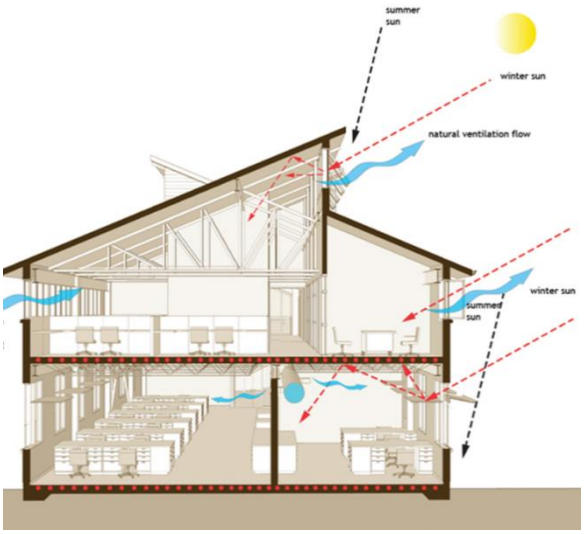
- Percentage of area that receives 300+ lux for 50%+ of the day ($sDA_{300/50\%}$)
- Annual sunlight exposure (visual discomfort) < 10%

2 – Simulation: Illuminance Calculations

- Between 300 lux and 3,000 lux for 9 a.m. and 3 p.m.

3 – Measurement

- Measure Illuminance Levels to be read above



Quality Views – EQc8

Traditionally the indoor environment is not a human's natural environment and we should have more connections to the outdoors. Provide views to connect occupants with the outdoor environment. **75%** of all regularly occupied floor areas, must have a direct line of sight for the building occupants to the outdoors through vision glazing placed between 30" and 90" above the finished floor as well as meet 2 of the following 4 kinds of views:

1. Multiple lines of sight 90° apart
2. Be able to see the **flora, fauna or sky**, **movement** or **objects** 25' from window
3. Unobstructed views within 3 times the head height of vision glazing
4. View factor (number of quality views with a 90° line) of 3 or greater

Note: Views into interior atria can count towards 30% of requirement.

CHAPTER 9

Innovation and Design (ID)

Innovation				IDc1.1 Innovation				IDc1.2 Exemplary Performance				IDc1.3 Pilot Credit				IDc2 LEED AP+ (appropriate specialty)			
6	6	6		13	13	13		12	12	12		13	13	13		01	01	01	

Innovation and Design (ID)

Overview

LEED provides credits to projects which achieve exceptional performance in sustainability above the requirements and out of the scope of the LEED Green Building Rating System.

There are no prerequisites for this category; projects can earn up to 6 points from the following credits:

- Innovation in Design
- LEED Accredited Professional

Innovation in Design

Projects can achieve these credits through any combination of the following paths:

- Innovative performance (1-3 Points)
- Exemplary performance (1-2 Points)
- Pilot Credits (1-3 Points)

Innovative Performance

ID credits for innovative performance are awarded for comprehensive strategies which demonstrate quantifiable environmental benefits not specifically addressed in the LEED rating system.

The criteria on which the strategies are evaluated are:

- Quantitative performance improvements of the strategy.
- Comprehensive application of the strategy to the entire project.
- Applicable to other projects
- Better than standard sustainable practices

Suggested strategies to achieve this credit:

- Provide an educational program covering green strategies and the environmental and human health benefits of green building practices.
- Develop an organic Landscaping and Integrated Pest Management Program
- Develop a comprehensive waste management and diversion program to divert significant volume of waste, the program can expand to provide services for the community by allowing other buildings' users bring in certain materials for collection and recycling.
- Develop an environmental green cleaning and housekeeping program
- Select low emitting furniture and finishing
- Use high volume fly ash in concrete

Fgure 111

Pilot Credit (1- 3 points)

• Achieve one pilot credit from USGBC's LEED Pilot Credit Library
• Registers through the USGBC's LEED Pilot Credit Library
• USGBC member companies can submit pilot credits.
• A pilot credit proposal includes:
  - Survey feedback questions
  - Submittal Documentation
  - Identified Guest Expert

Exemplary Performance

Exemplary performance points are awarded if the project outperforms the requirements of a credit. Exemplary performance points may be earned by exceeding the requirements of the credit to next threshold or achieving double the credit requirements. For example:

- Water use reduction credit, if a project exceeds the credit requirement which is 50% Water Use Reduction to the next threshold which would be 55% in this case, Exemplary Performance 1 point under Innovation in Design would be awarded for 45% and above.
- If a project is able to manage 100% of the rainwater which falls within the project boundary then an exemplary performance credit can be earned as well

Exemplary performance is not available for each credit and not available for any prerequisite.

