Green Building Academy

Educating for a Greener Destination

LEED Green Associate Made Easy

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LEED v4 Green Associate Made Easy – Version 2

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Preamble

LEED Green Associate Made Easy was first published in Jan 2011 as a free study guide and subsequently revised in Oct 2012 and November 2013 based on the feedback from candidates. It was very well received in the market more than 4000 Professionals have downloaded it. We have received very good feedback from the candidates. With the launch of LEED V4, we have the responsibility to improve the contents of the study guide to meet the expectations. In order to maintain and improve the quality of contents I need take support from my colleagues as well.

Why LEED Green Associate Made Easy?

With due respect, to the Authors of popular study guides in the market, I personally feel that these study guides are not very reader friendly. For a working professional who spends 8-10 hrs/day on work, in addition has to fulfill his family commitments may not be in a position to read a study material, which has more than 260 pages with tiny fonts and cramped line spacing. These study guides have very good content, but do not make it interesting for such a busy professional.

Following are the special features of LEED Green Associate Made Easy.

- Specifically designed for working professionals with concise but complete contents.
- We have improved from the previous versions of our publications by adding more graphics content

- The content of the book is structured by prerequisites and credits of the LEED Rating system. This will help the candidates to extend their preparation for LEED AP specialty exam.
- Online discussion forum at the end of each chapter enables the readers to clarify all their doubts by discussing with the Author's.
- Online version of the book is also available if the reader prefers to read using pc/laptops/android devices
- LEED Green Associate Made easy along with practice questions are sufficient to crack the examination

I would be pleased to hear your feedback & comments. Please feel free to contact me atbazeeth@greenbuildingacademy.org

Good Luck for the examination!

K.M. BAZEETH AHAMED
26th June, 2014.

Author's Profile

Mr. K M Bazeeth Ahamed is a trainer & consultant in Green Buildings. He has completed his Post Graduation in Mechanical Engineering from Birla Institute of Technology in 2002 and has spent 12 years in Academics, Research, Energy Audits and Green Building Consultancy. Mr. K M Bazeeth Ahamed is a Certified Energy Manager and Energy Auditor. He is a LEED AP with two specialties BD+C and O+M.He is also ASHRAE Certified Building Energy Assessment Professional and GSAS Green Certified Professional. He strongly believes certifications are the best way to develop and demonstrate professional skills. He has successfully trained more than 1500 professionals in LEED and Green Buildings.

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Supporting Authors

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Chapter1 – Introduction to Green Buildings & LEED Credentials

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- What is a Green Building?
- What is the significance of Green Buildings?
- What are the various Green Building rating systems?
- Why LEED?
- What are the various LEED Credentials?
- LEED Examination information

1.1 What are the characteristics of Green Buildings?

Green Buildings are

- Energy Efficient
- Water Efficient
- Provide better Indoor Environment& hence better living conditions
- Use environmental friendly or sustainable materials
- Produce Less waste
- Have lesser transportation requirement
- Protect/restore habitat

The above characteristics results in reduced environmental impact throughout the lifecycle of the building

1.2 What is the Significance of Green Buildings?

The major environmental challenges today are

- Climate change
- Depletion of resources
- Ozone depletion
- Land pollution
- Water Pollution
- Air Pollution

There is a common perspective that industries are the major part of greenhouse gas emissions. Interestingly fig 1.1 shows that buildings are the major contributors towards greenhouse gas emissions

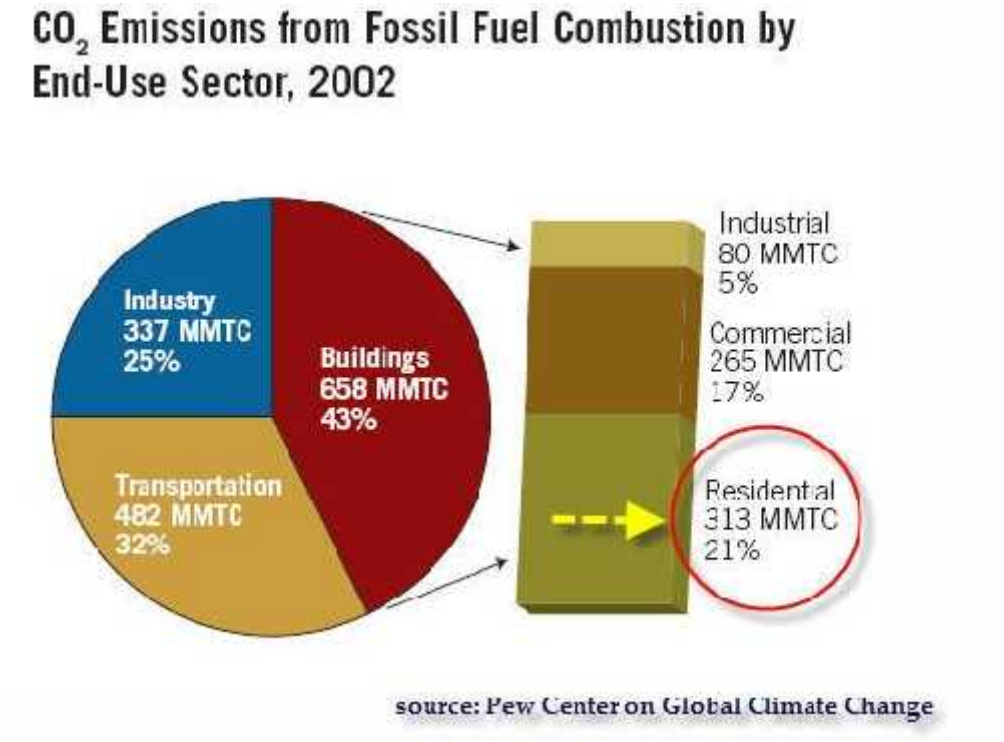


Fig 1.1 Building's Contribution to CO_2 emission

Buildings directly contribute towards all the above environmental pollution. Green Buildings can be major part of the solution to these environmental issues.

Interest for Green Buildings has gained significant momentum in GCC countries. Hence, we would like to provide some specific statistics related to GCC countries. Fig 1.2 shows that percapita CO_2 emission[1]ishigher in GCC countries. This could be because of climatic conditions, life style, lack of infrastructure related to public transportation etc.

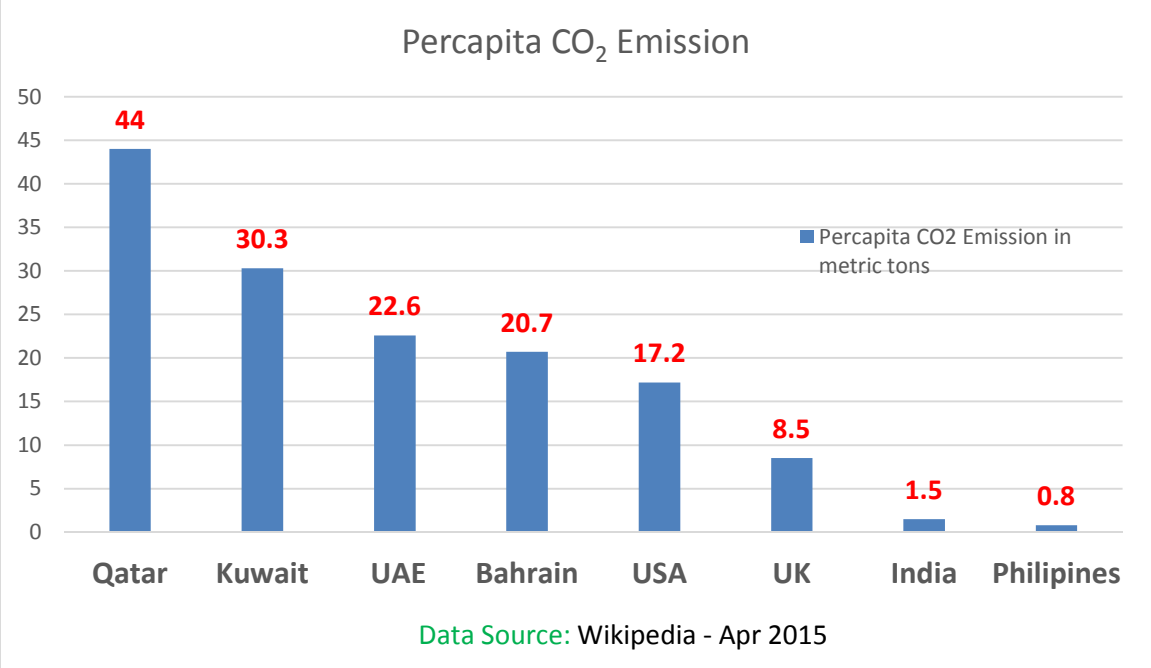


Fig 1.2 Percapita CO_2 Emissions of various countries

Fig 1.3 shows that Green Buildings can significantly reduce the resources used in buildings and contribute to reduced environmental impact.

[1]Percapita CO_2 emission is theCO_2 emission of the country divided by midyear population.

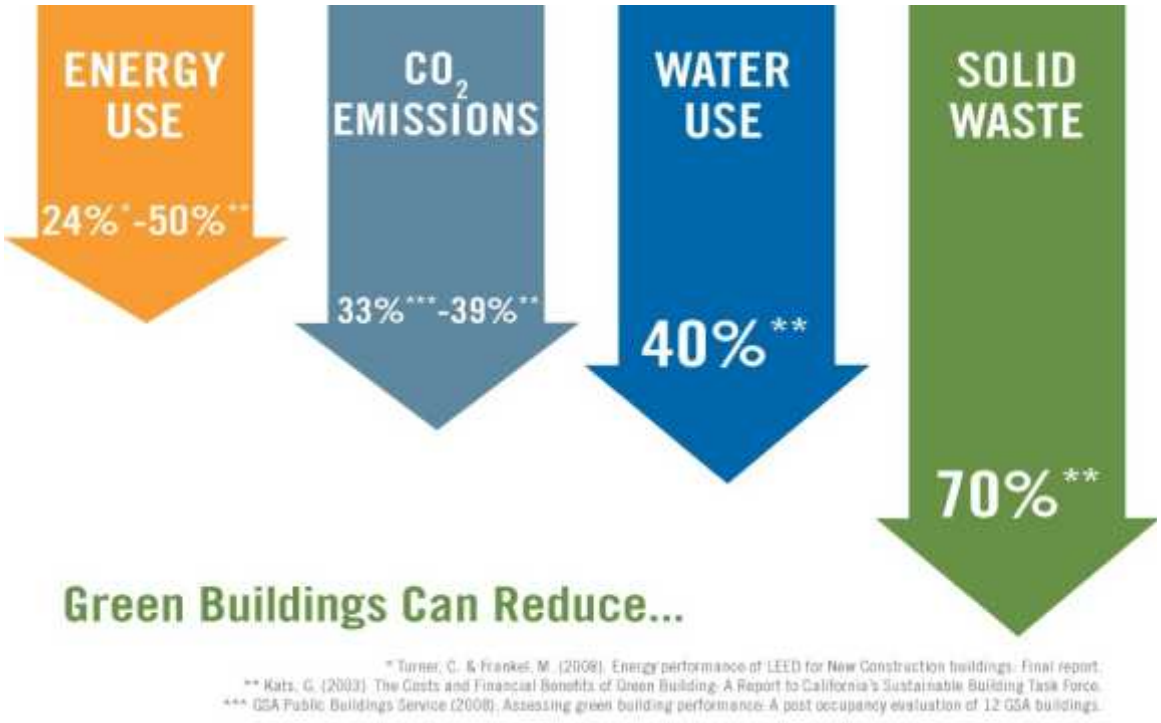


Fig 1.3 Environmental benefits of Green Buildings

1.3 How a building can be certified as Green Building?

Buildings are certified as Green Buildings byvarious Green Building rating systems.Green Building rating systems are tools which assess the building on various aspects like energy efficiency, water efficiency, materials used, indoor environmental quality, location of site etc and certify the buildings if they qualify their preset criteria.

There are numerous Green Building rating systems across the world. Below is a partial list of various Green Building rating systems

- Australia: **Green Star**
- Brazil: **AQUA / LEED Brazil**
- Canada: **LEED Canada/ Green Globes**
- China: **GB Evaluation standard for green building**

- Finland: **PromisE**
- Germany: **DGNB**
- Hong Kong: **HKBEAM**
- India: **GRIHA** and **IGBC**
- United Arab Emirates: **Pearl Rating System**
- United States: **LEED**
- United Kingdom: **BREEAM**
- Taiwan: **EEWH**
- Qatar: **GSAS**

1.4 Why LEED?

When there are various Green Building rating systems, why should someone bother about LEED? Here are some of the reasons

- LEED- Internationally recognized Green Building rating system
- Adapted in many countries like Brazil and Canada
- Popular& accepted in GCC countries. Fig 1.4 shows that there are more than 750 LEED registered projects[1] and 180+ LEED Certified Projects[2]in GCC countries.

[1]LEED registered projects: LEED registered projects are the projects which has expressed their interest to be LEED certified by filling an online application form. Registered projects are analogous to candidates who have applied for the exam

[2]LEED Certified Projects: LEED Certified projects are the projects which has been successfully assessed by GBCI and got LEED Certified. Certified projects are analogous to candidates who have successfully passed the examination.

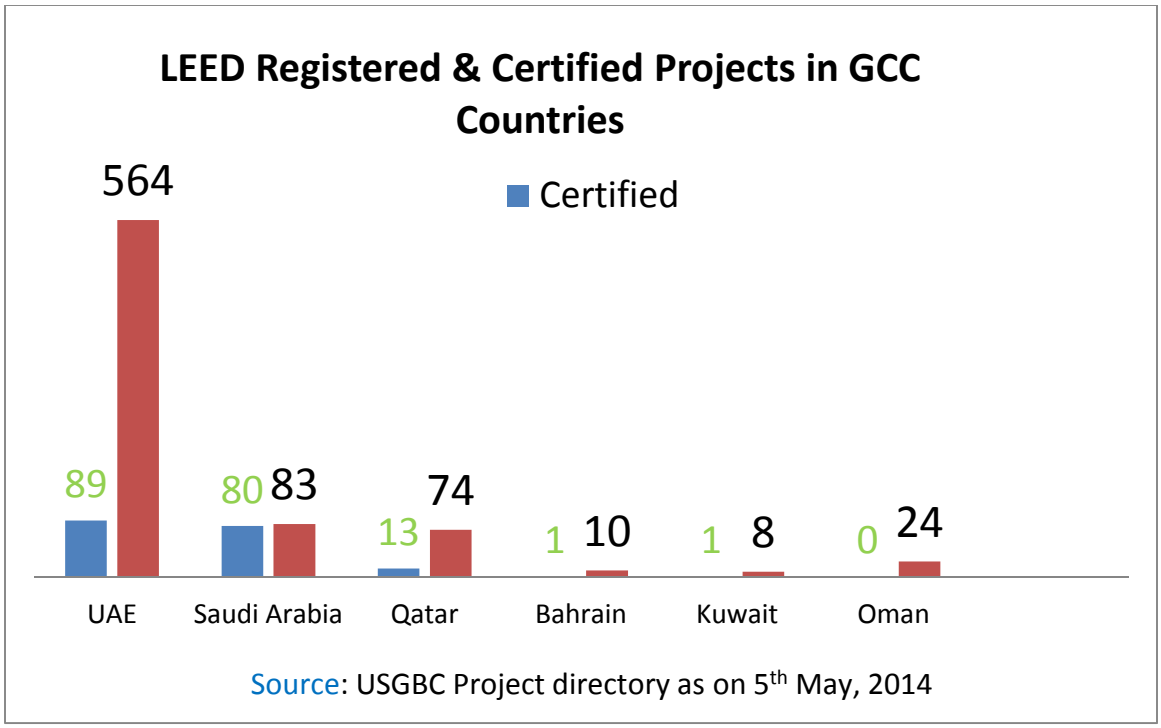


Fig 1.4LEED Projects in GCC Countries

1.5 What LEED Credentials you can earn?

LEED offers three levels of credentials for professionals as shown in Fig 1.5

Fig 1.5LEED Credentials

LEED Green Associate: LEED Green Associates have understanding of green building design, construction and operations. They possess knowledge level equivalent to 200 in LEED core curriculum.

LEED AP: LEED Accredited Professionals will be able to implement their knowledge by facilitating Certification process in a particular LEED rating system. They possess knowledge level equivalent to 300 in the LEED core curriculum. LEED AP Credential comes with a specialty; candidates can choose the specialty based on their profile. For example a Professional in design or construction may prefer to be a LEED AP BD+C; while a facility manager shall be interested in LEED AP O+M.

LEED Fellow: LEED fellows are LEED APs who have demonstrated exceptional achievement in LEED and Green Buildings.

Fig 1.6 Knowledge levels in LEED Curriculum

1.6 LEED Green Associate examination information

- Exam can be taken through prometric centers in any country.
- Exam Fee is USD 200 for members and USD 250 for non members
- Apply for exam through www.usgbc.org
- Computer based test, 100 multiples choice questions.
- Total duration is 2 Hrs and 20 minutes (10 minutes tutorial on interface + 2 Hrs exam + 10 minutes exit survey)
- Passing score 170/200 – This doesn't mean 85 percentage. The evaluation is based on relative performance against baseline performance.
- No negative marking
- Results are available immediately after the exam

1.7 LEED Green Associate + LEED AP combined examination

It is possible to take LEED Green Associate exam and the applicable LEED AP with specialty exam together. Exam Fee is USD 400 for members and USD 550 for non-members. The combined exam consists of two parts each part contains 100 randomly delivered multiple choice questions and each part must be completed in 2 hours. Part 1 is for LEED Green Associate and Part 2 for LEED AP specialty exam.

Generally, we do not recommend combined exams; unless the candidate is aggressive towards the exam preparation.

1.8 Exam interface

The exam interface is extremely user friendly and convenient. If you just know how to use the mouse and keyboard, you will be comfortable.

Fig 1.7 & Fig 1.8 are tentative screen shots of the interface in V3. This may be updated or changed by GBCI in V4 as there are translational aid, we will come up with updates in next revision. The interface may have the following buttons

Previous/Next: Navigation buttons used to go from one question to another.

Mark: Used to mark questions for reviewing later

Calculator: Pops up a calculator. However, there are no calculations in LEED Green Associate exam.

Review: Brings a screen as shown in fig 1.8 to summarize the questions answered/unanswered or marked. You can change the answers anytime within the allotted two hrs.

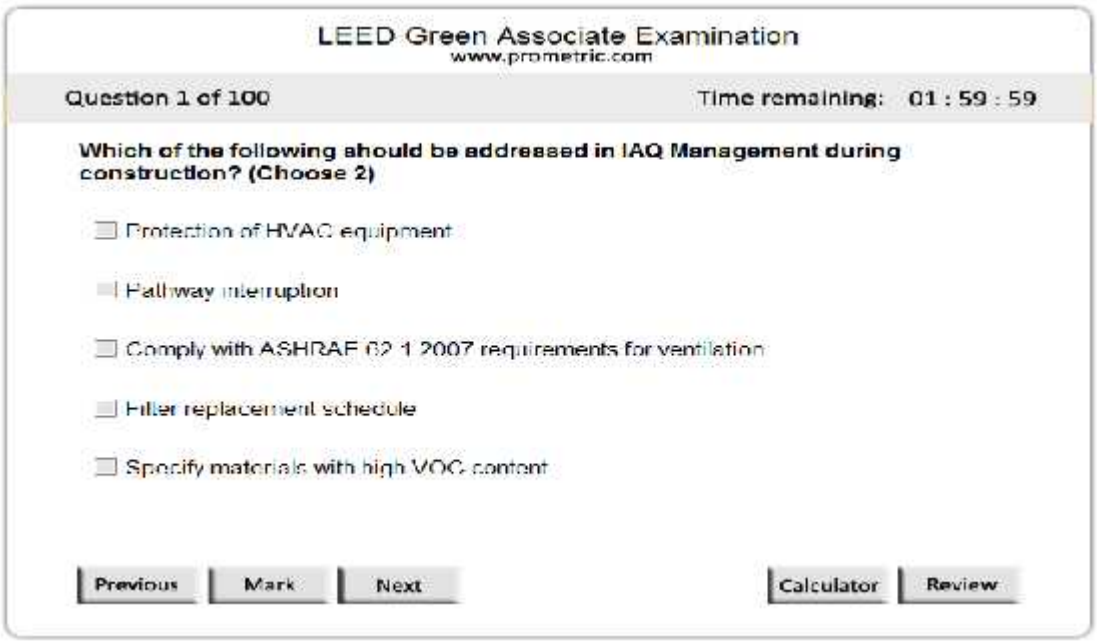


Fig 1.7 Exam Interface

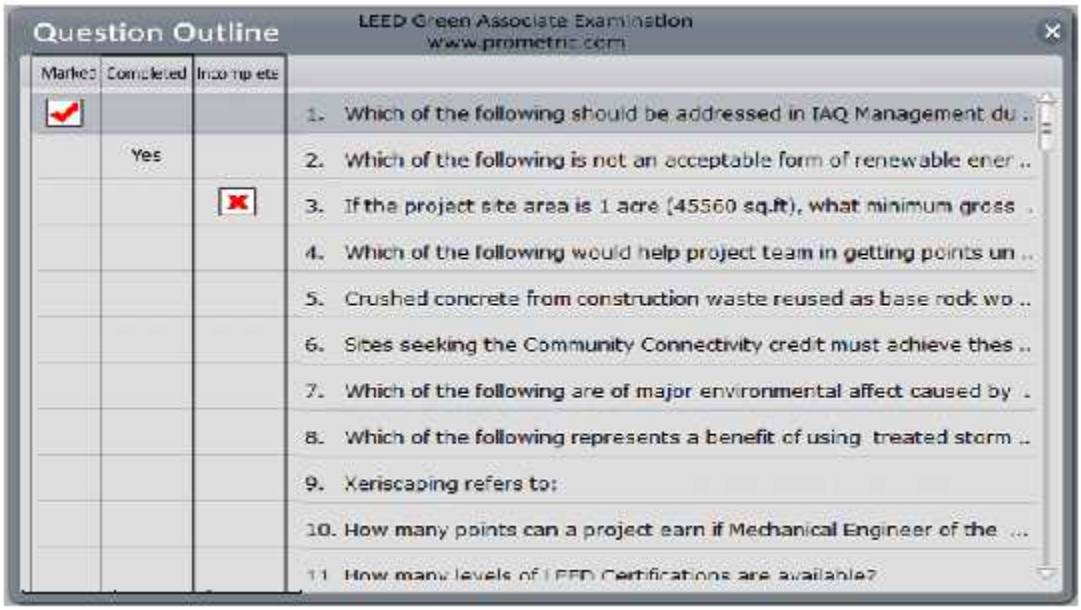


Fig 1.8 Review Screen

Summary

We have addressed

- What is a Green Building?
- What is the significance of Green Buildings?
- What are the various Green Building rating systems?
- Why LEED?
- What are the various LEED Credentials?
- LEED Examination information

Have a Question in this chapter?