LEED Accredited Professional

A LEED Accredited Professional **of the correct corresponding specialty (IE. A LEED for New construction project must have a LEED AP BD+C to earn the point)** on a project team qualifies the project for 1 point under the Innovation in Design category. The LEED AP must perform a principal role in the project and his/her certificate must be submitted with the project documents. No matter how many LEED APs are in the project, **only 1 point** can be earned under this credit. This credit essentially promotes the design integration to streamline the project certification process through involving LEED APs to educate other project team members and coordinate between them.

Figure 53

Figure 113

CHAPTER 10

Regional Priority (RP)

Regional Priority			
46	46	46	

RPc1 Regional Priority Credit			
1	1	1	

RPc2 Regional Priority Credit			
1	1	1	

RPc3 Regional Priority Credit			
1	1	1	

RPc4 Regional Priority Credit			
1	1	1	

Regional Priority (RP)

Overview

This credit addresses geographically specific environmental priorities. The USGBC regional councils identified different environmental regions and selected existing credits in the rating systems that should be a priority for each region according to the most crtical environmental issues. Regional Priority credits are listed by state and determined based on the project's **zip code** on USGBC website.

Figure 114

LEED online determines the project's Regional Priority credits based on the project's zip code. The project team then **automatically** earns 1 point in addition to any points earned in the credit.

For more information about zip code boundaries visit: www.usgbc.org/rpc

Even though 6 regional priority credits are listed, teams can only earn up to 4 points in this category.

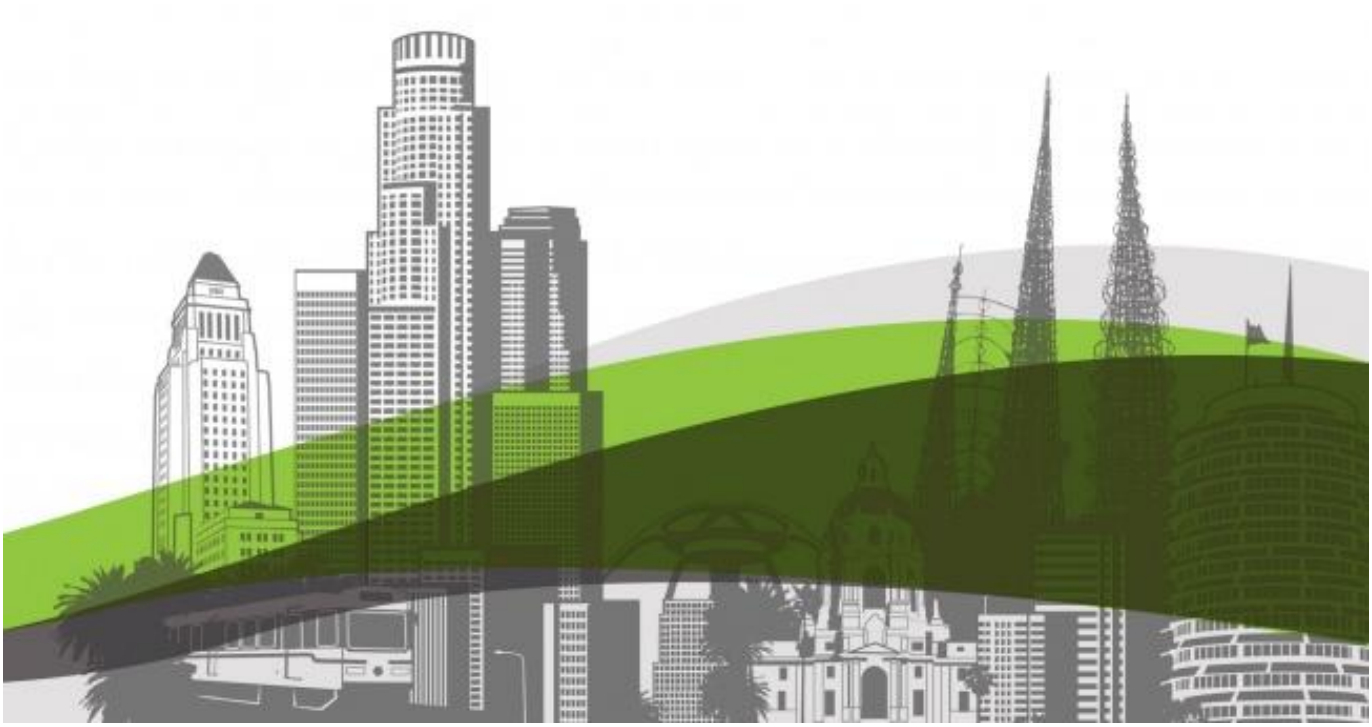
Example In Arizona, Zip code – 85003. The following credits are designated as regional priority credits

- High priority site
- Optimize energy performanceHeat Island Effect- Non Roof
- Renewable energy production
- Outdoor Water use Reduction
- Building life-cycle impact reduction
- Heat island reduction

The project can earn an extra 4 Regional Priority points for achieving 4 of the credits mentioned above.

CHAPTER 11

Additional Readings



Additional Readings

Overview and Links

As mentioned in class there are a number of documents in addition to this study guide that are commonly used for creating test questions. Please download and read the following:

1. **The LEED Green Associate Handbook – v4 Edition**
    a. http://leadinggreen.ca/wp-content/uploads/2014/07/LEEDv4-Green-Associate-Candidate-Handbook.pdf

2. **Introduction and Overview - LEED BDC V4 (Excerpt of Important sections only)**
    a. http://leadinggreen.ca/wp-content/uploads/2014/07/Introduction-and-Overview-LEED-BDC-V4.pdf

3. **Green Building Codes Background**
    a. http://leadinggreen.ca/wp-content/uploads/2014/08/GreeningtheCodes.pdf

4. **LEED Glossary of important terms**
    a. http://leadinggreen.ca/wp-content/uploads/2014/08/LEED-Glossary.pdf

5. **The Summary of Standards**
    a. See below – Page 84

6. **The Treatment by LEED® of the Environmental Impact of HVAC Refrigerants**
    a. See below – Page 85

7. **How to sign up on USGBC and register at Prometric**
    a. http://leadinggreen.ca/wp-content/uploads/2014/08/How-to-USGBC.pdf

LEED Green Associate Exam Tips

The Green Associate exam cover a lot of content but is not the most intellectually challenging exam. If you follow my step by step process it will lead to a successful exam. That process is the following:

1. Complete the live or online workshop
2. Read through this book at least once to solidify your understanding of all concepts
3. Re-watch parts of the recorded class if needed
4. Complete each mock exam and closely review the explanations of all correct and incorrect questions
    a. Once you achieve 80%+ consistently on all 5 mock exams you are ready!

LEED Green Associate Exam Notes

Location: Prometric Center nearest to you

Length: 2 Hours + 15 minute instruction video and no breaks

Type: Multiple Choice

Scoring: 170/200 is a pass, but 125/200 is the lowest possible score

- No part points
- No points off for incorrect questions
- The more difficult the question the more points it is worth, but the # is not known
- 170/200 is not equal to 85% of the questions answered correctly

Breakdown:

LEED Process (16 Questions)

Integrative Strategies (8 Questions)

Location and Transportation (7 Questions)

Sustainable Sites (7 Questions)

Water Efficiency (9 Questions)

Energy and Atmosphere (10 Questions)

Materials and Resources (9 Questions)

Indoor Environmental Quality (8 Questions)

Project Surroundings and Public Outreach (11 Questions)

15 pretest questions (Not worth points)

References

- USGBC: *http://www.usgbc.org/*
- GBCI: *http://www.gbci.org/homepage.aspx*
- LEED: *http://www.usgbc.org/DisplayPage.aspx?CategoryID=19*
- LEED Online: *https://www.leedonline.com/irj/portal/anonymous*
- LEED Candidate Handbooks: *http://www.gbci.org/main-nav/professional-credentials/resources/candidate-handbooks.aspx*
- ENERGY STAR: *http://energystar.custhelp.com/cgibin/energystar.cfg/php/enduser/std_adp.php?p_faqid=4908*
- *LEED Minimum Program Requirements (MPRs): http://www.usgbc.org/ShowFile.aspx?DocumentID=6715*
- *Credential Maintenance Program (CMP): http://www.gbci.org/CMP/about-cmp.aspx*
- *USGBC Trademark Guidelines: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1835&*
- *GBCI Trademarks: http://www.gbci.org/legal/trademarks/gbci.aspx*
- *Integrated Project Delivery (Wikipedia): http://en.wikipedia.org/wiki/Integrated_Project_Delivery*
- *Integrated Project Delivery: A Guide (AIA): http://www.aia.org/contractdocs/AIAS077630*
- *U.S. Doe Energy Building Codes: http://www.energycodes.gov/*
- *Fundamental Commissioning of Building Energy Systems: http://www.leeduser.com/credit/NC-2009/EAp1*
- *Regional Priority information: https://www.usgbc.org/RPC/RegionalPriorityCredits.aspx?CMSPageID=2435*

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Summary of Referenced Standards

Integrative Process

IPc1	Integrative Process	**ANSI Consensus National Standard Guide© 2.0 for Design and Construction of Sustainable Buildings and Communities**

Location and Transportation

LTc2	Sensitive Land Protection	**U.S. Department of Agriculture**, United States Code of Federal Regulations Title 7, Volume 6, Parts 400 to 699 **U.S. Fish and Wildlife Service**, List of Threatened and Endangered Species **NatureServe** Heritage Program, GH, G1, and G2 species and ecological communities **FEMA** Flood Zone Designations
LTc7	Reduced Parking Footprint	Institute of Transportation Engineers, Transportation Planning Handbook, 3rd edition
LTc8	Green Vehicles	American Council for an Energy Efficient Economy (ACEEE) annual vehicle rating guide (or local equivalent for projects outside the U.S.)