Discuss in our forum

Chapter 2 – Introduction to LEED Rating Systems

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- What is LEED?
- Principles of LEED
- Various LEED Rating systems
- How does the LEED rating systems work?
- USGBC, GBCI & LEED Online
- Minimum Program requirements of LEED

2.1 What is LEED?

LEED is an acronym for Leadership in Energy and Environmental Design. It is an internationally recognized green building rating system developed by US Green Building Council.

LEED is intended to provide building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions.

The features of LEED are:

- LEED provides third party verification that a building or community is designed, built and operated in a sustainable way.
- Voluntary certification system.
- Developed on consensus based approach.

LEED rating systems are developed based on triple bottom line **(3Ps)**:

- Social Responsibility (**People)** - Better living conditions for people
- Environmental Stewardship (**Planet**) - Less impact on environment
- Economic Prosperity (**Profit**) - Reduce the Life Cycle cost of building

Fig 2.1 Triple Bottom Line

2.2 Various LEED Rating Systems

2.2.1 LEED Rating System families

There are five 5 families of LEED Rating system as explained in fig 2.2. Each of these rating systems is applicable to different project typologies as explained in fig 2.3. There are 21 LEED adoptions in LEED V4.

LEED for BD+C	LEED for ID+C	LEED for O+M	LEED for ND	LEED for Homes
•Applicable for New construction and Major renovation of buildings	•Applicable for Projects whose scope is limited to interior fit out	•Existing buildings undergoing improvement •Minor upgrade may be included	•Applicable for Land development projects. Mixed use developments etc	•Applicable for all residential projects except high rise residential building

Fig 2.2LEED Rating systme families and their application

Major Renovation includes any of the following

a. Building Envelope Changes
b. HVAC system changes
c. Major Interior changes

2.2.2 Adoption of rating system to different project typologies

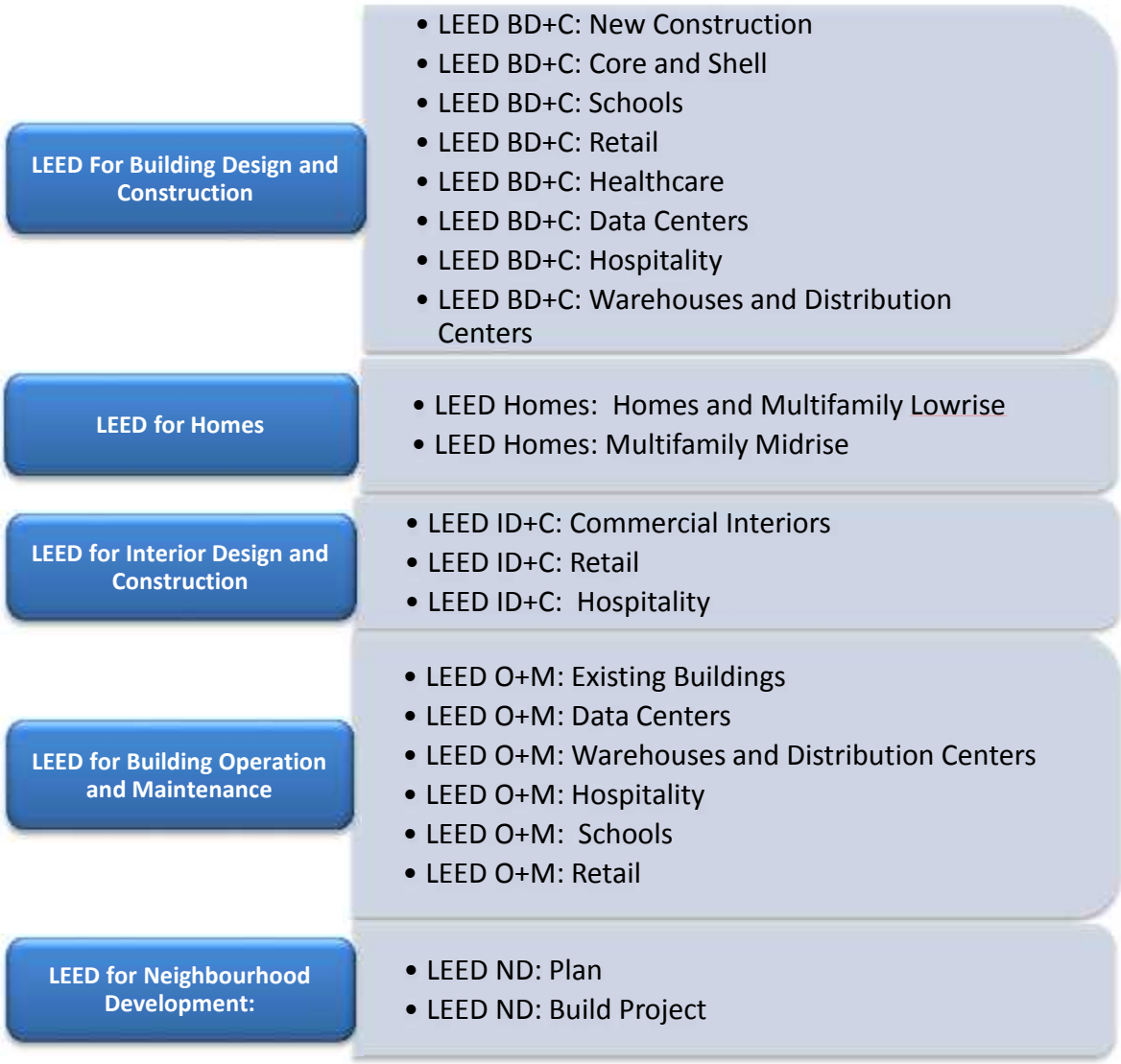


Fig 2.3 Adoption of LEED Rating system for different project typologies

LEED for Building Design and Construction:

LEED BD+C: New Construction

- Commercial occupancies, Institutional occupancies (museum, Church) and high-rise residential buildings i.e. residential buildings with nine and more habitable stories.

LEED BD+C: Core & Shell:

- Projects where developer has no control over the tenant fit out (shopping malls, commercial buildings, warehouses etc.).

LEED BD+C: Schools

- Academic buildings of K-12 schools shall qualify for LEED BD+C: Schools
- Nonacademic buildings of schools, post-secondary academic buildings and pre kinder garden buildings may also qualify either for LEED BD+C: Schools or LEED BD+C:NC as per project teams decision

LEED BD+C: Health Care

- Inpatient and outpatient health care facilities
- Licensed long term health care facilities.
- Medical offices, assisted living facilities and medical education and research centers.

LEED BD+C: Retail

- Retail building projects like banks, restaurants, apparel, electronics, big box etc.

LEED BD+C: Data Centers

- Specifically designed and equipped to meet the needs of high density computing equipment such as server racks used for data storage and processing.

LEED BD+C: Hospitality

- Buildings dedicated to hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.

LEED BD+C: Warehouse and Distribution Centers

- Buildings use to store goods, manufactured products, merchandise, raw materials or personal belongings

LEED for Homes:

LEED Homes: Homes and Multifamily Low-rise

- Single family housing
- Low rise multifamily housing(up to 3 habitable stories)

LEED Homes: Multifamily Midrise

- Multi-family residential buildings of 4 to 8 habitablestories above grade.

LEED for Interior Design and Construction:

LEED ID+C: Retail

- Retail interior projects like banks, restaurants, apparel, electronics, big box etc.

LEED ID+C: Hospitality

- Interior spaces dedicated to hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.

LEED ID+C: Commercial Interiors

- Applicable for *tenant spaces*excluding retail and hospitality projects.

LEED for Operations and Maintenance:

LEED O+M: Existing Buildings

- Applicable for existing buildings for sustainable operation and maintenance of the building.
- Shall also cover system upgrades, minor space-use change.

LEED O+M: Retail

- Existing buildings that areusedto conduct the retail sale of consumer product goods. Includes both direct customer service areas (showroom) and preparation or storage areas that support customer service.

LEED O+M: Schools

- Academic buildings of K-12 schools. Can also be used for higher education and non-academic buildings on school campuses.

LEED O+M: Hospitality

- Existing hotels, motels, inns, or other businesses within the service industry that provide transitional or short-term lodging with or without food.

LEED O+M: Data Centers

- Existing buildings specifically designed and equipped to meet the needs of high density computing equipment such as server racks, used for data storage and processing.

LEED O+M: Warehouse and Distribution Centers

- Existing buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage).

LEED for Neighborhood Development:

LEED ND: Plan

- Projects in conceptual planning or master planning phases, or under construction.

LEED ND: Build Project

- Applicable for completed development projects.

2.3 What happens when more than one rating system is applicable for a project?

Most projects fit into a particular rating system, there may be cases where a project is applicable for more than one rating system. Following guidelines are to be used under such scenario:

- Apply 60/40 rule i.e. select the rating system, which is applicable for 60% or more the project area.
- The rating system which is most applicable for the project should be selected.

Fig 2.4 Selection of LEED Rating system

2.4Understanding the LEED Rating System

LEED rating systems consists of credit categories. In most LEED V4 rating systems following are the credit categories

- Integrative Process
- Location and Transportation
- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality

Main Categories

- Innovation
- Regional Priority

Bonus Categories

Each of the above credit categories has:

- ✓ Prerequisites
- ✓ Credit
- ✓ Points

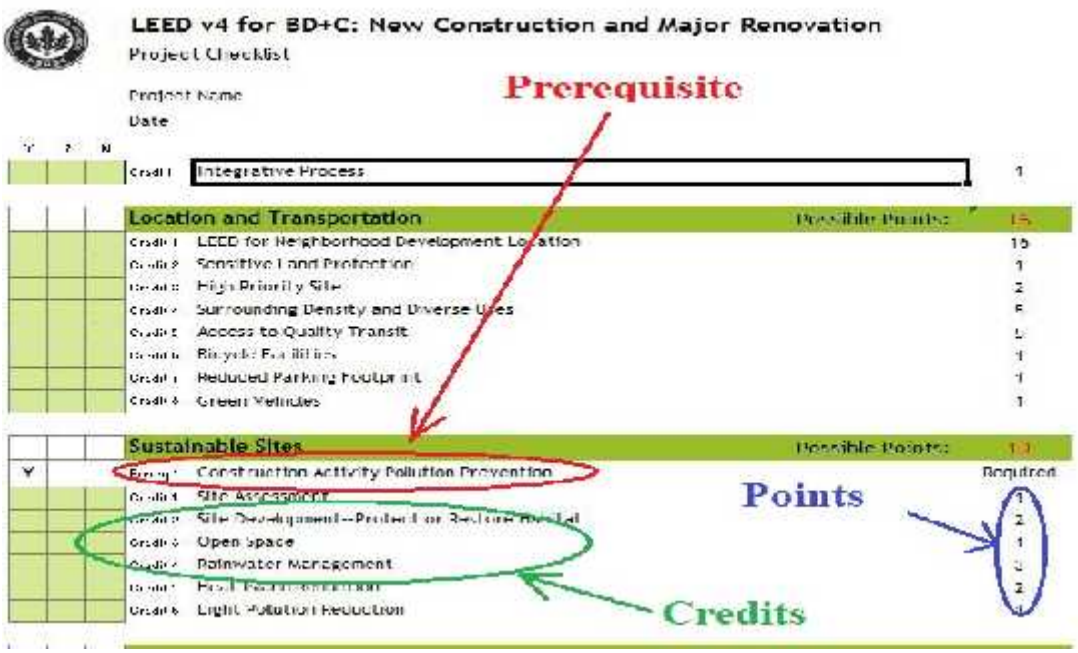


Fig 2.5 Illustration of Prerequisite, Credit and Points

- **Prerequisites** are mandatory requirements for a project to be certified.
- **Credits** are optional requirements. **Points** are awarded when project comply with credit requirements.

Example: Refer to fig 2.5, under Sustainable Sites category, Construction Activity Pollution prevention is a prerequisite. Projects should comply with this requirement in order to get LEED Certification. Other requirements like Site Assessment, Site Development etc. are credits which are optional. By meeting the credit requirements projects can earn points.

Based on the number of points scored, the projects may be awarded as LEED Certified, LEED Silver Certified, LEED Gold Certified or LEED Platinum Certified.

Fig 2.6 Various levels USGBC Levels of LEED Certifications

Fig 2.7 Summary of how LEED Rating system works

2.5LEED Impact Categories

Refer to fig 2.5; all credits do not carry equal number of points. Points are allotted based on how the credit supports LEED Goals. LEED Certified buildings are expected to make a positive impact by:

- Reducing contribution to global climate change
- Enhance individual human health
- Protect and restore water resources
- Protect and enhance biodiversity and ecosystems
- Promote sustainable and regenerative material cycles
- Build a green economy

- Enhance community quality of life

These LEED goals are called as impact categories. Each impact category has different weightage based on how significant they are. For example climate change is of much more significance compared to green economy.

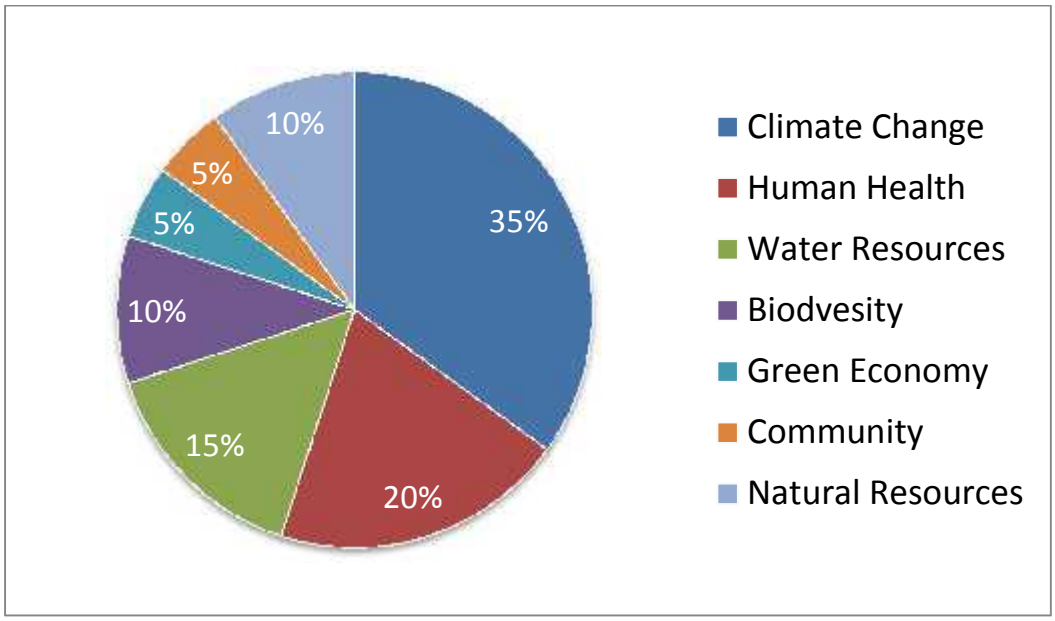


Fig 2.8 Weightage for different impact categories

2.6 LEED Reference Manuals:

LEED Reference Manuals are publications by USGBC, which details all technical aspects of a particular LEED Rating System. LEED Reference Manual details intent, requirements, strategies calculations etc. for each credit/prerequisite in a rating system.

Fig 2.9LEED Reference Manuals

2.7 USGBC, GBCI and LEED Online:

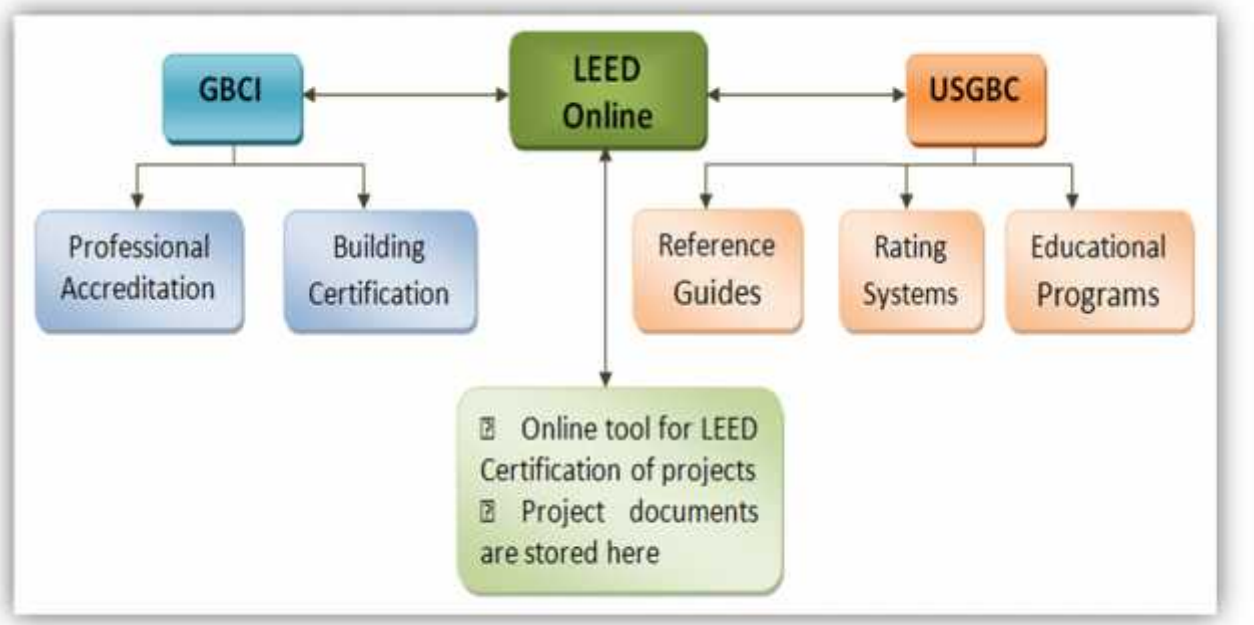


Fig 2.10GBCI,LEED Online & USGBC

The main roles of USGBC, GBCI and LEED online are illustrated below:

- USGBC is responsible for developing rating systems, reference guides and education program
- GBCI administers building certification and professional accreditation.
- LEED online is an online tool through which entire LEED Certification is handled.
    - It is an online storage system where all project details (credit templates, drawings, supporting documents etc.) for LEED documentation are stored.

- Project Team gets access to CIR database, rating system errata etc. through LEED online.(CIR is discussed in Chapter 11)

- Both **USGBC** and **GBCI** are linked with **LEED ONLINE**. It means that having user id registered with usgbc/gbci/leedonline, enable the person touse the same user id and password in www.usgbc.org or www.gbci.org or www.leedonline.com

It is worth noting the following points

- LEED Green Associate and LEED AP are not certifications. They are called as LEED credentials.
- Individuals cannot be members of USGBC. Only companies can be members. Full time employees of USGBC member companies can utilize the membership benefits. USGBC member companies can use USGBC member logo in websites, business cards and email signatures. Logo should not be used in products and packaging
- LEED does not endorse or certify any products.

About USGBC

US Green Building Council is a non-profit organization committed to a prosperous and sustainable future through cost-efficient and energy-saving green buildings.

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.

Vision

Buildings and communities will regenerate and sustain the health and vitality of all life within a generation.

GBCI was established in 2008 to administer project certifications and professional credentials within the framework of the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) Green Building Rating Systems™.

2.8 Minimum Program Requirements

Minimum Program Requirements (MPR's) are very basic requirements a project should comply to be eligible for LEED Certification.

- Must be in a permanent location on existing land.
- Must use reasonable & consistent site/LEED boundaries.
- Must comply with minimum project size requirements.
    - 1000 sq.ft for LEED BD+C and LEED O+M
    - 250 sq.ft for LEED ID+C.