Sustainable Sites

SSp1	Construction Activity Pollution Prevention	**Environmental Protection Agency (EPA)** Construction General Permit (CGP) – 2003/2012
SSp2	Environmental Site Assessment	**ASTM E1527**—05 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process **ASTM E1903**—11 Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process **40 CFR** Part 312: Standards and Practice for All Appropriate Inquiries; Final Rule
SSc1	Site Assessment	**ASTM E1527**—05 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process **ASTM E1903**—11 Standard Practice for Environmental Site Assessments: Phase II Environmental Site Assessment Process
SSc5	Heat Island Reduction	ASTM E903 and E892 Cool Roof Rating Council Standard (CRRC-1)
SSc6	Light Pollution Reduction	**Illuminating Engineering Society** and International Dark Sky Association (**IES**/IDA) Model Lighting Ordinance User Guide and IES TM-15-11

Water Efficiency

WEp2	Indoor Water Use Reduction	**Energy Policy Act (EPAct)** of 1992 and as amended **EPAct 2005**
WEc2	Indoor Water Use Reduction	**International Association of Plumbing and Mechanical Officials Publication IAPMO/ANSI UPC 1-2006**, Uniform Plumbing Code 2006, Section 402.0, Water-Conserving Fixtures and Fittings **International Code Council**, International Plumbing Code 2006, Section 604, Design of Building Water Distribution System **ENERGY STAR** **Consortium for Energy Efficiency** **WaterSense** **IgCC/ASHRAE 189.1** cooling tower and evaporative condenser requirements

Energy & Atmosphere

EAp1 **EAc1**	Fundamental Commissioning and Verification Enhanced Commissioning	**ASHRAE** Guideline 0–2005, The Commissioning Process **ASHRAE** Guideline 1.1–2007, HVAC&R Technical Requirements for the Commissioning Process **NIBS** Guideline 3–2012, Exterior Enclosure Technical Requirements for the Commissioning Process
EAp2 **EAc2**	Minimum Energy Performance Optimize Energy Performance	**ASHRAE 90.1–2010** and ASHRAE 90.1–2010 User's Manual ASHRAE 50% **Advanced Energy Design Guides** **Advanced Buildings Core Performance Guide** **COMNET** Commercial Buildings Energy Modeling Guidelines
EAp3 **EAc3**	Building-Level Energy Metering Advanced Energy Metering	**American National Standards Institute**, ANSI C12.20, Class 0.2 (± 0.2) Natural gas. **American National Standards Institute**, ANSI B109 Thermal energy (Btu meter or heat meter). **EN Standard**, EN-1434
EAp4 **EAc6**	Fundamental Refrigerant Management Enhanced Refrigerant Management	**U.S. EPA Clean Air Act**, Title VI, Section 608, Refrigerant Recycling Rule:
EAc5	Renewable Energy Production	**Center for Resource Solutions Green-e** Program Commercial Building Energy Consumption Survey (**CBECS**)
EAc7	Green Power and Carbon Offsets	**Green-e Energy** and Green-e Climate **U.S. Department of Energy's** Commercial Buildings Energy Consumption Survey (CBECS)

Materials & Resources

MRpPBT	PBT Source Reduction – Mercury **Healthcare only**	**GreenSeal** **California** AB1953 standard for lead water pipes used to convey water for human consumption
MRc2-4	Building Product Disclosure and Optimization	**Global Reporting Initiative** (GRI) Sustainability Report **Organisation for Economic** Co-operation and Development (OECD) Guidelines for Multinational Enterprises **Forest Stewardship Council (FSC)** **Sustainable Agriculture** Network The **Rainforest** Alliance **ASTM** Test Method D6866: International Standards ISO 14021–1999, Environmental Labels and Declarations—Self Declared Environmental Claims (Type II Environmental Labeling) **Chemical Abstracts Service** Health Product Declaration (HPD) Cradle-to-Cradle Certified (C2C)

Indoor Environmental Quality

EQp1 **EQc1**	Minimum IAQ Performance Enhanced IAQ Performance	ANSI/ASHRAE Standard **62.1-2010**: Ventilation for Acceptable Indoor Air Quality ASHRAE **52.2**-2007 **CIBSE** Applications Manual AM10/AM13, March 2005
EQp2	Environmental Tobacco Smoke (ETS) Control	**ANSI**/ASTM-E779-03, Standard Test Method for Determining Air Leakage Rate By Fan Pressurization

EQp3 **EQc9**	Minimum Acoustical Performance (Schools) Acoustical Performance	**ANSI/ASHRAE Standard S12-60-2010**, Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools **ASHRAE Handbook**, Chapter 48, Sound and Vibration Control, 2010 HVAC Applications **AHRI** Standard 885–2008
EQc2	Low-Emitting Materials	**CDPH** Standard Method v1.1–2010 **ISO** 17025 an Guide 65 **AgBB**—2010 **ISO** 16000 parts 3, 6, 7, 11 South Coast Air Quality Management District (**SCAQMD**) Rule **1168** South Coast Air Quality Management District (**SCAQMD**) Rule **1113** **ANSI/BIFMA**
EQc3	Construction IAQ Management Plan	**Sheet Metal and Air-Conditioning National Contractors Association (SMACNA) IAQ Guidelines** for Occupied Buildings under Construction, 2nd edition, 2007, ANSI/SMACNA 008–2008 (Chapter 3) ASHRAE **52.2–2007** **CEN** Standard EN 779–2002
EQc5	Thermal Design	**ASHRAE Standard 55-2010**, Thermal Comfort Conditions for Human Occupancy **ASHRAE HVAC Applications Handbook**, 2011 edition, Chapter 5, Places of Assembly, Typical Natatorium Design Conditions
EQc6	Interior Lighting	**The Lighting Handbook**, 10th edition, Illuminating Engineering Society of North America
EQc7	Daylight	**IES Lighting Measurements** (LM) 83-12, Approved Method: IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure The Lighting Handbook, 10th edition,Illuminating Engineering Society

Impact of HVAC Refrigerants

The Treatment by LEED® of the Environmental

Impact of HVAC Refrigerants

APROVED BY LEED STEERING COMMITTEE

OCTOBER 25, 2004

APPROVED BY USGBC BOARD

NOVEMBER 8, 2004

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PREFACE

This report has been 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. To undertake this assignment, the TSAC impaneled an *ad hoc* HCFC Task Group (HCFC TG), consisting of Reva Rubenstein, Ph.D. (Chair), David Didion, D.Eng., P.E., and Jeff Dozier, Ph.D.; biographical data on the TG appear in Appendix A of this report. TSAC members, Malcolm Lewis, D.Eng, P.E., Nigel Howard, Bruce Hunn, Ph.D., and Joel Ann Todd, reviewed drafts and provided technical input into the report.

TSAC has developed a nine-step process for preparing reports on technical issues. One of the most important elements of this process is obtaining input from the various stakeholders on an issue. Stakeholder input on a preliminary report was obtained in February 2004. Subsequently the TSAC released a revised draft final report in July 2004 that took into account the comments from stakeholders. Public comments on that revision were accepted through August 2004. Incorporating input from these later comments, this document is now the final report of this task given TSAC by the LEED Steering Committee.

The January draft of the report focused only on the refrigerants used in centrifugal water chillers. In this final phase of the work, the methodologies are expanded to the other major classes of HVAC equipment and the refrigerants used in them.

This report recommends a basis for the long-term evolution of LEED credits dealing with the atmospheric impacts of refrigerants, as well as for an interim approach that can be applied to the existing Energy & Atmosphere Credit 4.

EXECUTIVE SUMMARY

This report addresses the tradeoff between ozone depletion and global warming caused by anthropogenic release of refrigerants commonly used in HVAC systems. Our analysis considers refrigerants used now and in the past in both centrifugal water chillers and unitary equipment: a range of chlorofluorocarbons (CFCs, now banned under the Montreal Protocol), hydrochlorofluorocarbons (HCFCs, scheduled for phase-out under terms of the Montreal Protocol), and hydrofluorocarbons (HFCs).

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 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.

A complete analysis of the relative harms of ozone depletion and global warming is beyond the scope of this report, because the full implications of both anthropogenic effects are not known. We know that both are critically important issues, and LEED has attempted to address both—ozone depletion through Energy and Atmosphere (E&A) Credit 4, Ozone Depletion, and global warming through E&A Credit 1, Optimize Energy Performance. Version 2.1 of the LEED rating system awards one point for avoiding the use of any chlorine-containing refrigerants in buildings in E&A Credit 4. It also awards credits for varying amounts of energy savings, hence rewarding the use of a more efficient refrigerant in Credit 1. The current LEED system thereby reflects the dilemma described in the previous paragraph: there is no clear win-win solution, and an architect or builder must choose between competing environmental damages.