MPR for LEED Neighborhood Development:

The LEED project should contain at least two habitable buildings and be no larger than 1500 acres.

MPR for LEED Homes:

The LEED project must be defined as a "dwelling unit" by all applicable codes.

Site Boundary/LEED Boundary

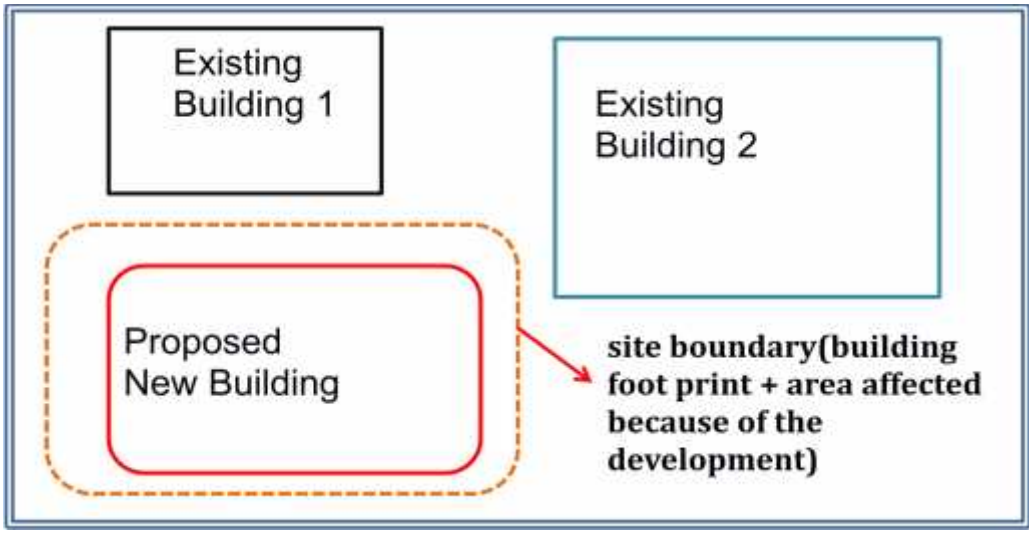


Fig 2.11 Site Boundary/LEED Boundary

The LEED project boundary is the portion of the project site submitted for LEED certification. For multiple building developments, the LEED project boundary may be a portion of the development as determined by the project team.

Purpose of MPR:

- To provide clear guidance to the customers.
- To reduce the challenges that may arise during the certification process.
- To protect the integrity of LEED program.

GBCI may revoke the certification if the project does not comply with MPR at any stage.

2.9 Requirements for a Project to be LEED Certified:

- The project should comply with Minimum Program Requirements of the rating system.

- The project should comply with all the prerequisites of the rating system.
- The project should earn minimum number of points required for certification.

2.10 What do we discuss in the next chapters?

Wewill discuss Prerequisites and Credits under each of category below

- Location and Transportation
- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Integrative Process
- Innovation
- Regional Priority

For each Credit/prerequisite of the above categories, we will discuss:

- What is the intent of each credit/prerequisite?
- Why the credit/prerequisite is significant?
- What strategies the Project team can peruse to comply with the credit?
- What are the key references or standards associated with the credit/prerequisite?

- What are the important terminologies associated with each credit/prerequisite?

Summary

We have addressed

- What is LEED?
- Principles of LEED
- Various LEED Rating systems
- How does the LEED rating systems work?
- USGBC, GBCI & LEED Online
- Minimum Program requirements of LEED

Have a Question in this chapter?

Discuss in our forum

Chapter3 – Location and Transportation

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Sensitive land protection
- High priority site
- Surrounding density and diverse uses
- Access to quality transit
- Bicycle facilities
- Reduced parking footprint
- Green Vehicles
- LEED for Neighborhood Development location

The overall objective of this credit category is to:

- Reduce the environmental impact by proper site selection.
- Reduce the environmental impact associated with transportation.
- Improve public health by increased physical activity.

3.1 Sensitive land protection:

Significance:

The intent of this credit isto avoid development of environmentally sensitive sites and hence reduces the environmental impact associated with the development.

Strategies:

1. The best strategy to achieve this credit is to develop a previously developed site. Previously developed sites have existing infrastructure like electricity network, water, sewage, telecom etc. hence reduces the load on infrastructure requirement.
2. Do not develop environmentally sensitive sites. Following sites are considered asenvironmentally sensitive:
   a. A farm land
   b. Land close to water bodies - development boundary to be atleast 100' away from water bodies
   c. Flood prone area - avoid development of site with floodplain subject to a 1% or greater chance of flooding in any given year
   d. Land close to wetland - development boundary to be at least 50' away from wetland.
   e. Land which is identified as landfor endangered species.

Fig 3.1 Example for wetland

Terminologies

Endangered Species: Population of organisms which is at risk ofbecoming extinct.

Wetland: A wetland is an area of land whose soil is saturated with moisture either permanently or seasonally.

3.2High Priority Site:

disadvantaged neighborhood
ala7ya2 alma7roma

Significance:

The intent of this credit is to

- Encourage project location in areas with development constraints
- Reduce the load on Greenfield sites and farm lands.

Strategies:

- Locate the project in infill site of an existing development
    - Infill development involves developments with in urban area

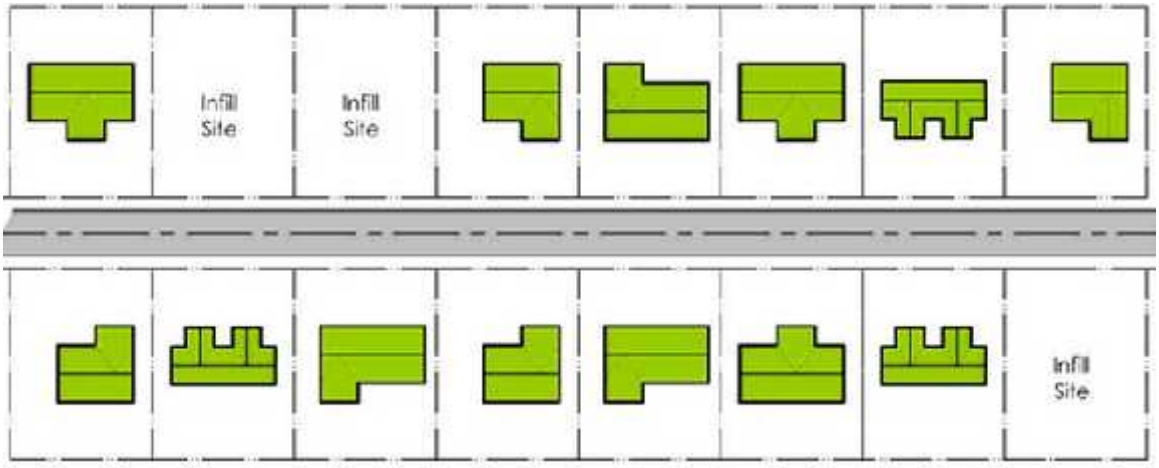


Fig 3.2 Infill development

- Redevelop brownfields

A brownfield site refers to previously developed land, which is or was occupied by a permanent structure.

Fig 3.3 Brownfield

- Priority Designation

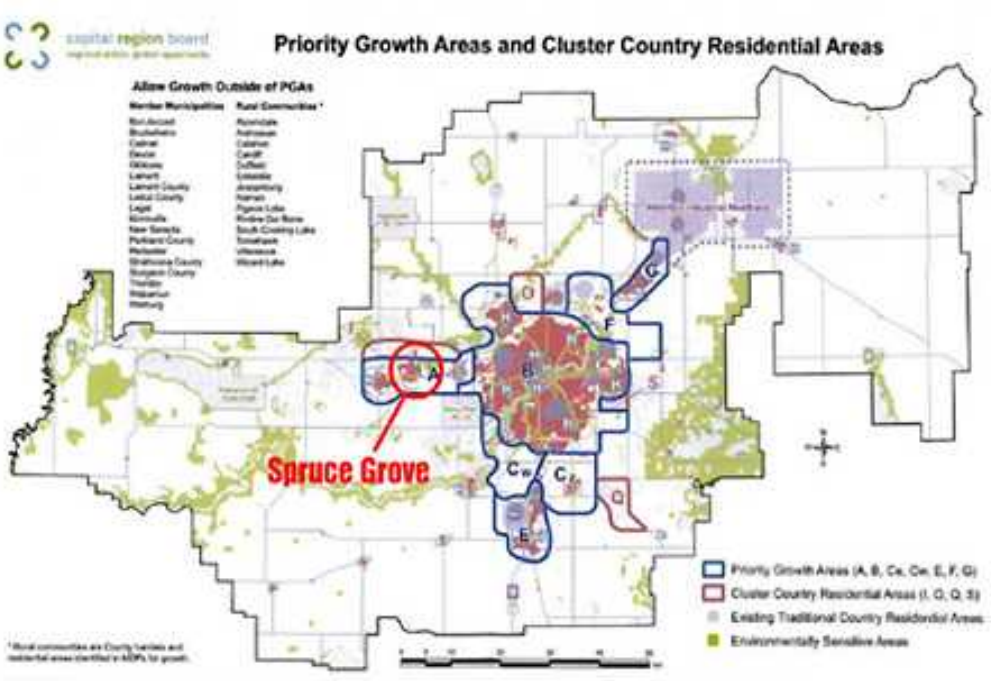


Fig 3.4 Priority Designation Map

Terminologies

Brownfield: Brownfield sites are contaminated or perceived to be contaminated sites. Brownfield sites require remediation prior to development. A site may be eligible for Brownfield redevelopment credit in any of the following cases:

a. Site declared as brownfield by government agencies
b. If the site is remediated by local voluntary cleanup programs
c. Contaminants are identified during environmental site assessment performed as per ASTM standards

Priority designations are the sites whose development is encouraged or supported by Government

3.3 Surrounding Density & Diverse use

Significance:

The intent of this credit is to

- To promote development in areas with existing infrastructure.
- To promote walk-ability and transportation efficiency
- Reduce vehicle distance traveled.
- Improve public health by encouraging daily physical activity

Strategies:

- LEED encourages high dense development. Land is a precious resource; high dense development has lesser building footprint thereby protecting greenfield sites and farmlands from development. Points are allotted based on density of project and surroundings within ¼ mile.

Fig 3.5 High dense development

- LEED encourages development with diverse use.
- A diverse use location shall have all day-to-day requirements like super market, restaurant, laundry, hospital, bank etc. within walking distance. Thiscan reduce automobile usage and increase physical activity of the occupants. Pointsare allotted based on number of diverse use spaces within ½ mile walking distance from project entrance.

este5dam motanawe3

Fig 3.6 Diverse use Map

-Food retail.
-Community serving retail.

-Services.
-Civic and community facilities.
-Community anchor uses

- Examples for diverse use given by LEED are
  - ✓ Bank
  - ✓ Church
  - ✓ Supermarket / convenience store
  - ✓ Day care
  - ✓ Dry cleaner
  - ✓ Fire station
  - ✓ Salon

- ✓ Hardware store
- ✓ Library
- ✓ Medical / dental office
- ✓ Park
- ✓ Pharmacy
- ✓ Post office
- ✓ Restaurant
- ✓ School
- ✓ Theatre / museum
- ✓ Community center
- ✓ Gym

3.4Access to quality transit

Significance:

The intent of this credit to:

E7tebas 7rary :Greenhouse gas

- Encourage development with transportation facilities.
- Reduce greenhouse gas emissions, air pollution, and other environmental and public health harms associated with automobileuse.

Strategies:

Select a site which has either access to rapid transit or bus stop.

- If the site has existing, planed orfunded train/metro station/bus terminal within ½ mile of pedestrian access it is said to have access to rapid transit.
- If the site have access to existing, planed orfunded bus stop, ride share, street car within ¼ mile of pedestrian access

3.5Bicycle facilities

Significance:

The intent of this credit is to:

- Promote bicycling and transportation efficiency
- Reduce vehicle distance traveled
- Improve public health by increased physical activity

Strategies:

- Select Site which has bicycle track

Fig 3.7 Bicycle Track

- In Residential Buildings, provide secure bicycle parking places
- In Commercial Buildings, provide secure bicycle parking places, showers and changing rooms

Fig 3.8 Bicycle Parking Places

3.6Reduced Parking footprint

Significance:

The intent of the credit is to minimize the environmental impact associated with parking facilitiesi.e.:

- Automobile dependence
- Land consumption
- Rainwater runoff

Strategies:

- Limit the number of parking to local zoning requirements
- If local zoning authority do not regulate parking, Institute of Transportation Engineering Handbook can be used

Fig 3.9 Limited number of parking

Terminologies

Local Zoning Authority: Agency which regulates open space requirement, building height, parking requirement and safety

requirements of building. In many cities, municipality acts as local zoning authority.

3.7 Green Vehicles

Significance:

Reduce pollution by promoting alternatives to conventionally fueled automobiles

Strategies:

- Provide preferred parking or discounted parking for carpool/low emitting (LE) and fuel efficient vehicles (FE).
- Preferred Parking -parking close to building entrance
- Discounted Parking - should be discounted at least 20%
- Provide fueling stations for LE/FE Vehicles

Terminologies

Low emitting vehicles are vehicles that are classified as zero emission vehicles (ZEV) by California air resource board (CARB).

Fuel efficient vehicles are vehicles which have achieved a minimum green score of 45 on the American Council for an Energy Efficient Economy (ACEEE) annual vehicle rating guide.

3.8 LEED for Neighborhood Development Location

Developing a site in LEED for ND is the best strategy which covers all the credits in this category and contributes to smart growth.

Smart growth is an urban planning and transportation theory that concentrates growth in compact walk-able urban centers to avoid urban sprawl.

- Advocates compact, transit oriented, walk-able, bicycle-friendly land use, including neighborhood schools, complete streets, and mixed-use development with a range of housing choices.

Fig 3.10 Smart growth principle

Summary

We have addressed

- Sensitive land protection
- High priority site
- Surrounding density and diverse uses
- Access to quality transit
- Bicycle facilities
- Reduced parking footprint
- Green Vehicles
- LEED for Neighborhood Development location

Have a Question in this chapter?

Discuss in our forum

Chapter 4 – Sustainable Sites

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Construction activity pollution prevention
- Site assessment
- Site development-protect or restore habitat
- Open Space
- Rainwater management
- Heat island reduction
- Light pollution reduction

4.1 Construction Activity Pollution Prevention

Construction activity pollution prevention is a pre-requisite in many rating systems.

Intent:

To reduce pollution from construction activities, the prerequisite mainly address erosion, sedimentation & airborne dust generation

Significance:

- Erosion results in loss of topsoil.
- Top soil is rich in biological nutrients and organic matter, which supports plant life.

- Loss of topsoil reduces the capacity of the site to support plantation. This may further increase the fertilizer requirement for the landscape thereby making more damage to the environment.
- Storm water run-off from the construction site is rich in contaminants because of construction materials and causes water pollution
- Erosion due to wind pollutes the air with particulate matter and suspended particles which results in respiratory problems for humans

Strategies:

Project team should prepare and implement a comprehensive Erosion and Sedimentation Control (ESC) plan complying with *EPA 2012 Construction General Permit, National Pollutant Discharge Elimination Scheme or applicable local standards*whichever is stringent.

Following are the potential strategies the project team can incorporate.

4.1.1 Stock Piling: Topsoil is removed from the site and piled in safe place, replaced by free drain gravel and finally restored after the construction.

Other Erosion and Sedimentation Control (ESC) strategies can be classified into **Stabilization strategies** and **Structural strategies.**

4.1.2 Stabilization Strategies

Temporary Seeding: Plant fast growing grasses to temporarily stabilize the soil.

Permanent Seeding: Plant grass, trees and shrubs to permanently stabilize the soil.

Mulching: Mulching is the process of spreading material like sawdust, straw, hay, grass, wood chips or gravel over the topsoil to stabilize it.

Fig 4.1 Mulching done in Walkway of a construction site

4.1.3 Structural Strategies:

Silt fencing: Construction post with fabric filter media to remove sediments from storm water run-off.

Fig 4.2 A typical Silt Fence in a construction site

Sediment Traps:A cavity where sediments from storm water are allowed to settle down.

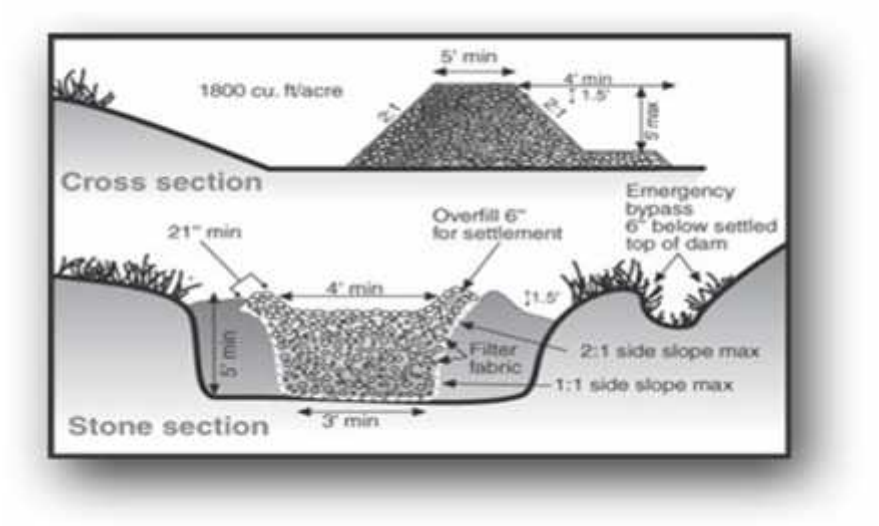


Fig 4.3 A typical section of Sediment trap

Sediment Basins: Similar to sediment traps but bigger in size. A pond with controlled water release structure to allow settling of sediments from the run-off.

Fig 4.4 A Sediment basin in a construction site

Earth Dikes: Construct a mound of stabilized soil to divert the run-off through the desired direction (ideally through sediment traps and basins).

Fig 4.5 A typical Earth Dike

Terminologies:

Erosion: Erosion is the process by which solid particles on the surface (soil and stones) are moved. Erosion in construction site happens because of storm water run-off, wind, foot traffic, construction vehicle traffic, steep slopes etc.

Storm water run-off: The storm water that flows out of the project site boundary through the surface is called as storm water run-off.

Sedimentation: Sedimentation is the process of addition of solid particles in water bodies. Sedimentation decreases the water quality and affects the aquatic life.

References/Standards:

a. EPA 2012 Construction General Permitb. Applicable Local standards

4.2 Site Assessment

Intent:

To assess site conditions before design to evaluate sustainable options.

Significance:

- Site Assessment identifies both
    - Favorable conditions such as favorable climate conditions, good solar access, and healthy plant populations
    - And liabilities, such as unhealthy soils, blighted structures, pollution sources, steep slopes, and extreme climate patterns.
- A site assessment informs good design decisions, such as appropriate plants for landscape, orienting buildings to take advantage of prevailing winds and solar access and optimizing the location of rainwater management features.
- A well-developed assessment conducted before or during the conceptual design phase may reduce project costs and risks, promote occupants' health, and honor a site's unique characteristics.

Strategies:

Conduct a Site Assessment Considering

- ***Topography:*** Contour mapping, unique topographic features, slope stability risks.
- ***Hydrology:***Flood hazard areas, delineated wetlands, lakes, streams, shorelines, rainwater collection and reuse opportunities,
- ***Climate:*** Solar exposure, heat island effect potential, seasonal sun angles, prevailing winds, monthly precipitation and temperature ranges.

- ***Vegetation:***Primary vegetation types, greenfield area, significant tree mapping, threatened or endangered species, unique habitat, invasive plant species.
- ***Soil:*** Natural Resources Conservation Service soils delineation, U.S. Department of Agriculture prime farmland, healthy soils, previous development, disturbed soils (local equivalent standards may be used for projects outside the U.S.).
- ***Human use:***Views, adjacent transportation infrastructure, adjacent properties, and construction materials with existing recycle or reuse potential.
- ***Human health effects:*** Proximity of vulnerable populations, adjacent physical activity opportunities, proximity to major sources of air pollution.

4.3 Open Space & Site Development – Restoring Habitat

Intent:

- Create exterior open space that encourages interaction with the environment, social interaction, passive recreation, and physical activities.
- To conserve existing natural areas
- Restore damaged areas
- To promote habitat and promote biodiversity.

Strategies:

- Reduce the building footprint. Achieve the required gross floor area by increasing the number of floors.
- Reduce the hardscape area and increase the open space

- Restrict the disturbance during the construction process within a minimum area from the development footprint.
- Restore all disturbed or compacted soils that will be re-vegetated within the project's development footprint.
- Preserve the undisturbed greenfield area.
- Use native or adaptive vegetation.
- Increase the open space of the project beyond the zoning(municipality or corporation) requirements.

Terminologies:

Native Plants: Native plants are plants that have developed naturally in a geological location for many years.

Adaptive Plants: Adaptive plants are not native for a particular geological location but can be adapted in the location without significant use of fertilizers, pesticides or irrigation requirements.

Invasive plants: Invasive plants are not native for a particular geological location and require significant effort in maintaining them.