The charge to TSAC was *"To review the atmospheric environmental impacts arising from the use of halocarbons in HVAC equipment and recommend a basis for LEED credits that gives appropriate credit to the alternatives."* Both direct and indirect effects were to be included in the analysis. To assess the relative differences for chillers and air conditioners, we normalize ozone depletion and global warming by cooling capacity, and we compare those values with total U.S. emission of ozone depleting and greenhouse gases, both from direct and indirect emissions. Although no single refrigerant is "best" when we consider both ozone depletion and global warming, we identify those that score well in both categories.

Our analysis suggests changes within the existing LEED credit structure, as well as in future versions of LEED, to better address these issues. The best approach is to devise a new credit structure that considers both ozone depletion and *direct* global warming impacts of refrigerants, as well as their *indirect* global warming impacts.

The current LEED structure awards credit for energy savings in E&A Credit 1 and thereby addresses *indirect* global warming effects, but it ignores the *direct* emission of greenhouse gases. Moreover, although the direct global warming effects of the refrigerants analyzed are smaller than the indirect effects resulting from energy generation to operate the HVAC equipment, they are not negligible and for some refrigerants they are as large as the indirect contribution.

Moreover, the near-term strategy to address global warming should consider other greenhouse gases along with CO_2 [1].The current E&A Credit 4 should be changed now to address this gap, but it is not feasible in the near term to change the number of credits dealing with refrigerants' atmospheric impacts, and the LEED credit structure cannot handle fractional credits. Therefore, we suggest that the existing single point in Credit 4 can be modified to accommodate both ozone depletion and direct global warming impacts, by awarding a credit to compounds that score "very well" in one of the categories and "well" on the other. There are no compounds that score "very well" in both.

This approach does not single out any refrigerant *per se*, but focuses on the impacts on the atmosphere of that refrigerant as applied in specific HVAC equipment configurations. This technically robust approach to considering refrigerant alternatives will encourage LEED users to evaluate both critical atmospheric effects. We also recommend that the credit be renamed from its current "Ozone Protection Credit" to "Refrigerant Selection Credit" to reflect its broadened purview.

In future versions of LEED, we recommend that all emissions of ozone depleting substances and greenhouse gases—not just from refrigerants—be considered in the credit structure. This could involve separate credits for ozone depletion and global warming.

1.0 INTRODUCTION

As the scientific community discovers new environmental problems, the desire to live with a minimal impact on our environment becomes more complex. Some choices have inherent environmental tradeoffs. Technologies, materials, or practices designed to ameliorate one problem may exacerbate another.

To make matters worse, the political recognition that one pollutant represents a societal threat, as compared to another, is not always timely. Such is the case with ozone depletion and global warming. While the legal protection of the ozone layer is well in place throughout most of the international community via the Montreal Protocol, the same nations lack agreement that global warming is a comparable threat. Therefore, the current regulatory program to protect stratospheric ozone was established without consideration of any impact on global warming. Although many governments, non-governmental organizations, and companies *do* believe the evidence of the magnitude and consequences of global warming is compelling enough to warrant action, a similar regulatory framework is not in place in the U.S.

The U.S. Green Building Council recognizes the critical importance of both issues and addresses them in its LEED™ rating system (Leadership in Energy and Environmental Design). Global warming is addressed in Energy & Atmosphere (E&A) Credit 1, which awards points for energy efficiency, and in other credits, which also contain provisions for proximity to public transportation, local energy generation, and use of energy from renewable sources. Ozone depletion is addressed in E&A Credit 4, which awards one point for avoidance of HCFCs and halons in HVAC and refrigeration equipment and fire suppression systems, and in E&A Prerequisite 3, which prohibits the use of CFC-based refrigerants.

The specific issue addressed in this report is a tradeoff between anthropogenic ozone depletion and global warming in the choice of refrigerants. The chlorine-based halogen refrigerants (e.g., HCFC-123) often represent the most efficient working fluids for the air conditioning industry, but their ozone-depleting effect is about 2% of that of CFC-11, which is no longer produced under the terms of the Montreal Protocol. HCFCs will be phased out in 2020 for new equipment under terms of the Montreal Protocol; production can continue until 2030 for servicing purposes. Some alternative compounds, such as HFC-134a, have virtually no effect on stratospheric ozone, but they are themselves greenhouse gases, so their leakage into the atmosphere exacerbates global warming. For thermodynamic reasons, they are also slightly less efficient than HCFCs, thereby requiring more power (with similar ideal equipment) and thus causing more carbon dioxide emission for the same amount of cooling.