Use of native or adaptive plants is a good practice in Green buildings. Invasive plants should always be avoided.

Building footprint: Building footprint is the area of the project site used by the building structure, defined by the perimeter of the building plan. Landscape, access roads, parking lots and non-building facilities are excluded from the building foot print.

Development footprint: Development foot print includes all the area affected because of the development of the building. It includes building

footprint, hardscape, access roads, parking lots and non-building facilities within the project site area.

Heat Island Effect: Heat island effect is the thermal gradient between urban and nearby rural areas. Heat island effect is discuss in detail under section **4.5**.

Open Space: Project site area- development footprint = Open Space Vegetated Roof can be counted for the credit calculation if the project satisfies the requirement for the credit Development Density & Community Connectivity.

4.4Rainwater Management:

There are two criteria in this credit:

Quantity Control– Controlling the velocity and volume of run-off from the project site.

Quality Control– Controlling the pollutants and contaminants from the run-off.

Intent:

- To reduce runoff volume
- Improve water quality by replicating the natural hydrology and water balance

Significance:

- In many cities storm water and sewage treatment are combined. Sewage treatment is an energy intensive process, when storm

water mixes with sewage it overloads the sewage treatment plant and consume more energy.

- Storm water run-off from hardscape areas, industrial areas, fertilized landscape etc., are rich in contaminants and hence pollutes receiving water streams.
- Reducing storm water run-off helps maintain the natural aquifer recharge cycle.
- Storm water run-off from fertilized land results in Eutrophication

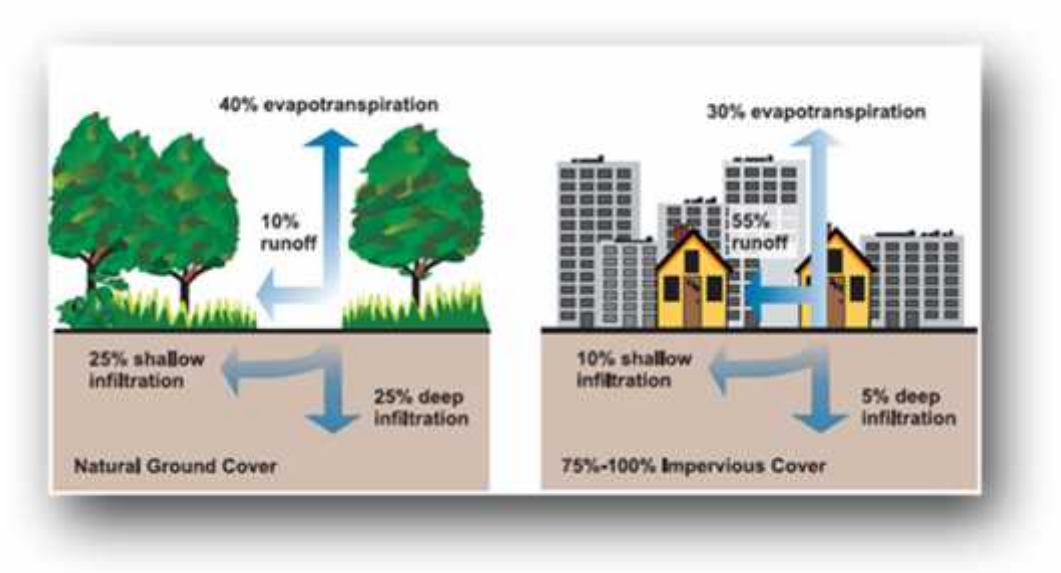


Fig 4.6 Impact of development on storm water runoff

Strategies:

- Reduce impervious area and increase infiltration. Cluster developments to reduce paved surfaces such as roads and sidewalks.
- Rainwater harvesting. Treated storm water can be used for irrigation and toilet flushing.
- Use pervious paving materials.
- Use vegetated roof, vegetated filter strips, bioswales, retention ponds.

Terminologies:

Aquifer: An aquifer is underground water bearing permeable rock from where underground water can be extracted usefully.

Impervious Surface: Surfaces that have less than 50% of perviousness and promotes storm water run-off instead of infiltrating into the sub-surface.

Rain Gardens:A rain garden is a planted depression that allows rainwater run-off from impervious urban areas like roofs, driveways, walkways, parking lots, to be absorbed.

Fig 4.7 A typical Rain Garden

Eutrophication: Eutrophication is the enrichment of inorganic plant nutrients (e.g. nitrate, phosphate) in fresh water bodies. It may occur naturally but can also be the result of human activity (cultural eutrophication from fertilizer run-off and sewage discharge).

Fig 4.8 An indicative example for Eutrophication

Vegetated Filter Strips: Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat flow from adjacent surfaces. Filter strips function by slowing run-off velocities and filtering out sediment and other pollutants and by providing some infiltration into underlying soils.

Retention Ponds/Sediment Basins: Retention ponds or sediment basins stores the storm water run-off temporarily and release it at very less velocity provide sufficient time for the sediments to settle down and storm water to infiltrate.

Bioswales: Bioswales are landscape elements designed to remove silt and pollution from surface run-off water. They consist of a swaled drainage course with gently sloped sides (less than six percent) and filled with vegetation, compost and/or riprap.

Fig 4.9 Anindicative example ofBioswale

Pervious Paving/Open Grid Paving: Pervious paving materials allow water to infiltrate as compared to impervious surfaces. There are variety of pervious paving materials available in the market.

Fig 4.10 An indicative example of pervious paving

Reference Standards: None

4.5Heat Island Reduction

Intent:

- To minimize effects of microclimates on human and wildlife habitats by reducing heat islands.

Significance:

- Heat island effect is the thermal gradient between urban and nearby rural areas
- Rural area experiences comparatively lesser temperature because of cooling effect evapotranspiration from plants. Whereas in urban areashardscape surfaces absorbs radiation, stores it and emit back to the atmosphere with a time delay. This contrast between urban and rural areas results in heat Island effect. Heat Island increases the temperature in urban area compared to the

nearby rural area from 2 to 10° F. This increases the heat gain of the building resulting in a bigger HVAC equipment and higher energy consumption.

- Increase in temperature because of heat island also affects the site habitat.

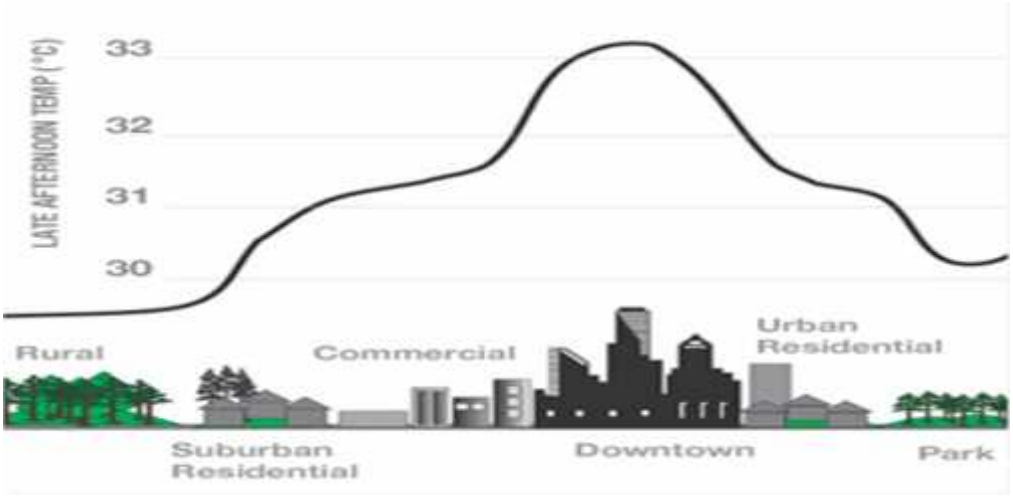


Fig 4.11 Impact of Urban Heat Island Effect

Strategies:

- Reduce impervious surface area.
- Use vegetated roof.
- Use high SRI coating materials in impervious surfaces.
- Provide underground parking to reduce the impervious area due to parking lot and drive ways.
- Shade hardscape area with trees, canopies etc.
- Use open grid pavement with at least 50% pervious.

Terminologies:

Solar Reflectance or Albedo: Solar Reflectance or Albedo is the measure of ability of a surface to reflect solar radiation.

Solar Reflective Index (SRI): Solar Reflective index is the measure of a materials ability to reject. Higher the SRI value, lower the heat island effect.

SRI is calculated based on Reflectance (reflectance) and emittance(emissivity). For a material to have a higher SRI both reflectance and emittance should be high.The table below summarizes Reflectance, Emittance and their influence in SRI of typical Construction Materials

SRI values for Solar Infrared Temperatures	Solar Reflectance	Infrared Emittance	SRI
Gray EPDM	0.23	0.87	21
Gray Asphalt Shingle	0.22	0.91	22
PVC White	0.83	0.92	104
White coating, 2 coats, 2 mils	0.85	0.91	107
Source: Lawrence Berkeley National Laboratory Cool Roofing Materials Database. These values are reference only and are not for use as substitutes for actual manufacturer data			

4.6Light Pollution Reduction

Intent:

- To increase night sky access, improve nighttime visibility, and reduce the consequences of development for wildlife and people.

Significance:

- Excess light comes at the cost of energy.

- Light trespass may cause sleep deprivation or may block an evening view in one's property.
- Light clutter may cause accidents.
- Light pollution disturbs nocturnal life of habitats.
- Sky glow disturbs the night sky view for astronomers.

Strategies:

- Use timers, occupancy sensors and daylight sensors to switch off unnecessary lights.
- Comply with the light trespass requirements of Illuminating Engineering Society and International Dark Sky Association (IES/IDA)
- Control light trespass from transparent surfaces by proper positioning and selection of lighting fixture or automatically closing the transparent openings after specified time.
- Use full cut-off fixtures in external lighting. Full cut-off fixtures reduce the chance of light to escape above the horizontal plane and hence reduces sky glow.

Terminologies:

Light Pollution: Light pollution is the alteration of light levels in the outdoor environment (from those present naturally) due to man-made sources of light.

Light trespass: Light trespass occurs when unwanted light enters one's property, for example, by shining over a neighbor's fence.

Light clutter: Light clutter refers to excessive groupings of lights. Groupings of lights may generate confusion, distract from obstacles

(including those thatmay be intended to illuminate), and potentially cause accidents.

Skyglow: Skyglow refers to the glow effect due to excess external light that can be seen over populated areas.

Lighting Power Density: Lighting Power Density (LPD) is measured in w/sq.m or w/sq.ft. It is the measure of power input per unit floor area for lighting.

Reference Standards:

Illuminating Engineering Society and International Dark Sky Association (IES/IDA).

4.8YouTube Video References:

- Eutrophication Animation: http://youtu.be/6LAT1gLMPu4
- Heat Island Effect & Cool Roofs: http://youtu.be/urbpBy_Z5lE
- Vegetated Roof/Green Roof: http://youtu.be/pp79mGpomf4
- Light Pollution: http://youtu.be/UdlGJNVUwmE

Summary

We have addressed

- Construction activity pollution prevention
- Site assessment
- Site development-protect or restore habitat
- Open Space
- Rainwater management
- Heat island reduction
- Light pollution reduction

Have a Question in this chapter?

Discuss in our forum

Chapter 5– Water Efficiency

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Outdoor water use reduction
- Indoor waste use reduction
- Building-level water metering
- Cooling tower water use
- Water metering

Intent:

The overall intent of this category is to

- Protect natural water resources
- Reduce the demand on municipal water supply systems
- Reduce the load on sewage treatment system
- Reduce the energy usage of buildings by reducing the load on water heating and pumping systems

5.1 Water Efficient – Landscaping

Significance:

- Landscape irrigation practices consume large quantities of potable water.

- Improved landscaping practices can dramatically reduce and even eliminate irrigation needs.
- Native or adaptive plants require less fertilizer and pesticides hence minimizes water quality degradation and other negative environmental impacts.
- Water-efficient landscaping helps conserve local and regional potable water resources.

Strategies:

- Water consumption for irrigation depends
    - Species factor (nature of plants):Species factor can be low, moderate or high. Plants with less species factor consumes less water and vice versa.
    - Irrigation Efficiency
    - Microclimate: Microclimate refers to the climate particular to the site.
    - Plantation density
- Consider Xeriscaping.Xeriscaping/xerogardening refers to landscaping that does not require permanent irrigation system. Irrigation system can be removed for such landscapes after 1 year.
- Native and Adaptive plants tend to consume less water compared to invasive plants. Consider use of native and adaptive plants in the landscape.
- Use efficient irrigation system. Drip irrigation has better efficiency compared to sprinkler.

- Reduce turf/grass area. Grass/turf requires more maintenance and consumes more water.
- Use intelligent controls in irrigation system such as controlling the irrigation with moisture sensors or weather based controllers etc.
- Use non potable water sources like treated grey water, treated storm water etc. for irrigation.
- Install sub meters to help operators manage water consumption and identify problemswithin the system.

Strategies in Operation and Maintenance Practices

- Schedule a routine maintenance for irrigation equipment. For instance if the nozzles of the sprinkler is blocked, water will not be directed to the target. It will run into hardscape areas. If grey water is used there may be a risk of grey water getting contact with human skin.
- Maintain an optimum height of lawns. If they are too short, the roots are exposed to sun which will increase the rate of evaporation.Do not dispose the clippings of the landscape.
- Consider using the landscape waste as mulch or biofertilizer. Mulch shall provide nutrients to the plants and at the same time shall reduce the water loss by evaporation

Terminologies:

Potable Water: Water with acceptable quality to drink.

Black Water: Definition of black water varies with different plumbing codes but wastewater from toilets and urinals is always considered black water.

Wastewater from kitchen sinks are classified as black water in many plumbing codes.

Grey Water: Grey water is defined by the Uniform Plumbing Code (UPC) as untreated wastewater that has not come in contact with toilet waste. This includes water from showers, sinks, bathtubs, washbasins and clothes washers.

Irrigation Efficiency: The amount of water (expressed as a percentage) used in irrigation that does not get evaporated.

The irrigation efficiency of drip irrigation (90%) is higher than that of sprinkler system (65%).

Base Case Consumption: Base case consumption is calculated based on standard practice of irrigation.

Design Case Consumption: Design case consumption is calculated based on actual design practice. To demonstrate water efficient landscaping project teams should prove that the water consumption in design case is less than that of base case.

Base case and design case water consumption for irrigation is calculated using EPA Water Sense water budget tool

30% water use reduction in design case water consumption over basecase is a prerequisite.

5.2 Water Efficiency – Indoor

Significance:

- Protect natural water resources.
- Reduce the load on municipal water supply and sewage treatment plants. Sewage treatment is highly energy intensive process compared to conventional water supply system.
- Increase energy efficiency within the building by reducing the load on water heating and pumping systems.

Strategies:

S.No	Description	Baseline water flow rate	Strategies
1	Toilets	1.6 gpf	High Efficient Toilets(1.28 gpf), Dual flush toilets, Composting toilets, treated grey water for flush
2	Urinal	1 gpf	Low flow urinals(0.5 gpf), waterless urinals, treated grey water for flush
3	Showers	2.5 gpm	Low flow shower 1.8 gpm or less
4	Faucets - Private	2.2 gpm	Low flow faucets 1.5 gpm or less
5	Faucets-commercial	0.5 gpm	
6	Kitchen Sink	2.2 gpm	Low flow faucet 1.5 gpm or less

- Use Energy Star or Water Sense certified appliances and plumbing fixtures
- Treat the waste water onsite to tertiary levels and reuse it or infiltrate it to reduce the load on sewage treatment plant.

Note: 20% water use reduction is a prerequisite. Hence projects should use fixtures efficient than EP Act requirements.

Strategies in Operation and Maintenance Practices

- Consider retrofitting existing faucets, showers with water efficient aerators and shower heads
- Consider retrofitting older leaky flush valves with efficient ones.
- Monitor and track water consumption periodically

Terminologies:

Gallons Per Minute: Gallons Per Minute (GPM) is the unit of flow rate measurement for flow fixtures like faucets, showers.

Gallons Per Flush: Gallons per Flush (GPF) is the unit of flow rate measurement for flush fixtures such as WCs and Urinals.

1 US Gallon =3.78 liters.

Baseline water consumption: Baseline water consumption is water consumed in the proposed project considering standard practices are followed in the project.

For water efficiency in indoor, the standard consumption is calculated based on Energy Policy Act 1992.

Baseline water consumption depends on occupancyof the project and base line flow rates of the fixtures.

Design Case Water consumption: Design case water consumption is the calculated water consumed in the project considering actual performance of the fixtures. Design case water consumption depends on FTE of the project, actual flow rates of the fixtures used in the project and not potable water used in the project (example treated grey water or treated storm water for toilet flush).

Metering Faucets: Metering faucets dispense water for a pre-determined period of time and deliver a pre-defined volume of water.

Non water (or composting) toilet systems: Non water (or composting) toilet systems are dry plumbing fixtures and fittings that contain and treat human waste via microbiological processes.

Non water (or dry) urinal: A non-water (or dry) urinal, replaces water flush with a trap containing a layer of buoyant liquid that floats above the urine, blocking sewer gas and odors.

Dual flush Toilets: Dual flush toilets have two buttons one for half flush and the other for full flush depending on the requirement. Dual flush toilets can save around 2/3rd of water used for flushes.

Water sense: Water sense is a third party certification for water efficient faucets, showers and water closets.

Reference Standard:

EPAct 1992: U.S. act addresses energy and water use in commercial, institutional, and residential facilities.

EPAct 2005: became U.S. law in August 2005.

Uniform Plumbing Code: Developed by IAPMO, defines water-conserving fixtures and fittings for water closets, urinals, and metered faucets.

International Plumbing Code: Developed by International Code Council, IPC defines maximum flow rates and consumption for plumbing fixtures and fittings, including public and private lavatories, showerheads, sink faucets, urinals, and water closets

5.3 Cooling Tower Water use

Strategies:

- No once through cooling equipment
- Use non potable water
- Maintain higher cycles of concentration.
- Submeter & Monitor water consumption

5.4Building Level Metering & Sub metering

- Building level metering is a prerequisite. Projects should have sub-meter for indoor water use, irrigation water use, cooling tower etc. to earn credit
- Project should commit to share water consumption data with USGBC for 5 years

Summary

We have addressed

- Outdoor water use reduction
- Indoor waste use reduction
- Building-level water metering
- Cooling tower water use
- Water metering

Have a Question in this chapter?

Discuss in our forum

Chapter 6 – Energy & Atmosphere

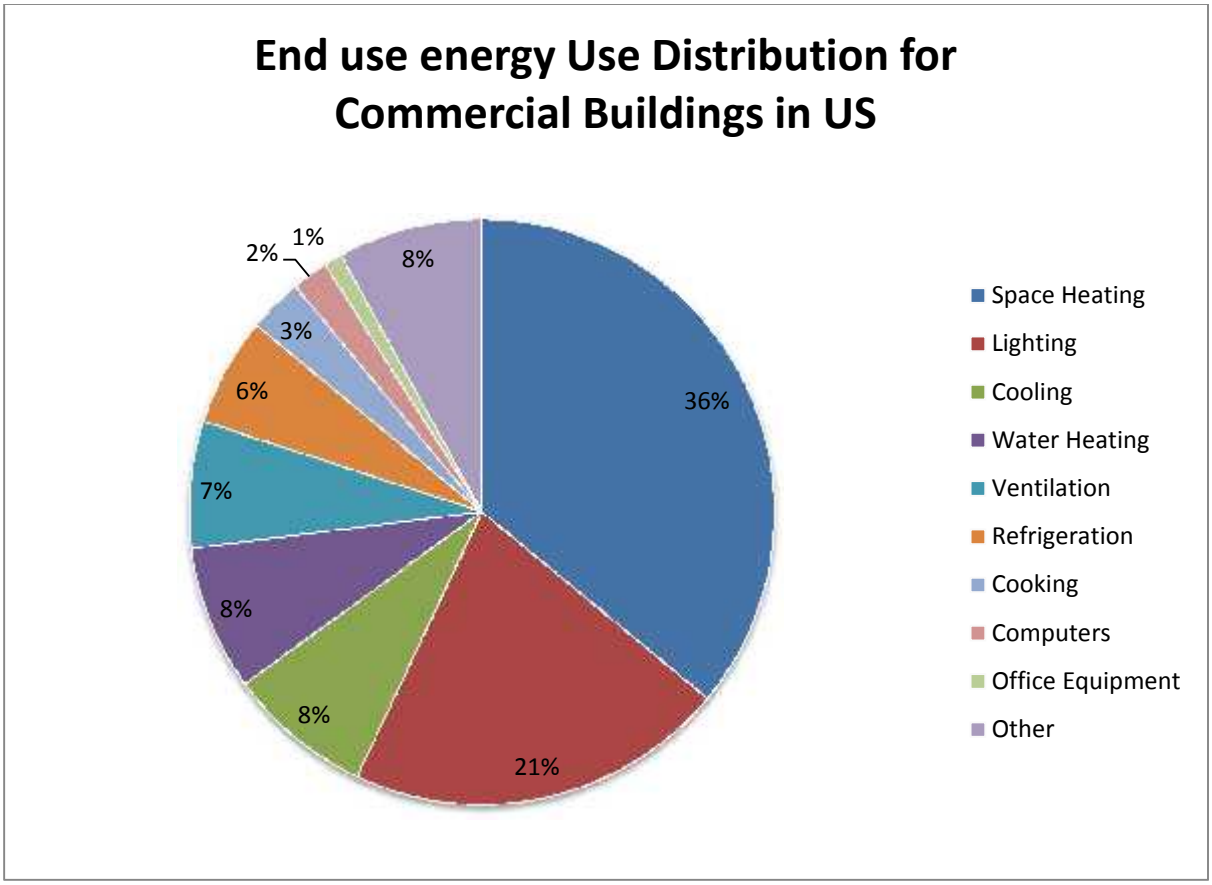
Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Fundamental & Enhanced commissioning and verification
- Minimum & Optimize energy performance
- Building-level & Advanced energy metering
- Fundamental & Enhanced refrigerant management
- Demand response
- Renewable energy production
- Green power and carbon offsets

Introduction

Buildings are the major consumers of Energy. The following chart provides the details of end use energy distribution for buildings in US.