Because of these considerations, the LEED Steering Committee charged its Technical Scientific Advisory Committee with the following tasks (see Appendix B):

> *"To review the atmospheric environmental impacts arising from the use of halocarbons in HVAC equipment and recommend a basis for LEED credits that gives appropriate credit to the alternatives. The review should consider:*
>
> - *"The direct effect of leaked halocarbons on the atmosphere (including but not necessarily limited to ozone depletion and global warming potential).*
> - *"The indirect effects on the energy efficiency of equipment in operation and the consequential effects on atmospheric emissions and impacts (including but not necessarily limited to global warming potential)."*

1.1 Current Status

The current LEED Version 2.1 rating system [2] addresses ozone depletion and global warming related to HVAC equipment as follows:

- E&A Credit 4 addresses the negative impact that a halocarbon has on the ozone layer. It awards one point for elimination of HCFCs and halons in HVAC and refrigeration equipment and fire suppression systems.
- E&A Credit 1 addresses global warming indirectly by awarding points for improved energy performance. If one refrigerant system is more efficient than another, it can contribute to the variety of ways a building designer can save energy.

LEED does not currently consider direct global warming effects of refrigerants from release into the atmosphere.

1.2 Significance

The credit system implicitly assumes that designers have the ability to make a trade-off between the building's impact on ozone depletion and indirect global warming as they select the HVAC refrigerant.

The current LEED rating system recognizes the merit of a reduction in a building's contribution toward global warming but it only addresses global warming *indirectly* as a function of energy consumption. If a more efficient refrigeration system is selected, LEED credits might be earned for the energy benefits in E&A Credit 1, but not earned in E&A Credit 4 if the refrigerant depletes ozone, even slightly. Therefore, if a cooling system achieves greater efficiency only at the environmental price of using a chlorine-containing refrigerant, an inevitable environmental conflict exists. Further, the current LEED system does not include direct impacts on global warming of refrigerant use. Is there a way to establish a quantitative description of a cooling system's *total environmental impact*, and should the assignment of LEED credits be revised? This issue is the focus of the study.

2.0 REFRIGERANT TYPES

A "refrigerant" is a working fluid that flows through a machine that is designed to pump heat from a lower temperature to a higher temperature. The overwhelming majority of such machines operate on the vapor compression cycle principle, and the fluids that meet all necessary criteria for a stable, safe, inexpensive, efficient performance are mostly in the halogen family. This means they are usually halogenated hydrocarbons. Ammonia is the most common exception. This family of chemicals fall into the following categories: CFC, HCFC, HFC, and a non-halogen refrigerants group called Natural Refrigerants. Table 1 lists the ozone-depletion (ODP) and global-warming potentials (GWP) of these chemicals used in this analysis. Over the last decade, estimates of some of these values have changed because of new knowledge, typically about atmospheric lifetimes. Values are published by the Environmental Protection Agency [3-6] and the World Meteorological Organization (WMO) [7]. Because the WMO values are better documented, we use that publication [7] as the preferred source, supplemented with values from EPA where necessary.

2.1 CFC (ChloroFluoroCarbons)

The molecules have one or more carbons, with *all* of the hydrogen atoms replaced by either chlorine or fluorine atoms. Because they are extremely stable, most of the refrigerants developed prior to the ozone crisis were of this group. However, their stability gives them a very long atmospheric life, allowing them to migrate to the stratosphere where they break up, and the free chlorine atoms reduce the amount of ozone. Manufacture of these chemicals is now banned in the developed countries that signed the Montreal Protocol. Developing countries who signed the protocol can produce CFCs until 2010, and significant amounts are still manufactured in some countries that did not sign the protocol.

2.2 HCFC (HydroChloroFluoroCarbons)

The molecules have one or more carbons, with *some* of the hydrogen atoms replaced by either chlorine or fluorine atoms. Typically these refrigerants are designed to be sufficiently stable within the machine but have a relatively short atmospheric life, thereby minimizing their damage to the ozone layer. Nevertheless, they are scheduled to be phased out in the future under

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

Refrigerant	ODP	GWP	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	$< 4\times10^{-4}$	12,240	ultra-low-temperature refrigeration
HFC-134a	$<1.5\times10^{-5}$	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	$\sim10^{-5}$	1,020	Insulation agent, centrifugal chillers
HFC-404A	$\sim10^{-5}$	3,900	low-temperature refrigeration
HFC-407C	$\sim10^{-5}$	1,700	HCFC-22 replacement
HFC-410A	$< 2\times10^{-5}$	1,890	air conditioning
HFC-507A	$\sim10^{-5}$	3,900	low-temperature refrigeration
Natural Refrigerants			
CO_2	0	1.0	
NH_3	0	0	
Propane	0	3	

Data sources: [3-7], with [7] considered the most reliable source to resolve differences

terms of the Montreal Protocol, so that even those refrigerants in this group that have a short enough atmospheric life that they do little ozone damage (less than 2% compared to CFC-11) are to be eliminated.