6.1 Minimum & Optimize Energy Performance

LEED gives significant importance to Energy Efficiency and address them as follows:

1. Minimum Energy Performance – Prerequisite.
2. Optimize Energy Performance – Credit (Offers Maximum number of points in most rating system).

Intent (Minimum Energy Performance):

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

Intent (Optimize Energy Performance):

To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use.

Significance:

- Energy directly related to Global warming
- Pollution to air, water and soil
- Depletion of resources
- Contributes to acid rain & smog

Strategies:

Minimum Energy Performance:

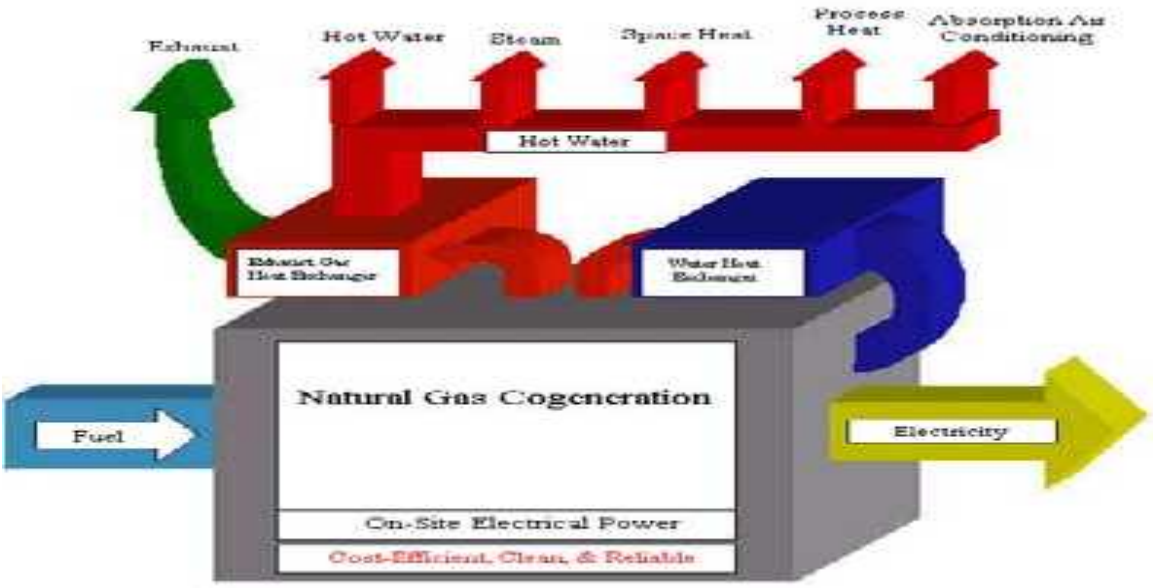
1. The Energy Performance of new buildings should be atleast 5% better than ASHRAE 90.1 2010 requirements.
2. Existing buildings can evaluate their energy performance by using energy star portfolio manager. To qualify for LEED EB O&M Certification buildings should score a minimum of 69 in energy star.

Optimize Energy Performance: Projects can earn points under optimize energy performance if the energy performance of the building is beyond the requirements of minimum energy performance. Projects can improve the energy performance by following strategies.

1. **Proper orientation of the building:**
    - Optimize day light and heat gain/heat loss
    - Glazing in appropriate direction to maximize day light and minimize heat gain/loss

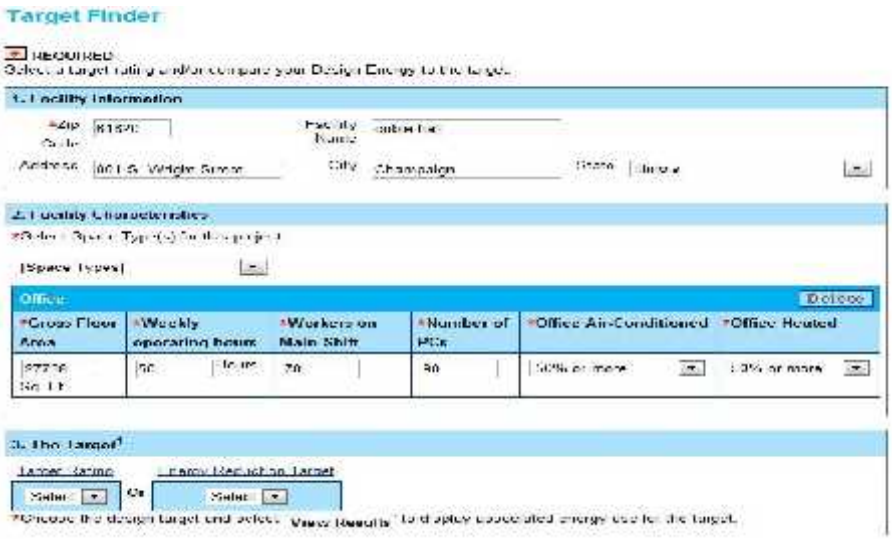
- Utilize shading of adjacent structures
- Optimize window the wall ratio

2. **Optimized Building Envelope:**
    - Optimize U (heat transfer coefficient) value for windows, external wall and roof by selecting appropriate insulation.
    - Optimize Solar Heat Gain Coefficient of the glazing.
3. **Efficient HVAC equipment and pumping system:**
    - Select HVAC equipment with higher Coefficient of Performance(COP)/Energy Efficiency Ratio(EER)
4. **Efficient Lighting:**
    - Efficient Lighting – LPD not to exceed ASHRAE 90.1- 2010
5. **Passive technologies:**
    - Consider passive technologies like day lighting, night venting, natural ventilation, geo thermal heat pump etc.
6. **Efficient Controls:**
    - Occupancy sensors.
    - Daylight sensors.
    - Demand control ventilation.
    - Shading controls.
    - Programmable thermostats.
7. **Cogeneration/Combined Heat and Power** is the use of a heat engine or power station to simultaneously generate electricity and useful heat. Cogeneration increases the thermodynamic efficiency compared to separate heat and power generation.



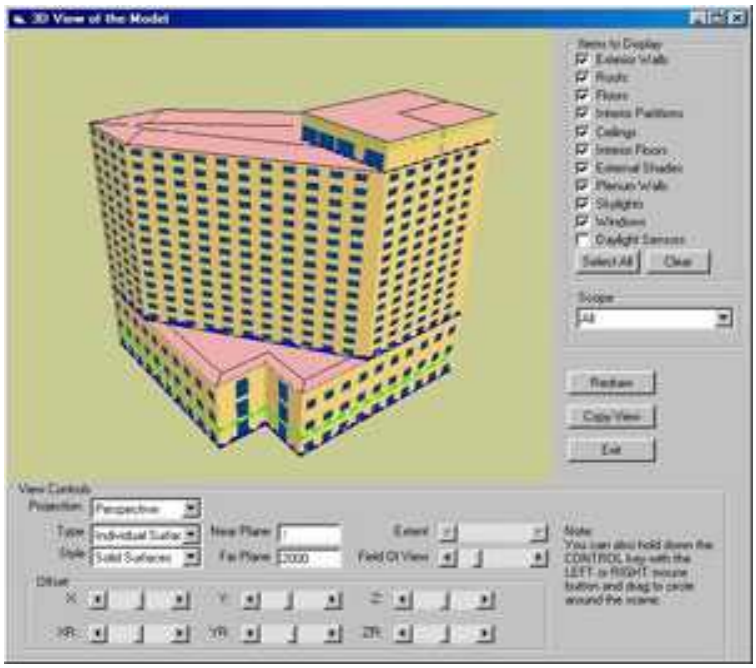
Tools used in Energy Efficiency

1. **EPA Energy star target finder** is a no-cost online tool that enables architects and building owners to set energy targets during design stage



2. **Energy Modeling** is used to evaluate cost and benefit of various energy conservation measures. The project team shall run an Energy Model (computer simulation) using ASHRAE 90.1 2010 standard as baseline and

as designed building as Design Case. Points will be awarded based on the percentage improvement of energy performance of design case over the base case.

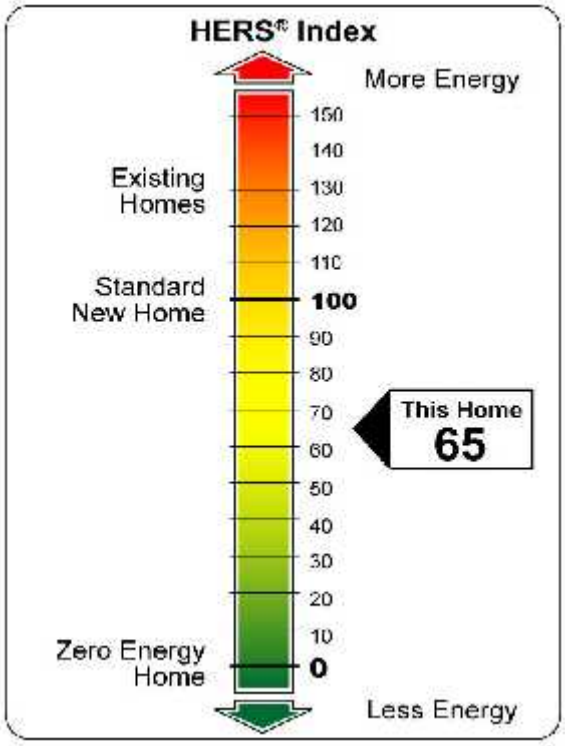


3. **EPA Energystar Portfolio Manager** is an Interactive online tool to record and track the energy and water consumption of a building or group of buildings.Portfolio Manager can help Facility Managers/ Building owners identify underperforming buildings andmake investment decisions. Projects that earn a score of 75 or higher may be eligible for ENERGY STAR certification

   Note: Energy star target finder is used to set design targets & Portfolio manager is used for tracking existing buildings performance

4. **HERs: Rating to evaluate energy efficiency in homes**

- The Home Energy Rating System (HERS) Index developed by RESNET (Residential Energy Services Network) is the INDUSTRY STANDARD by which a home's energy efficiency is measured.
- Lower the index better the efficiency
- HERS Index 65 means the home is 35 % more efficient compared to a new standard home



Standards & References:

ASHRAE 90.1 2010 – Standard for Energy Efficiency Except low rise residential building

6.2 Renewable Energy

Intent:

To reduce the environmental and economic harms associated with fossil fuel energy by increasing self-supply of renewable energy.

Significance:

- Energy production from traditional sources (such as coal, natural gas, and other fossil fuels) contributes to emissions such as oxides of sulfur, oxides of nitrogen, carbon dioxide, carbon monoxide etc. These pollutants are primary contributors to acid rain, smog, and climate change.
- The pollutants have widespread and adverse effects on human health, especially respiratory health.
- Using renewable energy generated either on-site or off-site is an excellent way for owners to reduce the negative environmental impacts associated with a building's energy requirements.
- Renewable energy has a positive impact on rural communities in particular; sitting and operating wind farms and biomass conversion facilities in rural areas enhances economic development.

LEED addresses renewable energy in two credits

1. **Onsite Renewable Energy**– Energy generated within the site. **Example:**Solar Water heater, Solar Photovoltaic cell, Wind turbine etc.
2. **Green Power and Carbon Offsets**– Green Power is renewable energy purchased from utilities or service providers.

The following energy sources are considered renewable:

- Photovoltaic Cells.

- Wind Energy.
- Solar Thermal Energy systems (solar hot water systems, solar powered absorption chillers).
- Geothermal Power (deep earth power generation).
- Low impact hydro-electric power.
- Tidal Energy.
- Energy from Biomass or biogas or biofuel (agricultural waste, animal waste, wood residue, Landfill gas etc.).

LEED does not consider the following as renewable energy:

- Fossil Fuel.
- Nuclear Energy (Hazards due to radiation).
- Conventional Hydro Power Plant (it disturbs aquatic life).
- Passive Technologies like Day lighting, geothermal heat pump (these can be considered in optimizing energy performance).
- Energy from forestry biomass (causes deforestation).
- Energy from wood coated with paints or coatings (because of potential contaminants).
- Energy by burning municipal waste (because of potential contaminants).

Terminologies:

Green E: Green E energy is a voluntary certification and verification program for renewable energy products.

Renewable Energy Certificates (RECs): Renewable energy certificates are tradable commodities representing proof that a unit of electricity was generated from renewable energy sources.

Strategies:

Onsite Renewable Energy: Renewable energy generated within the project can earn Onsite Renewable Energy Credit.

Green Power and Carbon Offsets:

Projects can earn this credit by adapting one of the three compliance path:

- **Case 1:**In Open electricity market, the consumer can choose for a utility provider who supplies Green E Certified Power
- **Case 2:**In closed electricity market, the utility provider has an option for Green E certified Power.
- **Case 3:**In closed electricity market if the utility provider does not have an option for Green E certified Power, the consumer can purchase Green E accredited Renewable Energy Certificates (REC's)to offset their power consumption from conventional sources.

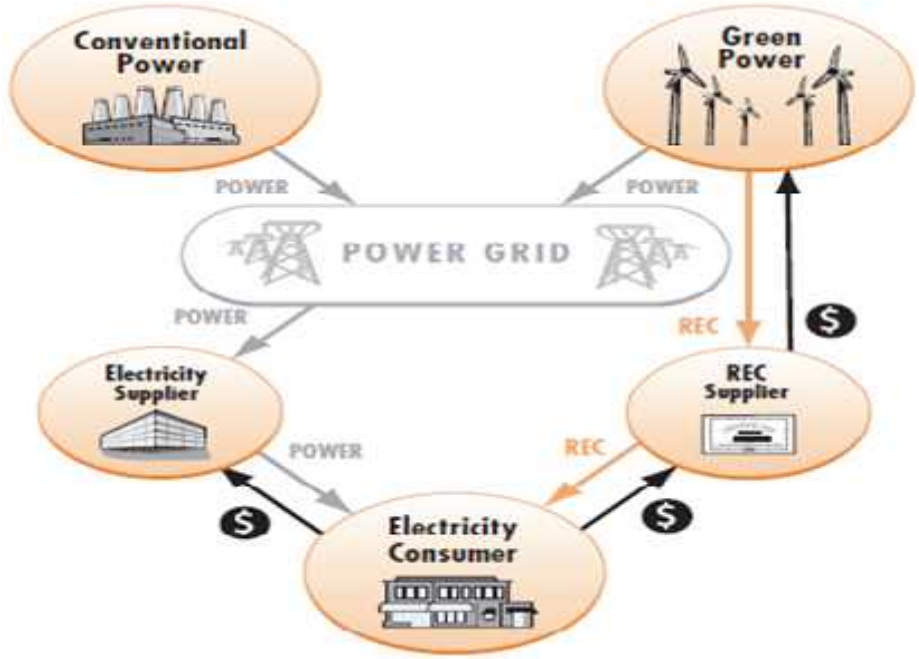


Fig 6.1 Conventional Power Vs Green Power

Fig 6.2 Sample Renewable Energy Certificate

Reference & Standards:

- Green E

6.3 Refrigerant Management

Intent:

To reduce stratospheric ozone depletion.

Intent:

To reduce ozone depletion and support early compliance with the Montreal Protocol while minimizing direct contributions to climate change.

Evolution of Refrigerants:

Natural Refrigerants:

Air, CO2, H20, ammonia (NH3) and Hydrocarbons (Propane, butane etc) are examples of natural refrigerants. These refrigerants are environmentally good but had some disadvantages.

- Air, CO2, H20 has poor refrigerant properties.
- Ammonia is toxic in nature.
- Hydrocarbons are explosive in nature particularly at high pressure.

ChloroFlouro Carbons (CFC): Example R11, R12

They have excellent refrigerant properties but have very high Ozone depleting potential and hence Montreal Protocol has decided to phase out CFC production from 1996 and derivatives of CFC are phased out by 2010.

Hydro ChloroFlouro Carbons (HCFC): Example: R22, R123

CFC's are replaced by HCFC's. Chlorine which is responsible for damaging the ozone layer is partially replaced by hydrogen atoms. Environmental impact of HCFC's is lesser than CFCs but still has an impact.

Montreal protocol has targeted to phase out HCFC's by 2030.

HFC (Hydro Fluoro Carbons): Example: R143, R407c, R410a

HFC's are replacement of HCFC's. As HFC's are chlorine free, it has zero Ozone Depleting Potential but has a Global Warming potential. Most of the air-conditioning manufacturers are presently using HFC as the refrigerants.

Chlorofluorocarbons	ODP	GWP	Common Building Applications
CFC-11	1.0	4,680	Centrifugal chillers
CFC-12	1.0	10,720	Refrigerators, chillers
CFC-114	0.94	9,800	Centrifugal chillers
CFC-500	0.605	7,900	Centrifugal chillers, humidifiers
CFC-502	0.221	4,600	Low-temperature refrigeration
Hydrochlorofluorocarbons			
HCFC-22	0.04	1,780	Air-conditioning, chillers
HCFC-123	0.02	76	CFC-11 replacement
Hydrofluorocarbons			
HFC-23	~ 0	12,240	Ultra-low-temperature refrigeration
HFC-134a	~ 0	1,320	CFC-12 or HCFC-22 replacement
HFC-245fa	~ 0	1,020	Insulation agent, centrifugal chillers
HFC-404A	~ 0	3,900	Low-temperature refrigeration
HFC-407C	~ 0	1,700	HCFC-22 replacement
HFC-410A	~ 0	1,890	Air conditioning
HFC-507A	~ 0	3,900	Low-temperature refrigeration
Natural Refrigerants			
Carbon dioxide (CO_2)	0	1.0	
Ammonia (NH_3)	0	0	
Propane	0	3	

Table 6.1 Summary of GWP & ODP of various refrigerants

Environmentally preferable of Refrigerants:

- No refrigerants at all (Natural Ventilation)

- Natural Refrigerants
- HFC
- HCFC

LEED Requirements on Refrigerants:

Fundamental Refrigerant Management (Prerequisite)

In new buildings:

- No CFCs

Major Renovation:

- No CFCs or
- Phase-out CFC before completion of the project

Existing buildings O&M:

- No CFCs or Phase-out within 5 years or
- Prove that replacement of CFC's are commercially not feasible(provide third party certificate that simple payback period of replacement would be more than 10 years) and Reduce the leakage rate of CFC based refrigerants to 5% or less using EPA Clean Air Act Procedures.

Enhanced Refrigerant Management:

- No hallons, CFC and HCFC in fire suppression system.
- Reduce overall environmental impact caused by refrigerants by
  - ✓ Select zero ODP refrigerants and refrigerants with lesserGlobal warming potential.
  - ✓ Reduce the leakage rate of refrigerants.
  - ✓ Select equipment with higher life.

- ✓ Select equipment which can operate at lower pressure

Terminologies:

CFC: Chloroflouro carbons.

HCFC: Hydro Chloroflouro carbons.

HFC: Hydro Flouro Carbons.

Montreal Protocol: International treaty to prevent damage of ozone layer.

GWP: Global Warming Potential.

ODP: Ozone Depleting Potential (considered more dangerous than Global warming).

Hallons: Material used in fire suppression system which has ozone depleting property.

Standards & References:

Montreal Protocol: International treaty on protection of ozone layer.

EPA Clean air act– Reduce the leakage rate of CFC's to less than 5% by EPA clean air act.

6.4 Fundamental & Enhanced Commissioning

Intent (Fundamental):

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

Intent (Enhanced):

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

Significance:

- Facilities that do not perform as intended may consume significantly more resources over their lifetimes than they should. Commissioning can minimize the negative impacts buildings have on the environment by helping verify that buildings are designed and constructed to operate as intended and in accordance with the owner's project requirements.
- Improved occupant well-being and productivity are other potential benefits when building systems function as intended. Proper commissioning of building systems can reduce employee illness, tenant turnover and vacancy, and liability related to indoor air quality and it can avoid premature equipment replacement.

Strategies:

Designate a Commissioning Authority for the project to lead the commissioning process; the scope of commissioning shall include at a minimum of the following energy related systems in the building heating.

- HVAC equipment and its associated controls.
- Lighting and day lighting controls.
- Domestic hot water systems.
- Renewable energy systems (e.g. wind, solar).

Terminologies:

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

Fundamental Vs Enhanced Commissioning: Fundamental Commissioning may start in later design phase and may end before occupancy. Whereas Enhanced commissioning should start early in the design process and ends after occupancy.

Fundamental Commissioning is a prerequisite and Enhanced Commissioning is a credit.

Commissioning Authority: The commissioning authority (CxA) is the individual designated to organize, lead and review the completion of commissioning process activities.

Basis of Design: Basis of design includes design information necessary to accomplish the owner's project requirements, including system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines.

6.5 Building level & Advanced Metering

Intent (Building level):

To support energy management and identify opportunities for additional energy savings by tracking building-level energy use.

Intent (Advanced Metering):

To support energy management and identify opportunities for additional energy savings by tracking building-level and system-level energy use.

Strategies:

- Metering system to provide building level energy consumption for all energy types like electricity, gas, chilled water.
- Advanced metering system to
  - Provide end use energy distribution
  - Log data on hourly basis
  - Monitor demand

6.5 Demand Response:

Design building and equipment for participation in demand response programs through load shedding or shifting.

6.6 YouTube Video References:

- Video Demonstrating RECs
  http://www.youtube.com/watch?v=LzPCdpBHvFI

Summary

We have addressed

- Fundamental & Enhanced commissioning and verification
- Minimum & Optimize energy performance
- Building-level & Advanced energy metering
- Fundamental & Enhanced refrigerant management
- Demand response
- Renewable energy production
- Green power and carbon offsets

Have a Question in this chapter?

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Chapter7 – Materials & Resources

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Storage of recyclable materials
- Construction Waste Management Planning & Implementation
- Building life cycle impact reduction
- Building product disclosure and optimization
    - ✓ Environmental product declarations
    - ✓ Sourcing Raw Materials
    - ✓ Material Ingredients

Introduction:

Buildings are the major contributor for solid waste generation. LEED encourages buildings to adopt Waste Reduction policy with three 'R's namely Reduce, Reuse and Recycle.

LEED Encourages using sustainable materials such as materials with recycled content, rapidly renewable materials, regional materials, salvaged or refurbished materials etc. These materials have lesserembodied energy compared to conventional materials

7.1 Storage of Recyclable Materials (Prerequisite)

Intent:

To reduce the waste that is generated by building occupants and hauled to and disposed of in landfills.

Significance:

- By creating convenient recycling opportunities for all building occupants, a significant portion of the solid waste stream can be diverted from landfills.
- Recycling of paper, metals, glass, cardboard and plastics reduces the need to extract virgin natural resources.

- Examples: recycling 1 ton of paper prevents the processing of 17 trees and saves 3 cubic yards of landfill space.
- Recycled aluminum requires only 5% of the energy required to produce virgin aluminum from bauxite. Diverting waste from landfills can help minimize land, waterand air pollution.

Strategies:

Provide a suitable and convenient storage facility for occupants to store recyclable materials and the haulers to periodically collect the recyclable materials.

- The storage facility shall collect minimum paper, cardboard, glass, plastics and metals.
- An occupant education program that addresses the environmental and financial benefits of recycling can encourage occupants to participate in preserving the environment.
- Proper signage to indicate storage place of recyclable materials
- Signage for “not be contaminated”.
- Security for high valued materials.

Terminologies:

Landfills: Landfills are waste disposal sites for solid waste from human activities.

Tipping Fee: Tipping fees are charged by a landfill for disposal of waste, typically quoted per ton.

Hauler: Hauler is a person or company which collects the recyclable materials and sends it to recycling facilities.

Comingled Recycling: Comingled recycling is the term used when all recyclable materials (paper, metal, plastics, cardboard, glass etc.) are collected in a single storage place. The hauler separates the materials and sends it for respective recycling facilities.

7.2 Construction & Demolition Waste Management Planning and Implementation:

Intent:

To reduce construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling materials.

Significance:

- Most of construction waste are recyclable (metal, cardboard, concrete, wood, asphalt etc.).
- Recycling of construction and demolition debris reduces demand for virgin resources and reduces the environmental impacts associated with resource extraction, processing and in many cases, transportation.
- Extends the lifetime of existing landfills through effective and can avoid the need for expansion or new landfill sites.

Strategies:

- Prepare a construction waste management plan in order to divert construction waste from landfill.

- Consider recycling, reusing, donating etc.
- Identify recyclable construction waste and source haulers for recycling.
- Consider Waste-to-energy
- Waste to Energy is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolization, anaerobic digestion, and landfill gas (LFG) recovery
- Excavated soil and land clearing debris are not considered in construction waste calculation
- Any hazardous/contaminated materials are not included in the calculation.
- Construction Waste Management Plan shall address how hazardous or contaminated materials will be handled in the project

Note: Excavated soil and land clearing debris are not considered to be construction waste and does not contribute to the calculation

7.3 Building Lifecycle Impact Reduction

Intent:

To encourage adaptive reuse and optimize the environmental performance of products and materials.

Building Reuse:

Significance:

- There is a huge stock of existing buildings with a potential to refurbish, rather than redevelopment. Building reuse is a very effective strategy for reducing the overall environmental impact of construction.
- Reusing existing buildings significantly reduces the energy use associated with the demolition process as well as construction waste.
- Reduces the requirement for construction materials and hence reduces the environmental impact associated with extracting, manufacturing and transporting of the materials.
- Infrastructure is already available

Strategies:

- Maintain the existing building structure (including structural floor and roof decking and envelope the exterior skin and framing, excluding window assemblies and nonstructural roofing material).
- Use existing interior nonstructural elements (e.g., interior walls, doors, floor coverings and ceiling systems).
- Hazardous materials, contaminated, damaged parts of building, Window glazing and MEP equipment, that are remediated as a part of the project must be excluded from the calculation of the percentage maintained.

Material Reuse

Significance:

- Reuse strategies divert material from the construction waste stream, reducing the need for landfill space and environmental impacts from associated water and air contamination.
- Use of salvaged materials also avoids the environmental impacts of producing new construction products and materials.

Strategies:

Identify potential materials that can be reused in the locality of the project in design stage and specify them in construction documents.

Terminologies

Refurbished Materials:

Refurbished materials products have completed their life cycle as consumer items and are then refurbished for reuse without substantial alteration of their form. Refurbishing includes renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.

Salvaged Materials:

Salvaged materials are construction materials recovered from existing buildings or construction sites and reused. Common salvaged materials include structural beams and posts, flooring, doors, cabinetry, brick and decorative items.

Materials with Recycled Content

Significance:

- Products with recycled content reduce virgin materials use and solid waste volumes.
- As the number of building products containing recycled content grows, the marketplace for recycled materials develops.

Strategies:

Identify potential materials with recyclable materials that can be used in the project and specify them in construction documents.

Terminologies:

Recycled Content:

Recycled content is the proportion, by mass, of pre-consumer or post-consumer recycled material.

Note: Materials which are reused in the same manufacturing process is not considered to be recycling. Example: A brick manufacturing unit which reuses the broken bricks generated in the manufacturing process is not recycling.

Post-Consumer Recycled Content:

The recycled material was generated by household, commercial, industrial, or institutional end-users and can no longer be used for its intended purpose. It includes returns of materials from the distribution chain (ISO 14021). Examples include construction and demolition debris, materials collected through recycling programs, discarded products (e.g., furniture, cabinetry, decking), and landscaping waste (e.g., leaves, grass clippings, tree trimmings).

Pre consumed recycled content:

Pre-consumer recycled content, formerly known as post-industrial content, is the percentage of material in a product that is recycled from manufacturing waste. Examples include planer shavings, sawdust, bagasse, walnut shells, culls, trimmed materials, over issue publications and obsolete inventories. Excluded are reworks, regrind, or scrap materials capable of being reclaimed within the same process that generated them (as stated in ISO 14021).

Fly Ash:

Fly ash is the solid residue derived from incineration processes. Fly ash can be used as a substitute for Portland cement in concrete.

Assembly Recycled Content:

Assembly recycled content is the percentage of material in a product that is either post-consumer or pre-consumer recycled content. It is determined by dividing the weight of the recycled content by the overall weight of the assembly.

Reference Standards:

ISO 14021

Rapidly Renewable Materials

Rapidly Renewable Materials:

Rapidly renewable materials are agricultural products, both fiber and animal, that takes 10 years or less.

Examples of rapidly renewable materials include bamboo flooring and plywood, cotton ball insulation, linoleum flooring, sunflower seed board panels, wheat-board cabinetry, wool carpeting, cork flooring, bio-based paints, geo-textile fabrics such as coir and jute, soy-based insulation and form-release agent and straw bales.

Significance:

- Many conventional building materials require large inputs of land, natural resources, capital, and time to produce. Conversely, rapidly renewable materials generally require fewer of these inputs and are likely to have fewer environmental impacts.
- Sourcing rapidly renewable materials reduces the use of raw materials whose extraction and processing have greater environmental impacts.
- Because of their intensive production and shorter growing cycles, rapidly renewable crops also require significantly less land to produce the same amount of end product; some are byproducts that are otherwise considered waste.

Strategies:

- Assess the potential rapidly renewable materials that can be used in the project and specify the same in construction documents.

Regional Materials

Regional Material:

Materials extracted, manufactured and assembled within 100 miles of radius from the project location.

Significance:

- The use of regional building materials reduces transportation activities and associated pollution. Trucks, trains, ships and other vehicles deplete finite reserves of fossil fuels and generate air pollution.
- Encourages and strengthen local economies.

Strategies:

Assess the potential regional materials that can be used in the project and specify the same in construction documents.

Note: Salvaged material sourced within 100 miles can also contribute to regional materials irrespective of the source of the original material

Certified Wood

Significance:

- The negative environmental impacts of irresponsible forest practices can include forest destruction, wildlife habitat loss, soil erosion and stream sedimentation, water and air pollution and waste generation.
- Encourages sustainable forestry.

Strategies:

- Assess the potential sustainable (material of reuse, materials with recycled content, rapidly renewable materials, regional materials, FSC certified wood) materials available in the market.
- Specify the suitable sustainable materials in construction documents

Terminologies:

Chain-of-custody (COC):

Chain-of-Custody is a tracking procedure for a product from the point of harvest or extraction to its end use, including all successive stages of processing, transformation, manufacturing and distribution.

Sustainable forestry:

Sustainable forestry is the practice of managing forest resources to meet the long-term forest product needs of humans while maintaining the biodiversity of forested landscapes.

FSC Certified Wood:

Principles and Criteria Certification by the Forest Stewardship Council (FSC) is a seal of approval awarded to forest managers who adopt environmentally and socially responsible forest management practices and to companies that manufacture and sell products made from certified wood.

7.4 Building product disclosure and optimization

Building product disclosure and optimization

- Environmental product declarations
- Sourcing Raw Materials
- Material Ingredients

Intent:

- To encourage the use of products and materials for which life-cycle information is available and that have environmentally, economically, and socially preferable life-cycle impacts.

- To reward project teams for selecting products from manufacturers who have verified improved environmental life-cycle impacts.

Health Product Declarations:

Health Product Declaration (HPDs) provide a full disclosure of the potential chemicals of concern in products by comparing product ingredients to a wide variety of 'hazard' lists published by government authorities and scientific associations.

Environmental Product Declarations:

Environmental Product Declaration (EPD)is a standardized way of quantifying the environmental impact of a product or system. Typically, an EPD will include information about a product's impact on global warming, ozone depletion, water pollution, ozone creation, and greenhouse gas

Corporate Sustainability Report:

Corporate sustainability reports (CSRs) help to identify products/manufacturer's that have been verified to be extracted or sourced in a responsible manner.

There are two aspects in this credit

1. Disclosure: This is about being transparent about health impacts, environmental impacts and sourcing of raw materials
2. Optimization: This is about using materials that has lesser impact on health, environment and responsibly sourcing raw materials. Optimization can be achieved by selecting materials that are certified by third parties like Cradle to Cradle certified products and GreenScreen Certified products

Note:

1. For all credits Materials and Resources credit MEP materials are excluded from the calculation
2. Furniture may be included for credit calculations but if included should be included consistently in all credit calculations
3. Only permanently installed materials are included in calculation. Scaffolding and other temporary construction materials are excluded

7.6 Useful Terminologies

Embodied Energy:

The embodied energy of a material can be taken as the total primary energy consumed in manufacturing and using a product

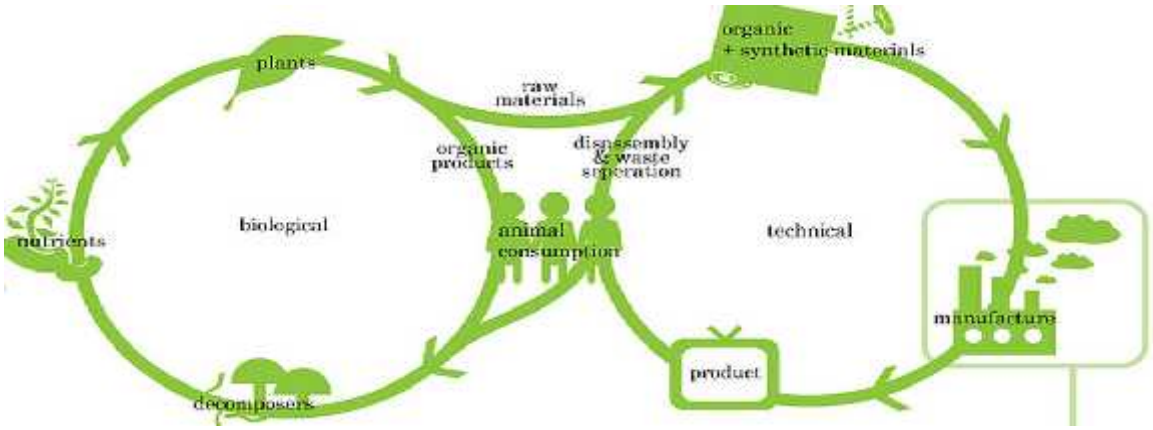
Common approaches for embodied energy are

- Cradle to Gate : Calculated from extraction till it comes out of the manufacturing unit
- Cradle to Site: Calculated up to site installation

- Cradle to Grave: Calculated up to end of use i.e. including dismantling and disposal

Cradle to Cradle:

- Conventional products have cradle to grave approach.
- Cradle to cradle products are environmentally preferred.
- Cradle to Cradle maintains materials in closed loops reducing waste disposal and landfill.



Source Reduction:

Source reduction can result from any activity that reduces the amount of a material needed and therefore used to make products. Some specific examples of source reduction practices are:

- Redesigning products to use fewer materials (e.g., light weighting, material substitution).
- Reusing products and materials
- Extending the useful lifespan of products.
- Avoiding using materials in the first place
- Using prefabricated materials to reduce waste on site

Summary

We have addressed

- Storage of recyclable materials
- Construction Waste Management Planning & Implementation
- Building life cycle impact reduction
- Building product disclosure and optimization
    - ✓ Environmental product declarations
    - ✓ Sourcing Raw Materials
    - ✓ Material Ingredients

Have a Question in this chapter?

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Chapter 8 – Indoor Environmental Quality

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Minimum indoor air quality performance
- Environmental tobacco smoke control
- Enhanced indoor air quality strategies
- Low-emitting materials
- Construction indoor air quality management plan
- Indoor air quality assessment
- Thermal comfort
- Interior lighting
- Daylight
- Quality views
- Acoustic performance

8.1 Introduction

What constitute Indoor Environment?

- Air Quality
- Thermal comfort
- Lighting comfort
- Acoustics

Why is IEQ Important?

- We spend 90% of our time indoor.
- Indoor 2-5 times more polluted compared to outdoors.
- Improvement in indoor environment improves productivity and reduces absenteeism.

8.2 Minimum indoor air quality performance

Intent:

To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).

Significance:

- Ventilation is the key to improve indoor air quality and provide sufficient oxygen for occupants.

Strategies:

- Ventilation design should comply with ASHRAE 62.1-2010.
- Provide 30% excess fresh air from minimum requirements of ASHRAE 62.1- 2010.
- Achievement of this credit has a negative implication on energy performance.
- *Heat/Energy recovery systems*and *demand control ventilation*can be used to reduce the negative impact of increased ventilation.

Heat Recovery Wheel/Heat Recovery Ventilation: Rotary heat exchangers used to precool/preheat the fresh by exchanging energy with return air

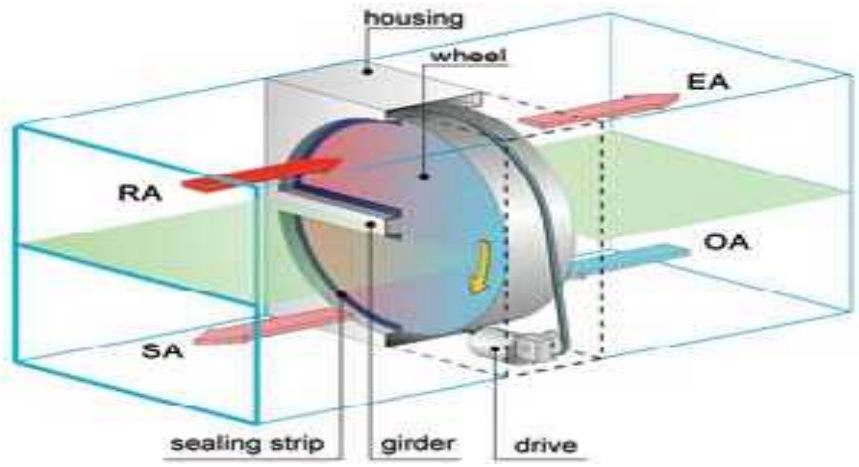


Fig 6.1 Mechanism of Heat Recovery Wheel

Demand Control Ventilation: Modulate the fresh air supply based on demand. CO2 Sensors are used to find out the requirement of fresh air.

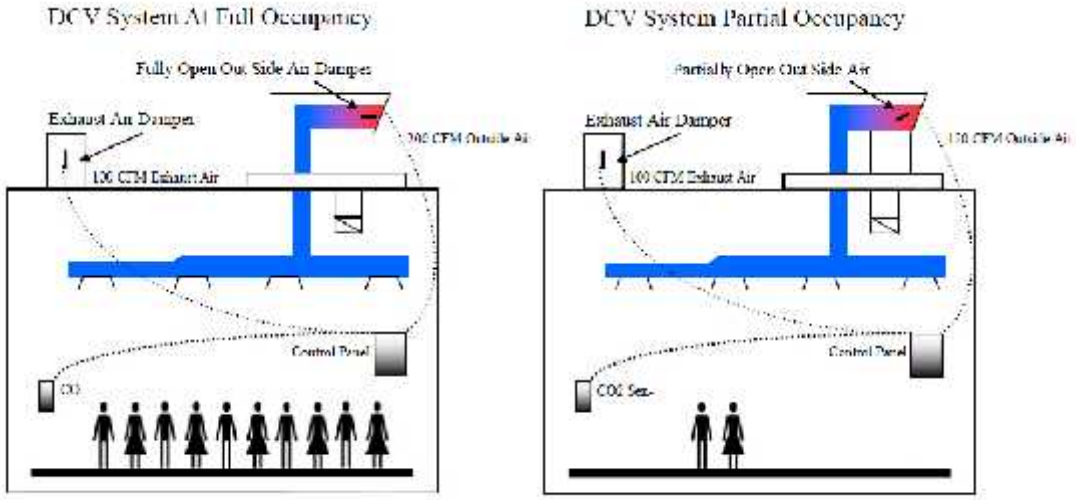


Fig 6.2 Operationof Demand Control Ventilation

Standards/References:

CIBSE Application Manual 10&ASHRAE 62.1 2010

8.3 Environmental Tobacco smoke control

Intent:

To prevent or minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to environmental tobacco smoke

Significance:

- Protect occupants from second hand smoke.
- Occupants exposed to second hand smoke risk lung cancer.

Strategies:

Non-Residential Projects:

- Prohibit smoking inside the building
- Prohibit smoking outside the building except designated smoking areas.
- Prohibit smoking outside the building if spaces used for business purposes.
- Provide signage indicating no smoking policy within 10’ of all building entrances

Residential Projects - Compartmentalization of smoking areas

- Prohibit smoking in common areas.
- Ensure air tightness in the unit by blower test
- Weather seal Window and door frames
- Seal penetrations in walls and ceilings
- Demonstrate a maximum leakage of 0.23cfm/sq.ft at 50 Pa

Exterior Smoking areas for both Residential and Non-Residential Projects:

- Exterior Smoking areas shall be atleast 25' away from windows, doors or air intake points

8.4 Enhanced Indoor air quality

Intent:

To promote occupants' comfort, well-being, and productivity by improving indoor air quality.

Significance:

- Protect the occupants from potentially hazardous particulates and chemical pollutants.

Strategies:

- Use entryway systems 10 feet long at all regular entrances.
- Directly exhaust chemical mixing areas such as copy room, janitor rooms, chemical storage rooms etc.
- In mechanically ventilated buildings, use MERV rated filters in accordance with ASHRAE 52.2-2007.

Standards & References:

- ASHRAE 52.2-2007 provides methodology to test MERV filters.

8.5 Low Emitting Materials

Intent:

To reduce concentrations of chemical contaminants that can damage air quality, human health, productivity, and the environment.

Significance:

- Finishing materials have high concentration of pollutants such as Volatile Organic Compounds (VOCs), Formaldehyde etc.
- These pollutants pose serious problems on IAQ and also contribute to smog.

Strategies:

Finishing materials shall with the requirements as summarized below

S.No	Material	LEED Compliance requirement
1	Adhesives, sealants, primers Wood finishes, floor coatings	Comply with VOC requirements of South Coast Air Quality Management District (SCAQMD)
2	Aerosol adhesives Architectural paints and coatings Interior anti-corrosive and anti-rust paint	Comply with Green Seal
3	Carpets	Comply with Green Label Plus (Carpet and Rug Institute)
4	Carpet cushion	Comply with Green Label (Carpet and Rug Institute)
5	Vinyl, linoleum, laminate, wood, ceramic, rubber flooring	Comply with FloorScore
6	Furniture and seating	Comply with GREENGUARD

Terminologies:

VOC Budget:

- If a small amount of a product non-compliant with the VOC limits of the standards, the project team may opt to perform a VOC Budget calculation.
- The VOC Budget is a weighted average calculation which can be used to show that the majority of the products comply.

8.6Indoor Air Quality Management during Construction

Intent:

To promote the well-being of construction workers and building occupants by minimizing indoor air quality problems associated with construction and renovation.

Significance:

- Protect construction workers and occupants from IAQ problems resulting from construction.
- Pollutants from synthetic materials, construction process, finishing materials etc. pose serious IAQ problems.

Strategies:

- Develop an IAQ Management Plan as per Sheet Metal and Air-conditioning National Contractors Association.
- SMACNA addresses IAQ Management in 5 areas as follows:

- Protection of HVAC equipment.
- Source control.
- Housekeeping.
- Pathway interruption.
- Scheduling.

- If permanently installed air handlers are used during construction, provide MERV (Minimum Efficiency Reporting Value) rated filters in all return grills.

8.7 Indoor Air Quality Assessment

Intent:

To establish better quality indoor air in the building after construction and during occupancy.

Strategies:

- Replace all AC filters if HVAC equipment is used during construction.
- Flush the building by supplying outdoor air.
- Conduct an IAQ test prior to occupancy.

8.8 Thermal comfort

Intent:

To promote occupants' productivity, comfort, and well-being by providing quality thermal comfort.

Significance:

- Reduce occupant complaints.

- Reduce absenteeism, Increases productivity, Increased occupant satisfaction.

Strategies:

- Thermal Comfort Design- Comply with ASHRAE standard 55-2010 for thermal comfort.
- Thermal comfort depends on parameters such as temperature, humidity, air velocity etc.
- Provide controls for the occupants to set their comfort levels.
- Thermostats, operable windows, accessible control dampers are considered as controls.
- Agree to conduct a thermal comfort survey and verification.
- Agree to take corrective action if more than 20% of occupants are not satisfied.

Standards & References:

- ASHRAE standard 55-2010 for thermal comfort.

8.9Interior Lighting

Intent:

To promote occupants' productivity, comfort, and well-being by providing high-quality lighting.

Significance:

- To provide the occupants with control of their lighting according to their requirement.

- Increases productivity.
- May provide an opportunity for save energy.

Strategies:

- Provide individual lighting control for a percentage of occupants.
- Provide lighting system controllability for all shared multi occupant spaces (meeting room, conference halls etc.).

8.10 & 8.11 Day light & Quality Views

Intent (Day light):

To connect building occupants with the outdoors, reinforce circadian rhythms, and reduce the use of electrical lighting by introducing daylight into the space.

Intent (Quality Views):

To give building occupants a connection to the natural outdoor environment by providing quality views.

Significance:

- Provide daylight and views to connect the occupants with outdoor.
- Research proves that children studied at daylight class rooms perform better than other children consistently.

Strategies:

- Optimize the glazing orientation to maximize daylight and minimize heat gain/heat loss
- Use day lighting devices such as light shelves, sun tubes etc.

- Use glare control devices like internal and external shades
- Automated shading devices shall be used to control operation of the shading devices in different time of the day.
- Reduce reflective glazing which may cause external glare and bird collision

8.12 Acoustic Performance

Intent:

To provide workspaces and classrooms that promotes occupants' well-being, productivity, and communications through effective acoustic design.

Strategies:

- Reduce background noise from HVAC Equipment
- Sound Transmission Class and Reverberation time to comply with relevant standards

Summary

We have addressed

- Minimum indoor air quality performance
- Environmental tobacco smoke control
- Enhanced indoor air quality strategies
- Low-emitting materials
- Construction indoor air quality management plan
- Indoor air quality assessment
- Thermal comfort
- Interior lighting
- Daylight
- Quality views
- Acoustic performance

Have a Question in this chapter?

Discuss in our forum

Chapter 9: Integrative Process

Learning Objectives

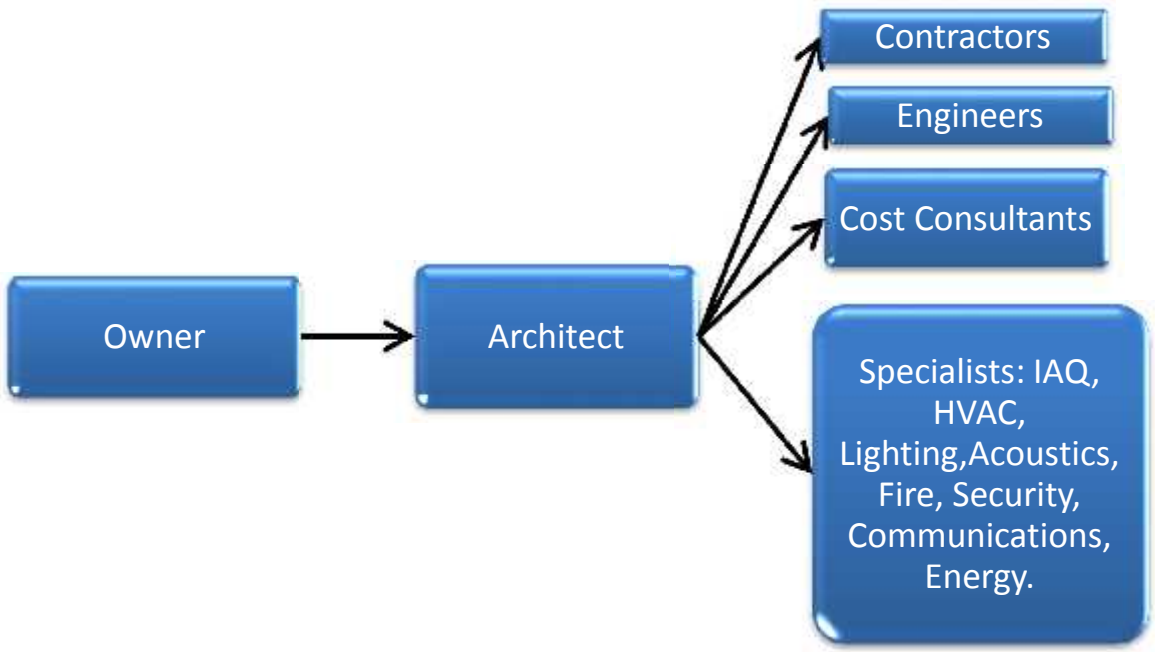
At the end of this chapter, candidates will have an understanding of

- Conventional Process
- Integrative Process
- LEED/ Green Building Charrette

Intent

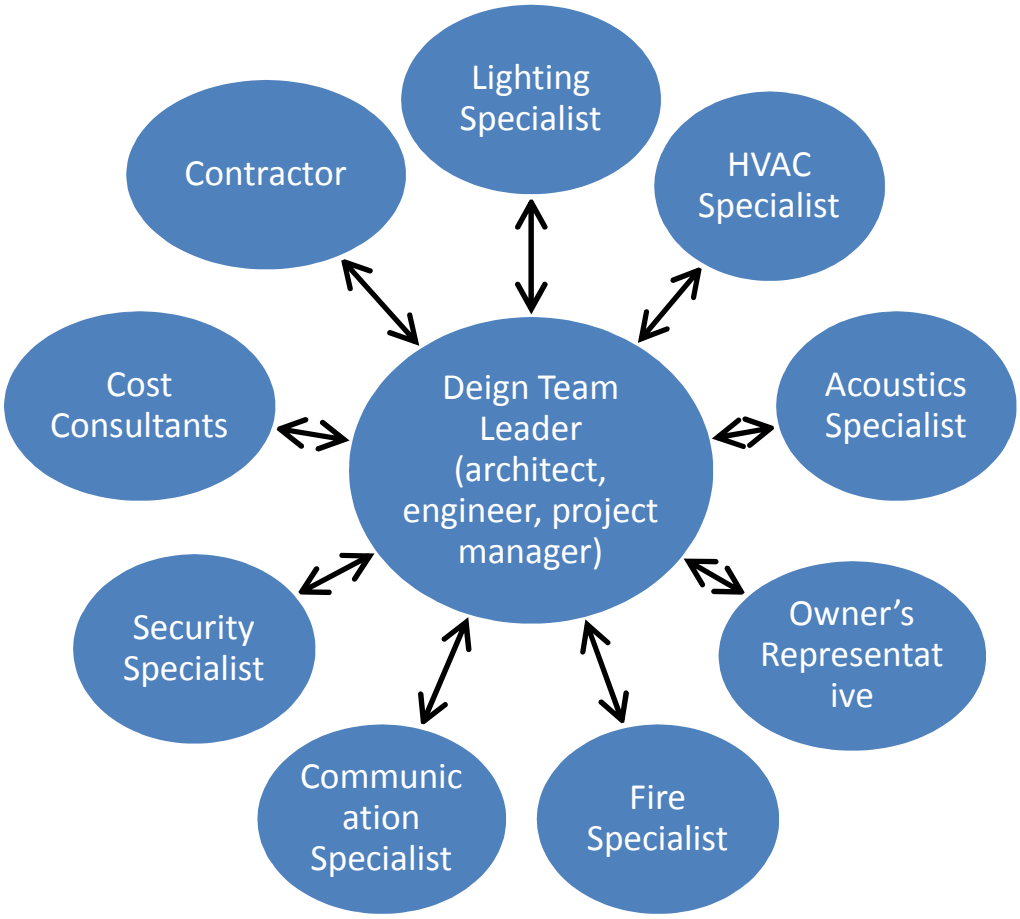
To support high-performance, cost-effective project outcomes through an early analysis of the interrelationships among systems.

9.1Conventional Process:



In a conventional Project delivery, Architect plays an important role in schematic design, once the schematic design is done. Different disciplines work isolated on their corresponding task. In this approach, the opportunities of synergies between different systems are missed. For example, the Architect in the design is not considering the HVAC Engineers input on orientation, WWR, building envelope impact etc.

9.2 IntegrativeProcess:



In integrated project delivery, the project team first sets project goals and objectives. The goals are set in LEED/Green Building Charrette.

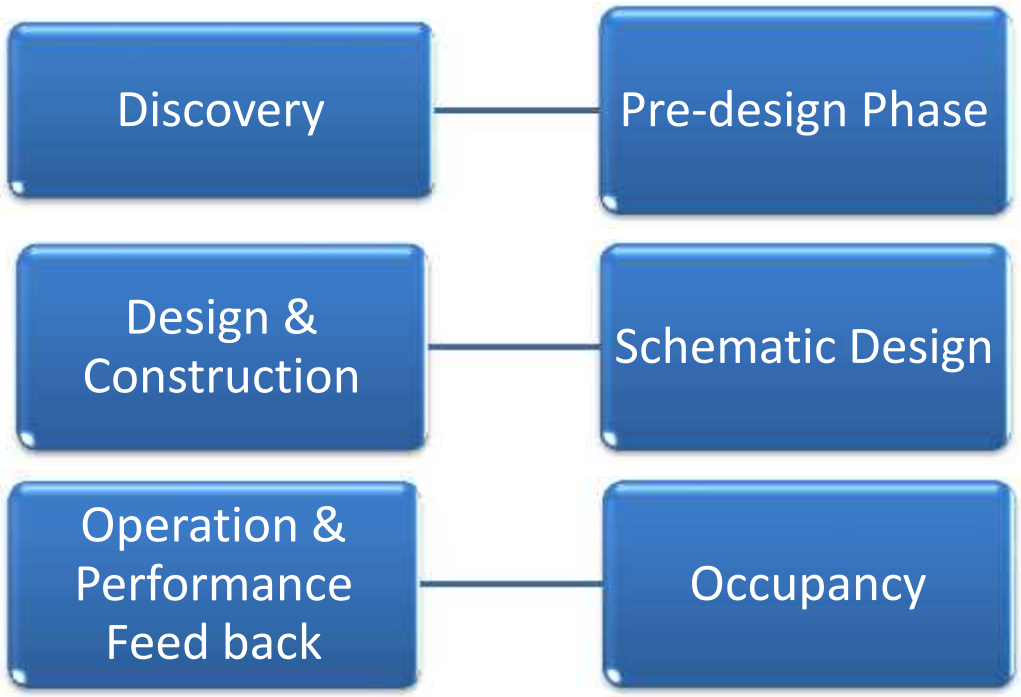
- Example for project goals can be reducing energy consumption by 40% from baseline or reducing water consumption by 50% from the

baseline. Tools like Energy Star Target finder, EPA Water budget tool etc. can be used to establish baseline.

- LEED or Green Building Charrette is a type of workshop where the project team members brain storm, collaborate and set project goals.

All project team members works towards the project goals right from predesign to completion of the project.

Phases of Integrative Process:



Discovery Phase:

Discovery phase is an expansion of conventional predesign phase.

In discovery phase project teams should understand project requirements, explore synergies between various building components, address budget, and schedule.

Design & Construction Phase:

This phase is an expansion of conventional schematic design phase

In Design & Construction phase project teams should

- Incorporate all of the collective understandings of system interactions that were found during discovery phase
- Take system approach/whole building approach and not individual component approach.

  Example: Projects should assess orientation, envelope, window to wall ratio, lighting levels, day light, thermal mass etc. to achieve the energy efficiency goal.

  Similarly for water efficiency, projects should asses the available rain water, gray water, condensate water etc. to meet the water demand of the project efficiently

Operation & Performance feedback:

This phase is an expansion of conventional occupancy and operation and maintenance phase

In this phase project teams should

- Measure the performance of the project and set feedback mechanism
- Feedback is critical in determining the success in achieving performance targets, informing building operations, and taking corrective action when targets are missed.

Example: Projects should continuously monitor energy and water consumption and compared it against the established goals. Corrective actions to be taken when the project deviates from established goals.

Summary

We have addressed

- Conventional Process
- Integrative Process
- LEED/ Green Building Charrette

Have a Question in this chapter?

Discuss in our forum

Chapter 10 – Bonus Categories

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Innovation
    1. Innovation
    2. LEED AP
- Regional Priority

10.1 Innovation

Innovation points are awarded to projects, which achieve exceptional performance in sustainability above the requirements set by the LEED Green Building Rating System.

There are two Credits under Innovation Category

1. Innovation
2. LEED AP

Project Team can earn Innovation Credit by following paths

1. Exemplary performance
2. Pilot Credits
3. Innovative Criteria
    a. Borrowing credits from other LEED Rating systems
    b. Innovation

10.1.1 Exemplary Performance:

Exemplary performance points are awarded if the project outperforms the requirements **specifically addressed by the LEED rating system.**

Exemplary Performance can be earned by exceeding the requirements of the credit to next threshold or achieving double the credit requirements.

Examples:

1. **Rating System:** LEED for BD+C: New Construction
   Credit Category: Water Efficiency.
   Credit: Indoor Water use reduction.

Exemplary Performance: 1 Bonus point under Innovation if the project exceeds the credit requirement to the next threshold (achieves 50% reduction of water use – 6points, achieve 55% reduction of water use – 6points + 1 point under Innovation).

Note: Exemplary Performance points are not available for all the credits in the rating system.

10.1.2 Pilot Credits:

- Pursuing credits in USGBC pilot credit library and providing input to USGBC can earn Innovation Point.
- The LEED Pilot Credit Library is a rating system development tool designed to test new and revised LEED credit language, alternative compliance paths, and new or innovative green building technologies and concepts.

10.1.3 Innovative Criteria

10.1.3.1 Borrowing Credits from Other Rating systems:

- Purse credits borrowed from other rating systems.
- Example: NC Project pursuing Green House Keeping borrowed from EBOM

10.1.3.2 Innovation:

- Innovation credit for innovative performance is awarded for comprehensive strategies which demonstrate quantifiable environmental benefits which are **not specifically addressed in the LEED rating system**.
- Intent, Requirement, calculation, design approach and strategies are proposed by project team

The following Points are worth noting in relation to Innovation:

- LEED Innovation Credits are evaluated for each project award of an Innovation Credit for one project at a specific point in time does not constitute automatic approval for a similar strategy in a future project.
- Innovation credits are not awarded for the use of a particular product or design strategy if the technology innovations in the achievement of an existing LEED credit.
- Approved Innovation credits may be pursued by any LEED project, but the project team must sufficiently document the achievement using the LEED credit equivalence process. This process includes identifying the proposed innovation credit intent, the proposed requirement(s) for compliance, the proposed submittal(s) to demonstrate

compliance, and a summary of potential design approaches that may be used to meet the requirements.

10.2 LEED AP

- One point shall be awarded if the project team has one principal participant who is a LEED AP with project specific specialty.
- The project can receive only one point regardless on the number of LEED APs in the project team.
- LEED AP helps streamline the application and certification process. LEED AP Credit is a construction submittal and hence participation of LEED AP is required throughout the project.

10.3 Regional Priority

- Incentive for the achievement of credits that address geographically-specific environmental priorities.
- The RP credit zones in LEED v4 are created using a Geographic Information Systems (GIS)-based program that allowed for environmental issues to be empirically mapped.
- Project's physical coordinates (X, Y) or name of the city need to be entered to accurately identify RP credits in USGBC website.
- Regional USGBC Chapters give recommendations for Regional Priority Credits for their region.

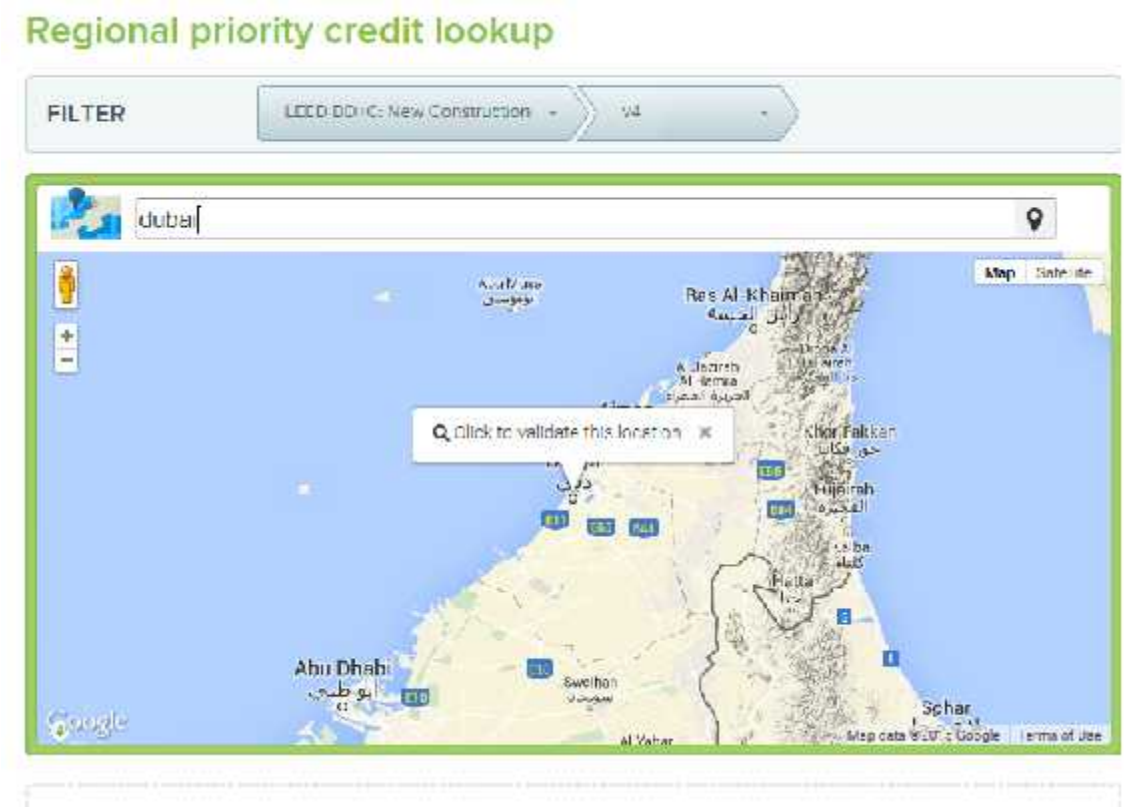


Fig 10.1 Screen shot from www.usgbc.org/rpc

Example: In Qatar.

The following credits are designated as regional priority credit:

- Renewable Energy Production
- Thermal Comfort
- Reduced Parking Footprint
- Site Development – Protect or Restore Habitat
- Outdoor Water Use Reduction – 50%
- Indoor Water Use Reduction – 30%

Projects in Qatar can earn 4 Bonus points if they achieve any 4 of the above credits.

Projects can access the database of RP credits for different locations from the link below:

www.usgbc.org/rpc

Summary

We have addressed,

- Innovation
  1. Innovation
  2. LEED AP
- Regional Priority

Have a Question in this chapter?

Discuss in our forum

Chapter 11 – More about USGBC and LEED

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- LEED Certification Process
- Uniqueness of LEED for Homes, BD+C: CS, O+M & ND
- LEED Credit checklist & Credit templates
- CIRs & LEED Interpretation
- LEED Volume program
- USGBC Mission, Vision
- History of LEED
- How LEED Rating systems are developed

11.1 Certification Process for LEED BD+C and LEED ID+C

Following are the stages of certification:

1. Project Registration.
2. Application.
3. Preliminary review.
4. Preliminary review response (clarification).
5. Final review.
6. Accept or appeal.
7. Appeal review (if applicable).
8. Certification or denial.

Project Registration:

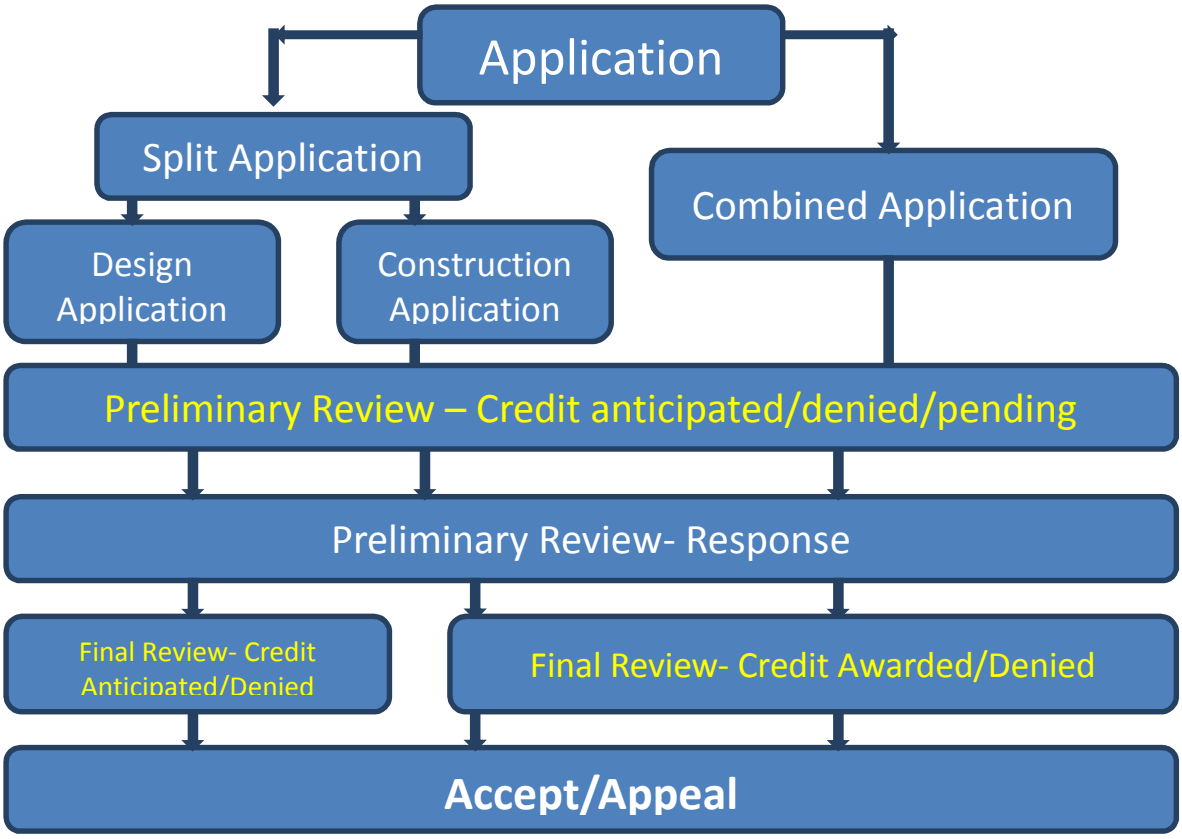
- Projects is done though online application in www.leedonline.com.
- Registration is done by Project Administrator who will be the point of contact between GBCI and project team.
- Registration fee: $900 for member companies & $1200 for non-member companies.
- Registration during pre-design is recommended.
- The following information are required to register the project:
    - Project type.
    - Project Administrator Contact information.
    - Registration fees (through card).
    - Project Owner information.
    - Project Details- scope, square footage, condition of the site, budget etc.

Preparing the Application:

- On completion of registration, project team gets access to LEED online which has online credit templates.
- Project Administrator assigns credit responsibilities for team members.
- Team members get access to corresponding credit templates/credit letters/credit forms for which they are responsible.
- Credit templates/credit letters/credit form is a dynamic pdf file used for the documentation.

- **Design/Construction Credits:** Each credit/prerequisite based on the nature of documentation required is labeled as Design credit or construction credit. For example Site Selection can be documented after design phase, Construction pollution prevention can be documented only after completion of construction.

Split Vs Combined Application/Review



Split review:

- Allows submitting project documentation Design Credits and Construction credits separately.
- Helps to anticipate credits that are possible for certification well in advance.

Combined design and construction application/review:

- All documentation is submitted and reviewed at one time. Advantageous only if project has commenced.

Design Application Review:

On Preliminary Design Review:

- GBCI will mark as credit anticipated/denied/pending.
- The project team can either accept the preliminary review as the final review or submit a response to the preliminary review.

On Final Design Review:

- GBCI will mark as credit anticipated/denied
- The project team can either accept the review or submit an appeal.

Construction Application Review:

On Preliminary Design Review:

- GBCI will mark as credit awarded/denied/pending.
- The project team can either accept the preliminary review as the final review or submit a response to the preliminary review.

On Final Design Review:

- GBCI will mark as credit awarded/denied.
- The project team can either accept the review or submit an appeal.

Appeal & Certification

- If the project team decides to appeal, an appeal fee of $ 500 ($ 800 for complex credits) is applicable for each credit appeal. Credits such as

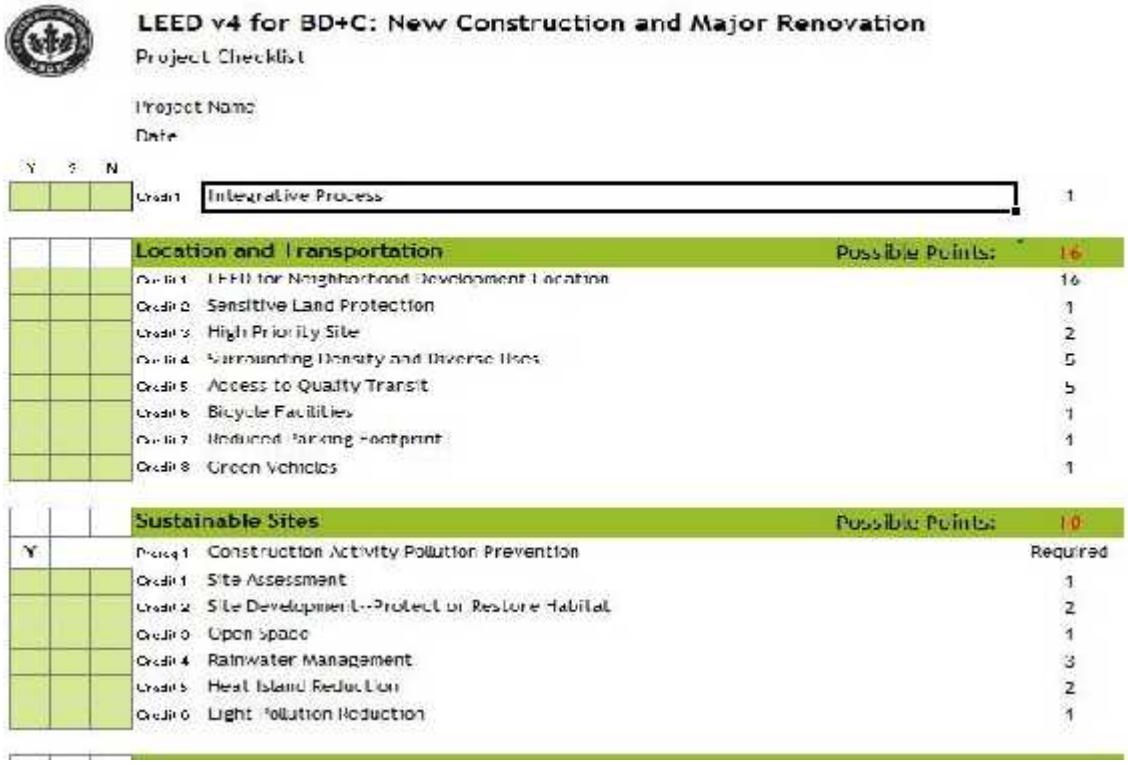
Optimized Energy Performance and Enhanced Commissioning are considered as complex credits.

- The appeal shall be reviewed by GBCI.
- After appeal review, the Project is either certified or denied.

LEED Online Credit Template/Credit Letter:

- Dynamic pdf file used by project team member to do calculations, fill data related to the project and upload supporting documents to demonstrate credit compliance

LEED Project Score Card/Checklist:



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

Project Checklist

Project Name

Date

Y	?	N			
			Credit	Integrative Process	1
			Location and Transportation	**Possible Points:**	**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
			Sustainable Sites	**Possible Points:**	**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

- Excel sheet published by USGBC which summarizes the credits under each category and possible number of points

- Used to evaluate possibility of achieving each credit during the design phase
- Used to estimate the number of points and target level of LEED Certification

LEED BD+C: CS Pre-certification

- LEED BD+C: CS projects have a unique feature of getting pre-certified. Pre-certification is the formal recognition of GBCI that the owner or developer has established LEED BD+C: CS certification as a goal.
- Pre-certification is offered with lesser documentation as compared to final certification. Pre-certified projects still have to comply with all the requirements of final documentation. Precertification does not guarantee that the project will be LEED Certified.

11.2 Certification process for LEEDO+M

- Certification process of O+M is same as in BD+C except that there is no design or construction phase and hence there is no split application /review.
- The credits are documented after assessing the performance of the building during performance period. Performance Period is the time period during which the buildings performance is measured for credit evaluation.
- Unlike other rating systems LEED O+M has validity for the certification. Projects have to apply for recertification at least once in 5 years to retain their certification.

11.3 LEED for Homes Certification Process

Unlike other LEED certification process, USGBC/GBCI does not involve directly in LEED for Homes Certification.

LEED for Homes is facilitated by LEED for Homes providers & Green Rater. LEED for Homes provider are contracted by USGBC/GBCI to provide administrative & Technical support to the project team.

Green Raters are part of project team who connects the project team with LEED for Homes provider by site inspections and verification.

Steps in LEED Homes Certification:

1. Contact LEED for Homes provider establish a preliminary or target rating. LEED for Homes provider are listed in usgbc website.
2. Project team holds preliminary meeting with LEED for homes provider to discuss the project certification. The project certification goals are set and responsibilities are assigned to the project team members. The project team may include LEED AP (Homes spatiality) to guide the members.
3. On receipt of go ahead signal from LEED for Homes provider the project team can register the project with GBCI.
4. Project team proceeds with the project to meet the targeted goals.
5. Green Rater performs inspections and required tests to ensure the required performance targets are met.
6. Green Rater completes the project documentation and submits it to LEED for Homes provider.

7. LEED for Homes provider reviews the documentation and submits it to GBCI for Review.
8. GBCI reviews and provide the certification.

11.4 LEED for Neighborhood Development:

As LEED for ND is applicable for townships and not for individual buildings. The credit categories in LEED for ND are different. Following are the credit categories in LEED ND

- Smart Location and Linkages
- Neighborhood Pattern & Design
- Green Infrastructure and Buildings
- Innovation in Design Process
- Regional Priority

11.5 Credit Interpretation Request/Ruling (CIR)

- The Project Credit Interpretation Request (CIR) and ruling process is designed to allow Project Teams to obtain technical and administrative guidance on how LEED requirements including Minimum Program Requirements, Prerequisites and Credits pertain to their projects.
- A CIR may be submitted at any time after the point in which a project is registered.
- CIR to be submitted through LEEDONLINE by selecting a particular credit or prerequisite.
- Each CIR shall address only one credit or prerequisite or LEED requirement.

- CIR should not be in letter format, project teams should not give project information. Project Information is already available through LEEDONLINE.
- Project teams need not submit drawings or cut sheets or specifications etc. Only specific background information is sufficient.
- CIR should not exceed 600 words.
- Project Teams must submit the CIR inquiry and the ruling with their LEED application in order to ensure a complete review.
- Project Teams should note that neither the credit language nor the minimum achievement thresholds can be changed through the CIR process.
- CIR rulings do not in any way guarantee that a LEED MPR, prerequisite or credit will be satisfied or achieved. The project Applicant must still demonstrate and document satisfaction of all LEED requirements during the LEED certification process.
- CIR rulings of LEED v3 and later rating system are project specific.
- USD 220 – Each CIR

11.6 LEED Interpretations

LEED Interpretations are precedent setting CIRs, which is applicable for other projects at similar situation.

11.7 LEED Volume Program

The LEED Volume Program is for organizations planning to certify a large number of design and construction projects or existing buildings.

- Streamlined approach to certify multiple buildings and spaces in different locations.
- Use of prototype standards —to simplify the LEED documentation for multiple buildings or spaces of a similar type or management, achieving certification faster and at a lower cost than with individual building reviews.

Example: Marriot – a hotel chain in different countries can opt for LEED volume program for all their facilities.

11.8 USGBC Mission and Vision

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.

Vision

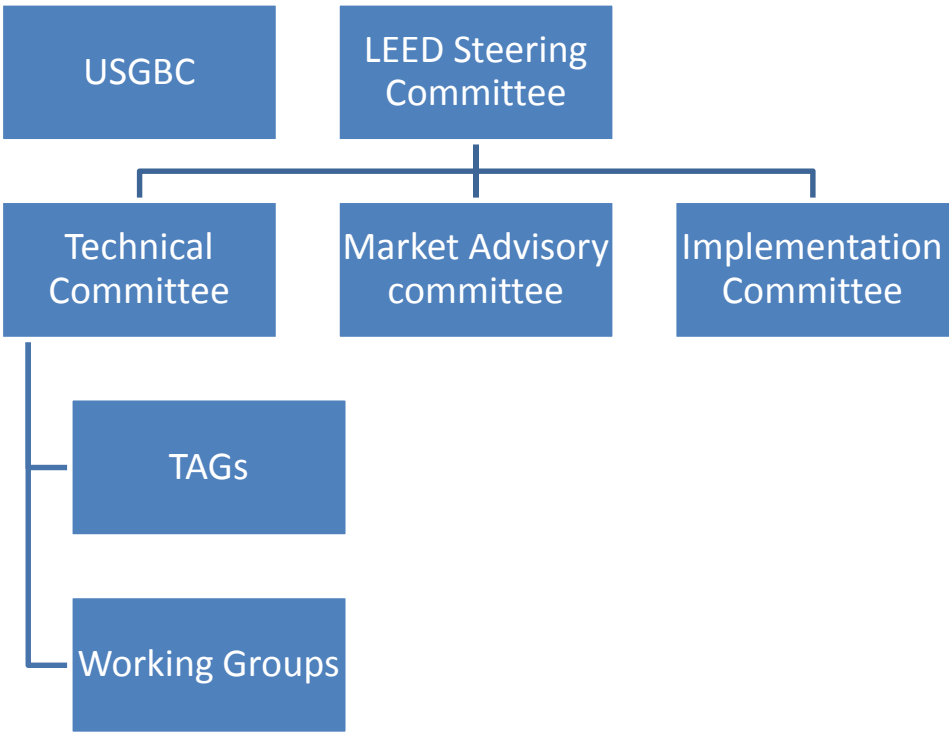
Buildings and communities will regenerate and sustain the health and vitality of all life within a generation.

11.9 History of LEED Rating System

- 1993: Formation of USGBC
- 1998: LEED version 1.0 Pilot Version launched
- 2000: LEED version 2.0 launched
- 2005: Launched pilot LEED-certification program for homes
- 2005: USGBC launched LEED-Existing Buildings (EB)
- 2005: USGBC launched LEED-Commercial Interiors (CI)

- 2005: USGBC launched LEED-New Construction 2.0 (NC 2.0)
- 2009: Launched LEED V3 including LEED-Neighborhood Design (ND)
- 2014: Launched LEED V4 for 21 adoptions

11.10 How LEED Rating systems are developed



- Draft LEED Rating Systems are developed by different committees and working groups
- Steering committee approves draft rating system
- Rating system is then open for public review and comments
- Comments are incorporated
- Rating system goes for voting, USGBC Members can vote on the rating system
- Rating system approved if 2/3rd of members vote affirmative

11.11 YouTube Video References:

- LEED Online Demonstration

  http://www.youtube.com/watch?v=UlrrHqBrcCs
- LEED for Homes Certification Process

  http://www.youtube.com/watch?v=dnYq_O-RTL8

Summary

We have addressed

- LEED Certification Process
- Uniqueness of LEED for Homes, BD+C: CS, O+M & ND
- LEED Credit checklist & Credit templates
- CIRs & LEED Interpretation
- LEED Volume program
- USGBC Mission, Vision
- History of LEED
- How LEED Rating systems are developed

Have a Question in this chapter?

Discuss in our forum

Chapter 12 – Value of Sustainable Cost Vs Benefit

Learning Objectives

At the end of this chapter, candidates will have an understanding of

- Cost of Green Buildings
- Life-Cycle Cost Analysis

12.1 Cost of Green Buildings

Definitions:

Hard Costs: The physical costs for the construction of a project, including all building and landscaping materials.

Soft Costs: The non-physical costs that go into a project. This includes architectural, engineering and legal fees, as well as other pre- and post-construction expenses.

Operation & Maintenance Costs: Cost associated with operating the facility throughout its life. It includes utility bills, minor upgrades, maintenance of equipment etc.

Life-Cycle Costs: The sum of all costs over the full life span (or specific period) of the building. This includes purchase price, installation, operation, maintenance and upgrade costs.

Life-Cycle Cost = Hard Cost + Soft Cost + Operation & Maintenance cost + all other cost associated with ownership

Life Cycle Cost Analysis (LCCA): LCCA is a method for assessing the total cost of facility ownership. Takes into account all costs of acquiring, owning, and disposing of a building or building system. LCCA is useful to evaluate alternatives like high performance HVAC system, glazing system etc. that have higher initial cost but reduced operational

(LCCA ≠ LCA)

Life Cycle Assessment (LCA): LCA is the investigation and valuation of environmental impact of building throughout its life span

Points to be considered while evaluating the cost of Green Buildings:

- In general, project team looks at only first cost, but it is interesting to note that operation and maintenance cost is higher than first cost. In many cases. The best practice to evaluate various sustainability measures is to perform a Life Cycle cost analysis. For example, solar water heater may add an initial cost but will reduce the energy bills over the life of the solar water system.
- Have sufficient contingencies for R&D to evaluate various options.
- Have an experienced sustainability or Green Building consultant. Often fee paid Green Building consultants are only a small portion of savings they have generated.

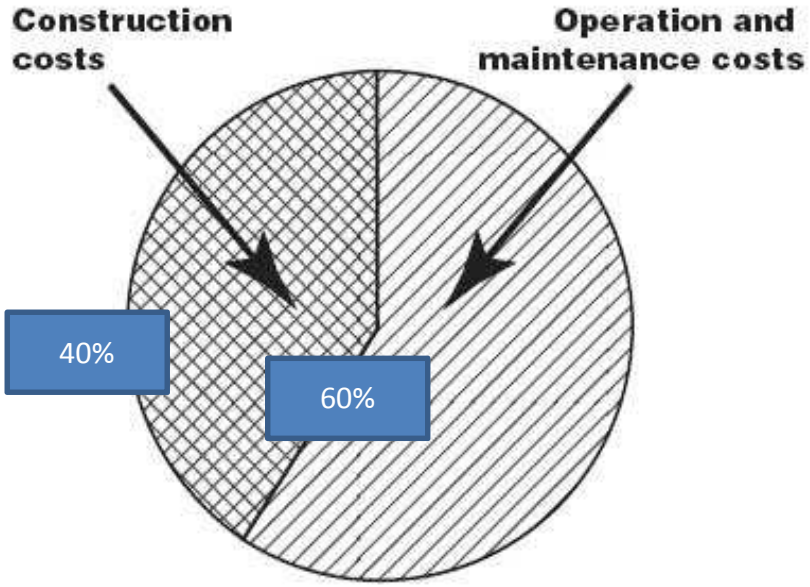


Fig 12.1 Construction Vs Operation and Maintenance costs

12.2 Summary of "Cost of LEED Revisited by Davis Langdon"

"**Cost of Green Revisited**: Re-examining the Feasibility and Cost Impact of Sustainable Design in the Light of Increased Market Adoption":

1. Many projects are achieving LEED within their budgets and in the same cost range as non-LEED projects.
2. Construction costs have risen dramatically, but projects are still achieving LEED.
3. The idea that green is an added feature continues to be a problem.

12.3 References:

- Life Cycle Cost Analysis: http://wbdg.org/resources/lcca.php, Sustainable Building Technical Manual / Joseph J. Romm, Lean and Clean Management, 1994
- http://www.fs.fed.us/t-d/pubs/htmlpubs/htm08732839/page01.htm

Summary

We have addressed

- Cost of Green Buildings
- Life-Cycle Cost Analysis

Have a Question in this chapter?

Discuss in our forum