2.3 HFC (HydroFluoroCarbons)

The molecules have one or more carbons, with *some* of the hydrogen atoms replaced by fluorine atoms. HFCs typically have a negligible impact on the ozone layer, but many have a significant GWP value. There is a strong movement in Europe to expand their areas of application.

2.4 Natural Refrigerants (CO_2, H_2O, NH_3, HC, Air)

Five refrigerants, arbitrarily grouped under this title in the early 1990s, are environmentally benign to the atmosphere. They were and are used as refrigerants in various applications, but all have significant limitations for buildings. There is a strong movement in Europe to expand their areas of application.

2.4.1 CO_2 (carbon dioxide)

Currently being considered for automotive air conditioning, it is inherently inefficient for building applications. Moreover, its operation at a pressure of 100 atmospheres may raise safety concerns. As the gas to which other compounds are normalized, its GWP is 1.0 mass unit CO_2 equivalent.

2.4.2 H_2O (water)

Water is used for making ice for some limited industrial applications. Because of its very low vapor pressure, machine size per unit capacity is of an order of magnitude larger than current building machinery. Although it is the main gas responsible for absorption of infrared radiation in the atmosphere, its very short atmospheric lifetime (9 days) makes any anthropogenic emission completely benign.

2.4.3 NH_3 (ammonia)

Ammonia is widely used in industrial applications because of its excellent thermodynamic performance. Building, fire, and hazardous materials codes apply limitations because of safety concerns.

2.4.4 HC (hydrocarbons)

Propane, butane, ethane, isobutene, and isopentane are good refrigerants thermodynamically, but their flammability limits capacity inside buildings to be not much larger than a home refrigerator. HCs are sometimes used as blend components in service fluids to avoid the need for lubricant change with conversions to HFCs.

2.4.5 Air (78% N_2, 21% O_2, 1% H_2O, + trace gases)

Inherently inefficient compared to all other refrigerants, air is being considered in Europe for railway air conditioning.

2.5 Other Building Applications

Halocarbons are also used in buildings for applications other than working fluids in cooling equipment. In particular, they are used in the cells of foamed insulation and in fire fighting systems. Although these fluids are of the same chemical family as the machinery fluids, such

applications are beyond the scope of the current assignment to the TSAC. Since their use causes emission to the atmosphere, with consequences for both ozone depletion and global warming, future versions of LEED should consider the building's total effects, including those of the non-refrigeration applications.

3.0 Market Distribution for Various Refrigerant Types and HVAC Equipment Types

The LEED E&A Credit 4 applies to all types of HVAC systems, including unitary (direct expansion package rooftop equipment, split system, through-the-wall, and heat pumps) and water chillers (centrifugal, reciprocating, screw, and absorption). There is significantly more unitary HVAC equipment specified and installed than water chillers, both in terms of number of units and total amount of refrigerant charge [8]. However, our analysis is similar for all types of cooling strategies and therefore applies to both small and large units.

Approximately 50% of the water chillers in existing buildings still use CFC-11 as refrigerant [8], and many of these remaining chillers are old, inefficient and often leaky; retrofitting them is not cost-effective. Of particular significance for *LEED for Existing Buildings*, it makes sense to encourage the retrofitting of existing chillers using CFC-11 to HCFC-123 only for the newer CFC-11 chillers [9]. Replacement with new energy-efficient chillers is the choice most owners should make now. The annual volume of refrigerants sold for replacement in existing building equipment is four times that sold for new equipment, so the significance of the existing buildings market cannot be ignored.

4.0 Direct and Indirect Effects of HVAC Equipment and Refrigerants on Ozone Depletion and Global Warming

To compare the environmental impacts on ozone depletion and global warming of all refrigerants, we adapt a simple model, based on one developed for EPRI [10], to calculate *life cycle* values for an *ozone depletion index* and a *global warming index*. The impacts occur through two mechanisms:

- *direct* impacts from the leakage of gases that deplete ozone through stratospheric chemical reactions or warm the atmosphere through their absorption of Earth's thermal emission, and
- *indirect* global warming impacts, which occur through the amount of electricity consumed as a function of the chiller's operating efficiency—the lower the chiller's efficiency, the more electricity is consumed and consequently the more CO_2 emissions are generated.

However, because LEED E&A Credit 1 addresses the indirect global warming impacts, we focus on a comparison of the direct impacts, which are not currently addressed in LEED, although we show how both would be calculated.

4.1 Direct Effects

Metrics for Analysis of Direct Effects. Our analysis of direct effects uses performance-based metrics of the *life-cycle ozone depletion index* and *life-cycle direct global warming index* of the refrigerant used by HVAC for a building, normalized per Ton of Cooling Capacity and per Year of Equipment Life for the HVAC equipment. The equations describing these two factors are: