Leadership in Energy and Environmental Design
LEED™

The
United States
Green
Building
Council

usgbc.org

U.S. Green Building Council

- National non-profit organization with over 600 members nationwide
- USGBC promotes the design, construction, and operation of buildings that are environmentally responsible, profitable, and healthy places to live and work
- Formed in 1993
- Represents all aspects of the building industry

What is Green Design?

- Design and construction practices that significantly reduce or eliminate the negative impact of buildings on the environment and occupants:
  - Sustainable site planning
  - Safeguarding water and water efficiency
  - Energy efficiency
  - Conservation of materials and resources
  - Indoor environmental quality

What Is LEED?

- LEED is a tool for green building design to help design teams and owners determine green project goals, identify green design strategies, measure and monitor progress, and document success

LEED's development

- Begun in 1995
- LEED version 1 launched December 1998
- 50 pilot projects
- Evaluation and refinement based on feedback and expert review
- 11 buildings certified
- LEED version 2 approved March 2000
- 1 building certified
- 62 projects registered under LEED 2.0

Universities using LEED

- Carnegie Mellon Institiute
- Colorado College
- Connecticut College
- Evergreen State College
- Massachusetts Institute of Technology
- Montana State University
- Lewis & Clark College
- University of Nebraska
- Northland College
- Oberlin College
- Pima County Community College
- University of California at Santa Barbara
- University of North Carolina Asheville
- University of Texas
- University of Wisconsin

Other LEED Users

- Alcoa
- Armstrong
- Herman Miller
- Johnson Controls
- Monsanto
- Owens Corning
- Johnson Wax
- US Air Force
- US Navy
- Pentagon
- EPA
- DOE/NREL
- Department of Interior
- Natural Resources Defense Council

The environmental impact of the building design, construction and operation is significant.

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

LEED Rating Systems

- New Construction
  - LEED for New Construction and Major Renovations is designed to guide and distinguish high-performance commercial and institutional projects.
- Existing Buildings
  - LEED for Existing Buildings: Operations & Maintenance provides a benchmark for building owners and operators to measure operations, improvements and maintenance.
- Commercial Interiors
  - LEED for Commercial Interiors is a benchmark for the tenant improvement market that gives the power to make sustainable choices to tenants and designers.
- Core and Shell
  - LEED for Core & Shell aids designers, builders, developers and new building owners in implementing sustainable design for new core and shell construction.

energy Appalachian

LEED Rating Systems Cont.

- Schools
  - LEED for Schools recognizes the unique nature of the design and construction of K-12 schools and addresses the specific needs of school spaces.
- Retail
  - LEED for Retail recognizes the unique nature of retail design and construction projects and addresses the specific needs of retail spaces.
- Healthcare
  - LEED for Healthcare promotes sustainable planning, design and construction for high-performance healthcare facilities.
- Homes
  - LEED for Homes promotes the design and construction of high-performance green homes.
- Neighborhood Development
  - LEED for Neighborhood Development integrates the principles of smart growth, urbanism and green building into the first national standard for neighborhood design.

The Benefits of Green Building Accumulate

- Strong marketing potential
- LEED registered projects now account for almost 10% of all new building construction
- Produces a lifetime of low operating costs
- Enhances personnel performance
- Creates durable buildings of higher value
- Is typically accomplished for the same or slightly higher (or lower) costs
- It's the finished product that sells the idea
- Minimizes our use of Natural Capital
- Reduces pollution and waste

USGBC LEED™

Six Categories of Credits:

- Sustainable Sites (14 points)
- Water Efficiency (5 points)
- Energy and Atmosphere (17 points)
- Materials and Resources (13 points)
- Indoor Environmental Quality (15 points)
- Innovation and Design Process (5 points)

==========

TOTAL possible points (69 points)

The LEED Rating System

The LEED Rating System is a performance oriented *points* system with various levels of certification:

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

LEED Prerequisites are non-negotiable

Seven prerequisites are mandatory to achieve certification

1. Erosion and Sedimentation Control
2. Fundamental Building Commissioning
3. Minimum Energy Performance
4. CFC reduction in HVAC&R Equipment
5. Storage and Collection of Recyclables
6. Minimum IAQ Performance
7. Environmental Tobacco Smoke Control

The LEED Certification Process

Eligibility – All commercial buildings as defined by the prevailing energy codes include offices, retail and service establishments, institutional buildings hotels and residential buildings four or more habitable stories.

Registration – Register the project with the USGBC; it is recommended to do this early in the process

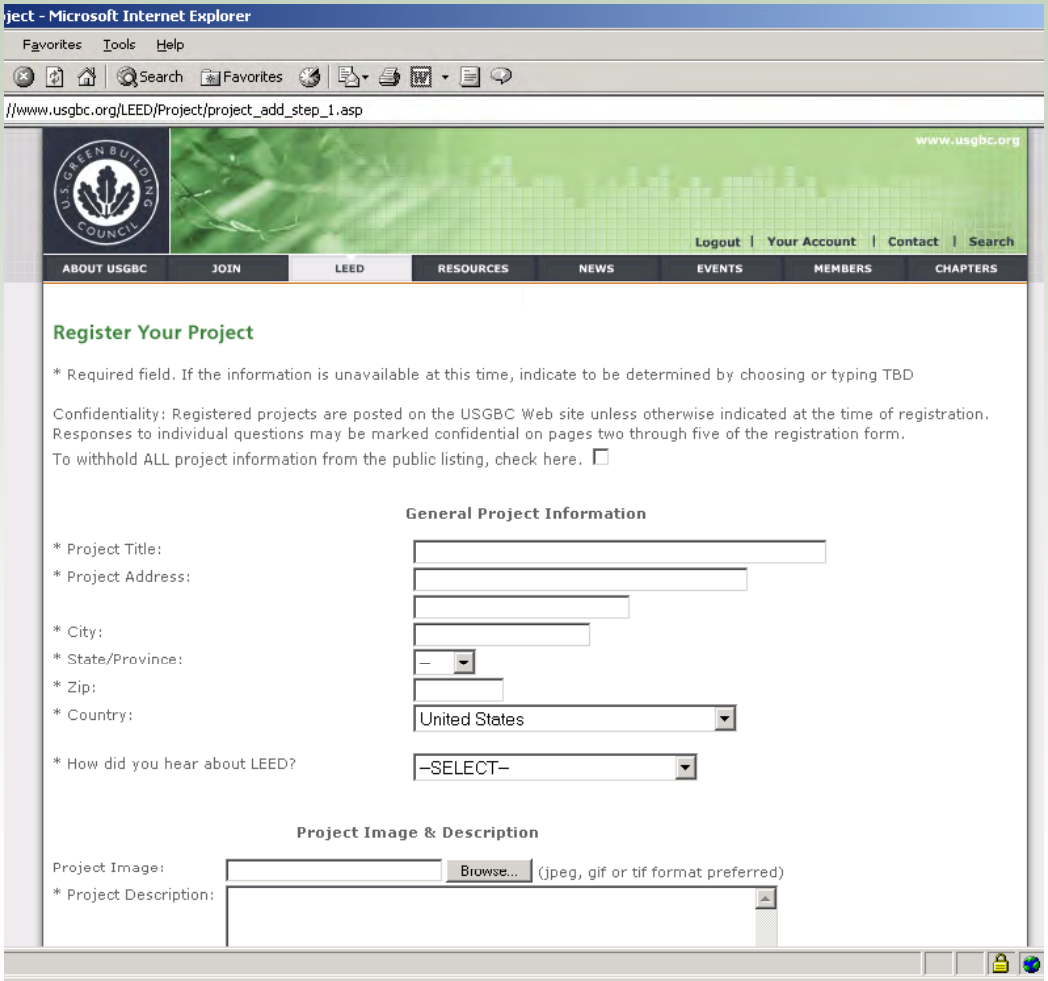
Documentation – Throughout design and construction

Certification – At or near occupancy

Certification Reaps Benefits

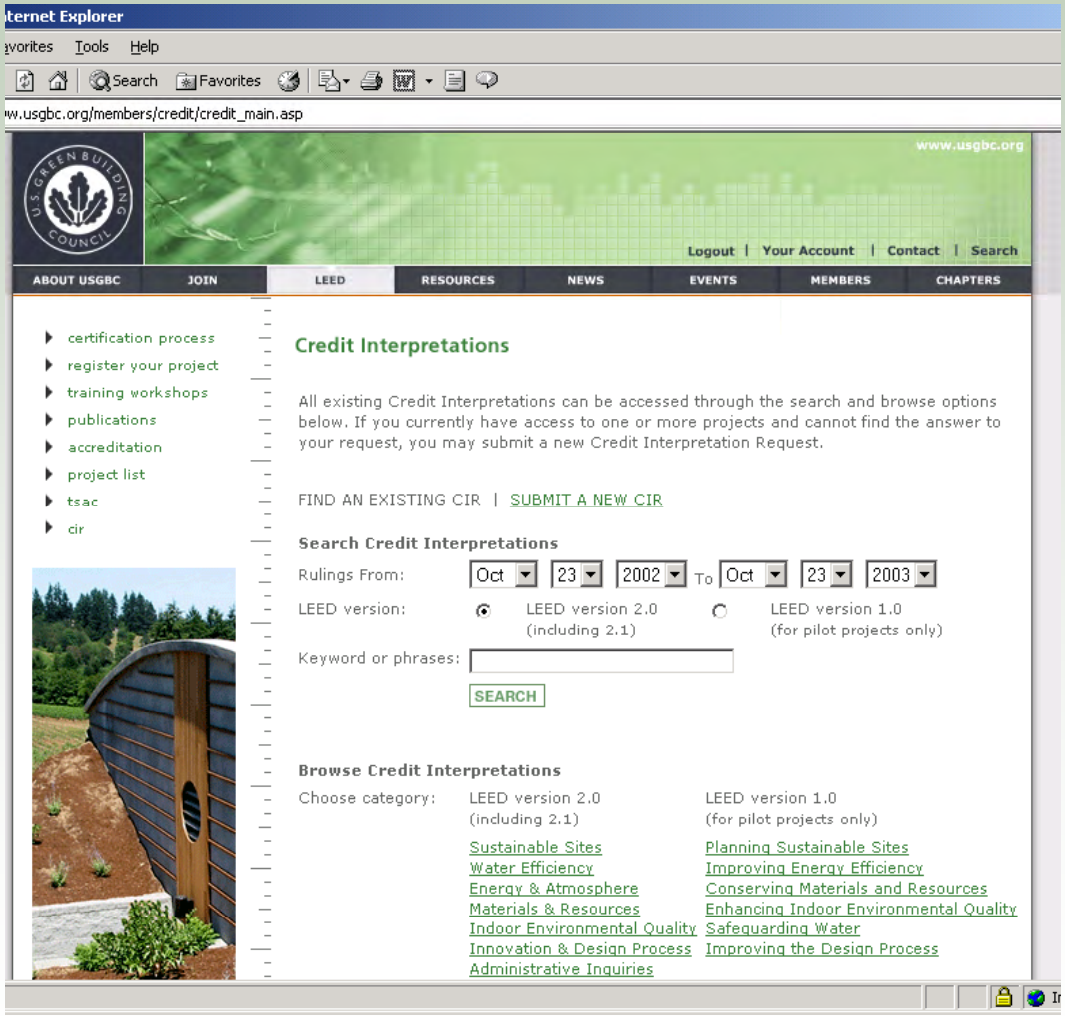
- Third party validation of achievement
- Recognition of quality buildings
- Recognition of environmental stewardship
- Qualify for state and local government incentives
- LEED certification plaque to mount on building
- Official certificate
- Marketing exposure through USGBC web site, case studies, and media coverage.

Project Registration is Executed Online



- Access to certification resources i.e. Letter Templates & CIR databases
- Two free credit interpretation requests per registered project
- Online project listing

CIR – Credit Interpretation Requests



- Many credits have gray areas that need clarification
- Searchable database
- Organized by LEED credit
- Constantly updated
- Two free with registration
- $220 for each CIR thereafter

energy Appalachian

LEED Registration and Certification Costs

Item	**Less than 75,000 Square Feet**	**75,000 - 300,000 Square Feet**	**More than 300,000 Square Feet**
	Fixed Rate	Based on Square Ft.	Fixed Rate
Registration			
Members	$750	$0.01 per Square Foot	$3,000
Non-Members	$950	$0.0125 per Square Foot	$3,750
Certification			
Members	$1,500	$0.02 per Square Foot	$6,000
Non-Members	$1,875	$0.025 per Square Foot	$7,500
All fees are subject to change.			

The LEED Scorecard

LEED
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

SCORECARD

Yes	?	No		
0	0	0	**Sustainable Sites**	**14** Points

Y					
			Prereq 1	**Erosion & Sedimentation Control**	Required
			Credit 1	**Site Selection**	1
			Credit 2	**Urban Redevelopment**	1
			Credit 3	**Brownfield Redevelopment**	1
			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
			Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles	1
			Credit 4.4	**Alternative Transportation**, Parking Capacity and Carpooling	1
			Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space	1
			Credit 5.2	**Reduced Site Disturbance**, Development Footprint	1
			Credit 6.1	**Stormwater Management**, Rate and Quantity	1
			Credit 6.2	**Stormwater Management**, Treatment	1
			Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	1
			Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof	1
			Credit 8	**Light Pollution Reduction**	1

energy Appalachian

The LEED Letter Template

SS Credit 1: Site Selection

Declaration not made
(Civil Engineer or Responsible Party)

I, , declare that no buildings, roads or parking areas have been or will be developed on portions of sites that meet any one of the following criteria:

☐ Prime farmland as defined by the United States Department of Agriculture in the United States' Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5),

☐ Land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by the Federal Emergency Management Agency (FEMA),

☐ Land which is specifically identified as habitat for any species on Federal or State threatened or endangered lists,

☐ Within 100 feet of any water including wetlands as defined by United States' Code of Federal Regulations 40 CFR, Parts 230-233 and Part 22, and isolated wetlands or areas of special concern identified by state or local rule, OR greater than distances given in state or local regulations as defined by local or state rule or law, whichever is more stringent,

☐ Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner (Park Authority projects are exempt).

	Points Documented
SS Cr 1 (1 point): Site selection avoiding inappropriate locations	0

Name: #N/A

Organization: #N/A

Role in project: #N/A

Signature: _____

Date: 5/20/2005

energy Appalachian

Integrated Design

- Integrated Design means to fully integrate traditional design criterion of function, form, economy and schedule in balance with environmental goals.
- The “environmental” part needs to have equal consideration to these traditional components.

Integrated Design

- Team Selection
  - Attitude, creativity
  - Cross disciplinary interests
- Goal Setting
  - Assessment
  - Understanding
- Design Charrette
- Champions
- Team Work
- Optimization of Systems
  - Lots of tools available
- Follow Through
  - Construction
  - Commissioning
  - Maintenance

Credit Structure

- Each credit identifies the intent, requirements and technologies and strategies
- Offers educational information rather than simply a statement of required elements
- performance-based not prescriptive

Credit Requirement

- Identifies specific elements needed to achieve the credit
- Defines actionable items
- Where practical, includes components of referenced standards and critical compliance issues

Credit Technologies & Strategies

- Includes a summary of recommended technologies and strategies to meet the credit requirements
- Refers readers to the Reference Guide when calculation methodologies or detailed strategies are available to assist with compliance

Sustainable Sites

- Erosion and Sedimentation control (prerequisite)
- Site selection
- Urban redevelopment
- Brownfield redevelopment
- Alternative transportation
- Reduced site disturbance
- Stormwater management
- Reduce heat islands
- Light pollution reduction

Sustainable Sites

Prerequisite 1 - Erosion and Sedimentation Control

1. Provide an erosion and sedimentation control plan
2. Prevent topsoil loss due to storm and wind erosion
3. Prevent sedimentation of storm sewer and streams
4. Prevent polluting the air with dust and particulate matter

Sustainable Sites

Credit SS 1 - Site Selection

Avoid building on (5 criteria):

- Prime agricultural land
- Land less than 5 feet above the 100-year flood plain
- Within 100 feet of wetlands
- Threatened species habitat
- Prior public parkland

Sustainable Sites

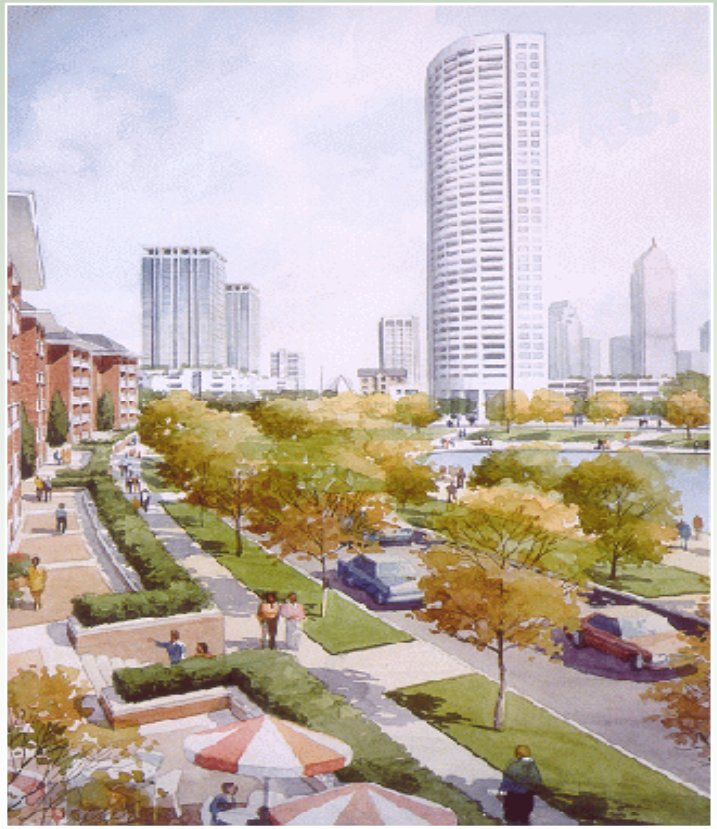
Credit SS 2 - Urban Redevelopment

- 60,000 sq. ft. per acre
- Density radius
- 2 story downtown development

Sustainable Sites

Credit SS 3 - Brownfield Redevelopment

- Remediate and develop a Brownfield site
- Definition of brownfield can include perceived contamination



Sustainable Sites

Credit SS 4 - Alternate Transportation(4 points available)

- SS 4.1 Public transportation Access
- SS 4.2 Bicycle storage and changing rooms (5%) and showers
- SS 4.3 Alternative-fuel vehicles (3%)
- SS 4.4 Parking capacity and carpooling

Sustainable Sites

Credit SS 5 - Reduced Site Disturbance (2 points available)

- SS 5.1 Protect or restore open space
  - 5 feet beyond roads, curbs, walkways, etc
  - 40 feet beyond building perimeter
  - 25 beyond constructed areas
- OR, on previously developed sites, restore 50% degraded habitat
- SS 5.2 Development footprint
  - Exceed open space requirement by 25%
  - Campus, bases etc. have special requirements

Sustainable Sites

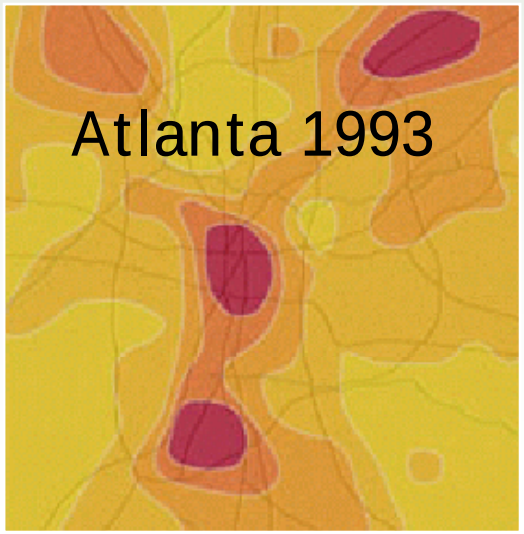
Credit SS 6 - Stormwater Management

- SS 6.1 - Rate and Quantity
- SS 6.2 - Treatment

Sustainable Sites

Credit SS 7 - Landscape & Exterior Design to Reduce Heat Islands

- SS 7.1 - Shade 30% of non-roof impervious surfaces
  OR use light-colored/reflective materials for 30%
  OR place 50% of parking underground
  OR use open grid pavement for 50% of parking
- SS 7.2 - High performance roof OR 50% vegetated roof



Sustainable Sites

Credit SS 8 - Light Pollution Reduction

- Meet IESNA foot-candle levels AND design so that zero direct beam illumination leaves the building site

Water Efficiency

- Efficient landscaping
- Innovative technologies
- Use reduction

Water Efficiency

Credit WE 1 Water Efficient Landscaping

- WE 1.1 - Use micro irrigation or capture water to reduce irrigation by 50%
- WE 1.2 - Use only captured water or install no permanent irrigation system

Water Efficiency

Credit WE 2 - Innovative Wastewater Technologies

- WE 2 - Reduce water use for sewerage conveyance by 50%

Water Efficiency

Credit WE 3 - Water use reduction

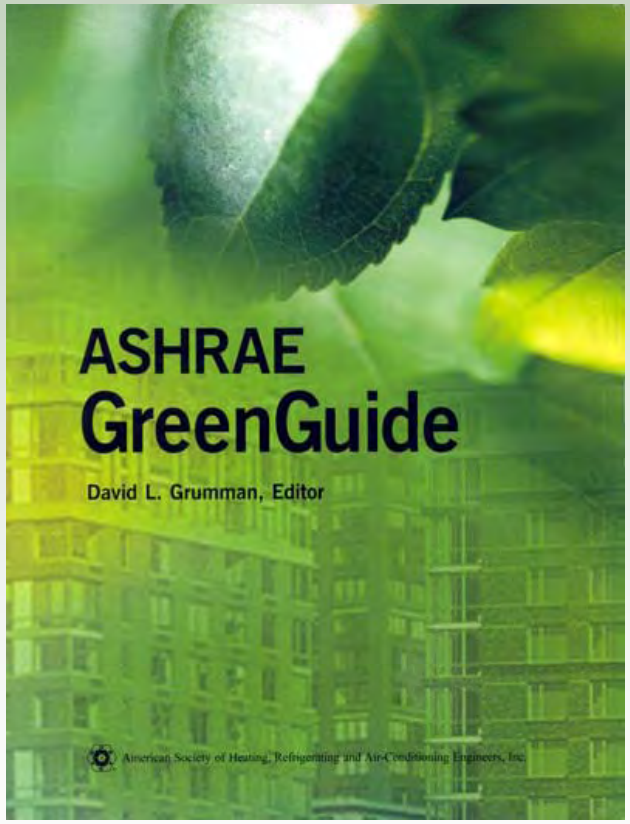
- WE 3.1 - Reduce potable water use by 20%
- WE 3.2 - Reduce potable water use by 30%

Energy and Atmosphere

- Fundamental building commissioning (prerequisite)
- Minimum energy performance (prerequisite)
- CFC reduction (prerequisite)
- Optimize performance
- Renewable Energy
- Additional commissioning
- Eliminate HCFCs and Halons
- Measurement and verification
- Green power

Energy and Atmosphere

- Fundamental Building Commissioning
- Reduce CFC's in HVACR Equipment
- Minimum Energy Performance



Energy and Atmosphere

Credit EA 1 - Optimize Energy Performance

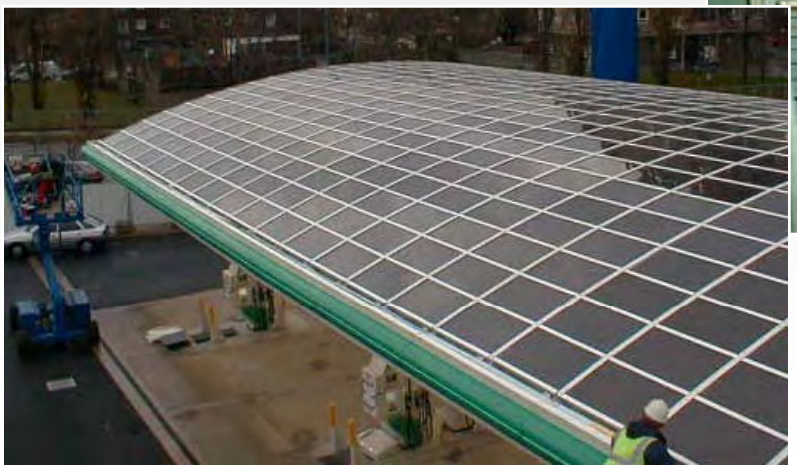
- Compliance with 90.1 is Prerequisite
- Design to exceed ASHRAE 90.1-1999 (ECB)
- Model buildings to optimize performance

New	Existing	Points
20%	10%	2
30%	20%	4
40%	30%	6
50%	40%	8
60%	50%	10

Energy and Atmosphere

Credit EA 2 - Renewable Energy (3 points possible)

Energy Use	Points
5%	1
10%	2
20%	3



Energy and Atmosphere

Credit EA 3 - Additional Building Commissioning

- Prerequisite is fundamental Cx
- Cx spec
- Mech spec + TAB
- Elec spec
- Introductory Architectural spec.

Energy and Atmosphere

Credit EA 4 - Elimination of HCFC's and Halons

- Global Warming Potential (GWP)
- Ozone Depletion Potential (ODP)
- CFC / HCFC / HFC

Energy and Atmosphere

Credit EA 5 - Measurement & Verification

Credit EA 6 - Green Power

Materials and Resources

Recyclables (prerequisite)

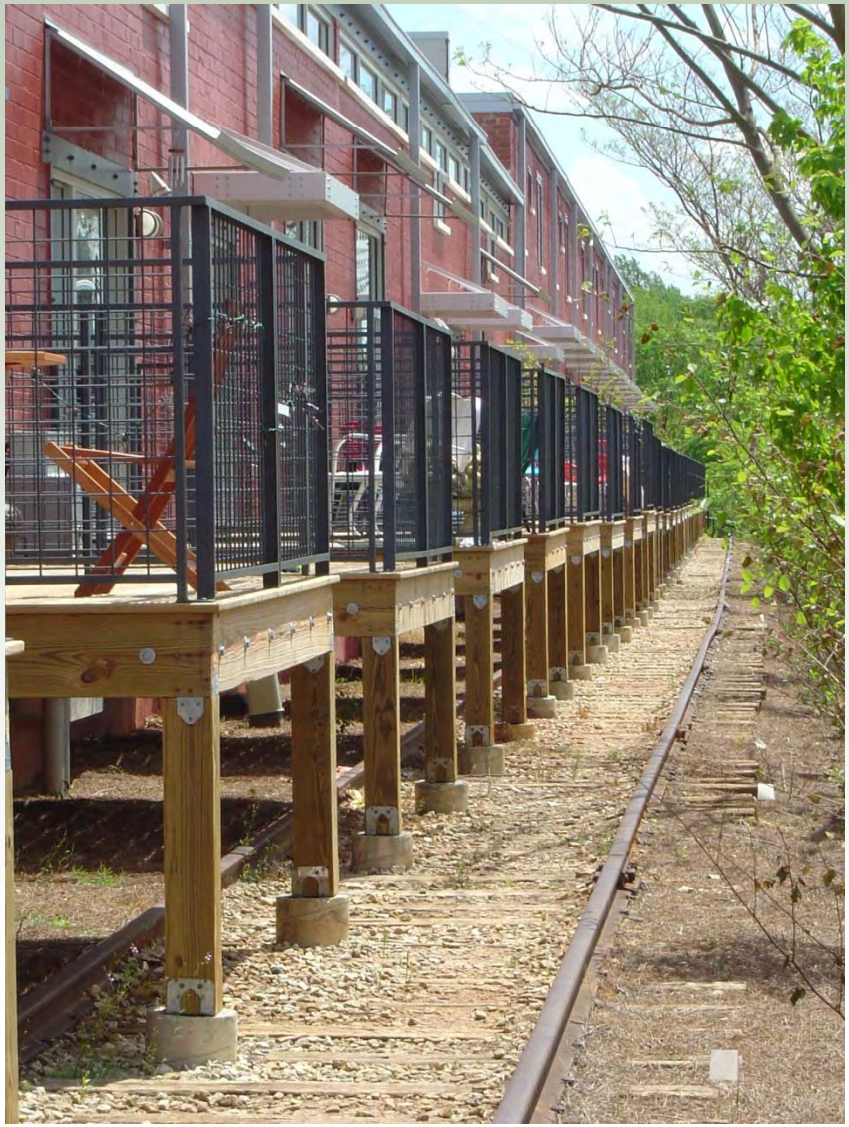
- Building reuse
- Construction waste
- Resource reuse
- Recycled content
- Regional materials
- Rapidly renewable materials
- Certified wood

Materials and Resources

- MR Prerequisite 1 -Storage & Collection of Recyclables

  - Design an adequate method and area for separation, collection, and storage of recycled materials including:
    - Paper
    - Cardboard
    - Glass
    - Plastics
    - metals

Materials and Resources



3 Points Available

- Maintain 75% of existing shell
- Maintain 100% of existing shell
- Maintain 100% of existing shell AND 50% of non-shell
- Do not block railroad tracks

Materials and Resources

Credit MR 2 - Construction Waste Management

- MR 2.1 - Recycle/salvage 50% C & D and land clearing waste
- MR 2.2 - Recycle/salvage 75% C & D and land clearing waste

Materials and Resources

Credit MR 3 - Resource Reuse

- MR3.1 - Specify salvaged/ refurbished for 5% of all materials
- MR3.1 - Specify salvaged/ refurbished for 10% of all materials

Credit MR 4 - Recycled Content

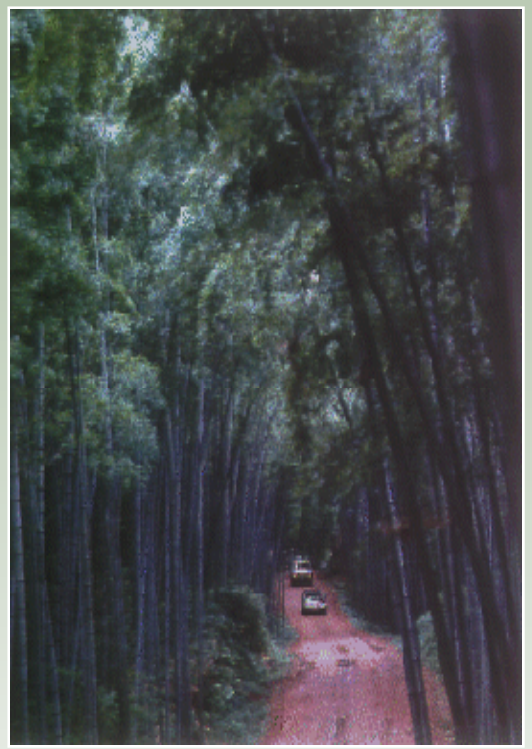
- MR 4.1 - 5% recycled content (post-consumer + 1/2 post-industrial)
- MR 4.2 - 10% recycled content (post-consumer + 1/2 post-industrial)

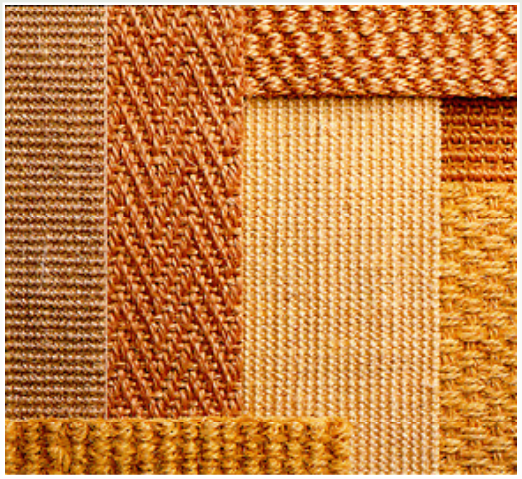
Credit MR 5 - Local / Regional Materials

- 20% Manufactured locally
- Half of above locally harvested

500 Mile Area Local & Regional Materials

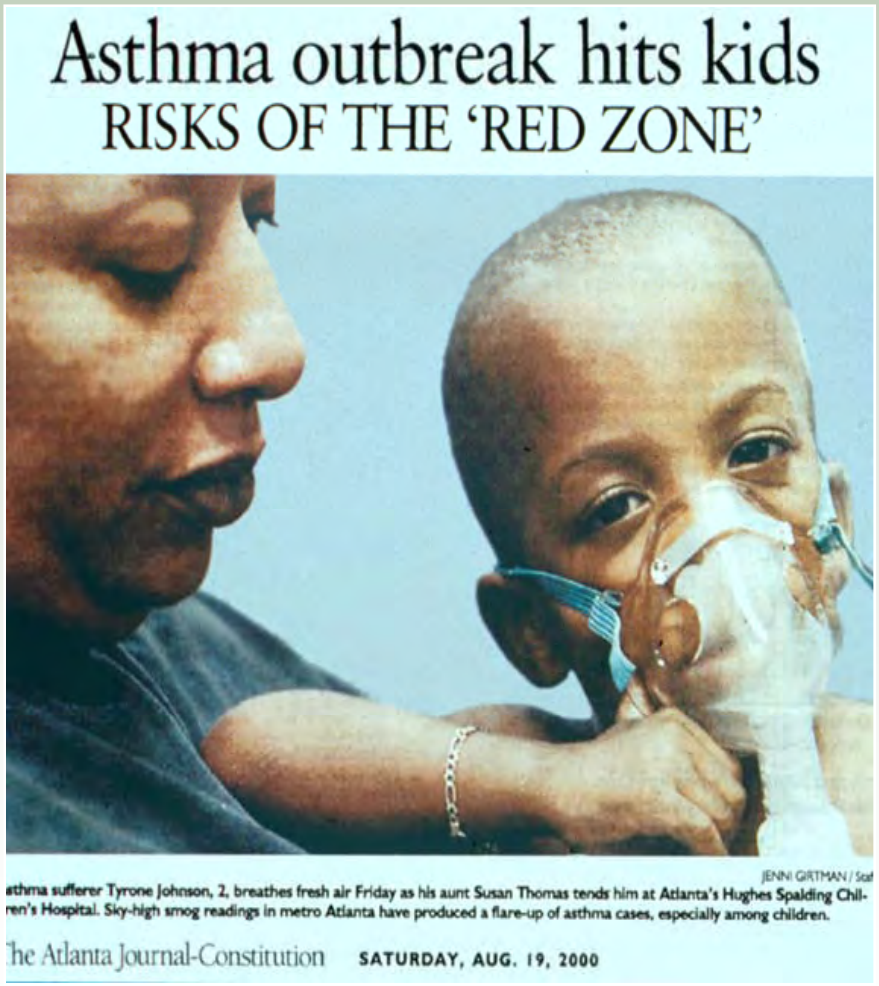
Materials and Resources





- Credit MR 6 - Rapidly Renewable Materials
  - materials harvested in less than 10 year cycles
- Credit MR 7 - Certified Wood
  - 50% wood-based materials FSC certified

Indoor Environmental Quality (IEQ)



Asthma outbreak hits kids
RISKS OF THE 'RED ZONE'

JENNI GIRTMAN / Staf

sthma sufferer Tyrone Johnson, 2, breathes fresh air Friday as his aunt Susan Thomas tends him at Atlanta's Hughes Spalding Chil-ren's Hospital. Sky-high smog readings in metro Atlanta have produced a flare-up of asthma cases, especially among children.

The Atlanta Journal-Constitution SATURDAY, AUG. 19, 2000

Minimum IAQ (prerequisite)

ETS (prerequisite)

- CO_2 Monitoring
- Ventilation effectiveness
- Construction IAQ
- Low-emitting materials
- Indoor pollutants
- System controllability
- Thermal comfort
- Daylight and views

Indoor Environmental Quality

Prerequisite:
Minimum IAQ Performance

- ASHRAE 62-1999

Prerequisite: Environmental Tobacco Smoke Control

- No smoking in building OR engineered facility with specialty ventilation

Indoor Environmental Quality

Credit EQ 1 - Carbon Dioxide (CO_2) Monitoring

- Install CO_2 monitoring system AND ensure that indoor CO_2 levels are not greater than 530 ppm over outdoor levels

Credit EQ 2 - Increase Ventilation Effectiveness

- Design ventilation system for air change effectiveness (Eac) > 90%

Indoor Environmental Quality

Credit EQ 3 - Construction IAQ Management Plan

- EQ 3.1 - During Construction: Meet or exceed SMACNA IAQ 1995 guidelines, protect absorptive materials from moisture damage, filter all air if fans used, and replace all filtration prior to occupancy
- EQ 3.2 - Before Occupancy: Conduct a two-week building flush-out with 100% outside air OR conduct a baseline IAQ test procedure consistent with EPA protocol for RTP campus

Indoor Environmental Quality

Credit EQ 4 - Low-Emitting Materials

- EQ 4.1 - Adhesives and sealants
- EQ 4.2 - Paints and coatings
- EQ 4.3 - Carpets
- EQ 4.4 - Composite wood-products

Indoor Environmental Quality

Credit EQ 5 - Indoor Chemical and Pollutant Source Control

- No cross-contamination of areas
- Provide permanent walk off systems
- Ventilate chemical usage areas (janitorial, photo and copying rooms)
- Plumb drains for appropriate chemical mixing & waste

Indoor Environmental Quality

Credit EQ 6 - Controllability of Systems

- Provide operable windows, airflow, temperature, and lighting controls

Credit EQ 7 - Thermal Comfort

- ASHRAE 55-1992, comfort standards
- Install temperature and humidity monitoring system

Indoor Environmental Quality

Credit EQ 8 - Daylight and Views

- Minimum Daylight Factor of 2% for 75% of spaces occupied for tasks
- Provide direct line of sight to 90% of regularly occupied spaces

Innovation and Design Process

- ID 1.0 to 1.4 - Innovation in Design (4 points possible)
- ID 2 - LEED Accredited Professional

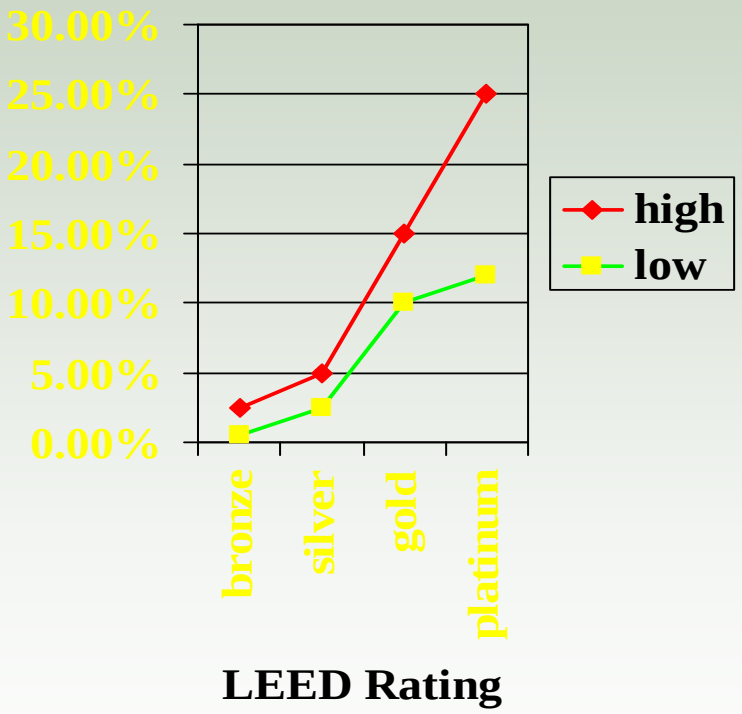
Certification Application

- Three ring binder, electronic media, or combination including:
  - Application Form and LEED Project Scorecard
  - Completed documentation checklist and specified documentation per credit (tabbed)
  - Information must be well organized and credit compliance documented efficiently

Does it Cost More?

- If the stakeholder is committed at the project conception…and
- The design and construction team has moderate sustainability experience….
- A LEED certified building can be achieved on a conventional budget

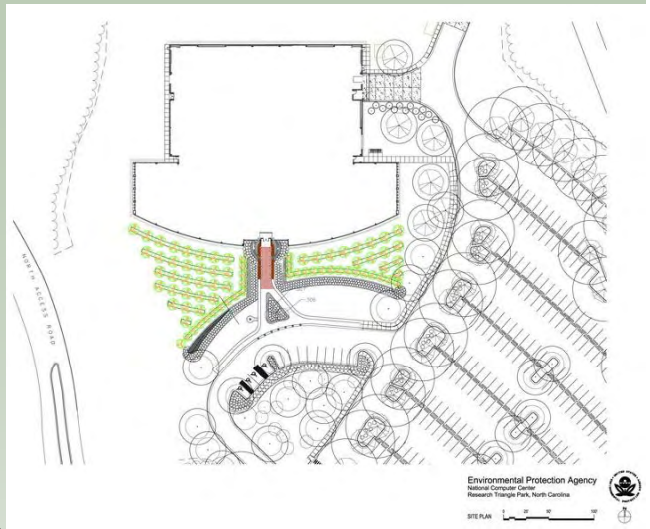
Green Buildings & Initial Costs



- 4 LEED levels: Bronze, Silver, Gold, Platinum
- Initial costs tend to be higher
- Integrated design promises lower costs

EPA Computer Center

U.S. EPA National Computer Center Overview



- Location: Research Triangle Park,
- Building type's Commercial office
- New construction
- 101,000 sq. feet (9,380 sq. meters)
- Project scope: 2-story building
- Suburban setting
- Completed January 2002
- Rating: U.S. Green Building Council **LEED-NC**, v.2/v.2.1--Level: **Silver** (35 points)

Design: Kevin Montgomery, AIA
O'Brien/Atkins Associates, PA
Architect (Designer)

Research Triangle Park, NC

Owner & Occupancy

- Owned and occupied by U.S. Environmental Protection Agency, Federal government
- Typically occupied by 206 people, 40 hours per person per week

Building Programs

- Indoor Spaces: Data processing, Office, Outdoor Spaces: Wildlife habitat (65%), Parking (15%), Drives/roadway (4%), Interpretive landscape (2%), Restored landscape (2%), Pedestrian/non-motorized vehicle path (1%)

Land Use & Community

Green Strategies

- **Responsible Planning**
  - Ensure that development fits within a responsible local and regional planning framework
- **Support for Appropriate Transportation**
  - Provide showers and changing areas for bicycle and pedestrian commuters
  - Provide access to public transportation
- **Property Selection Opportunities**
  - Look for a property where infrastructure needs can be combined

Water Conservation and Use

Green Strategies

- Development Impacts
  - Minimize development impact area
- Runoff Reduction
  - Use planted swales instead of curbs and gutters
- Landscape Plantings
  - Landscape with indigenous vegetation
- Low-Water-Use Fixtures
  - Use automatic faucet controls for lavatories
- Managing Stormwater
  - Utilize sheet flow
- Demand for Irrigation
  - Select plants for drought tolerance
- Low-Impact Siting
  - Site development carefully to protect significant ecosystems
- Site Planning
  - Provide for solar access

Energy

Green Strategies

- **Daylighting for Energy Efficiency**
  - Use south-facing windows for daylighting
  - Orient the floor plan on an east-west axis for best use of daylighting
  - Locate frequently used areas on the south side of the building
  - Use atrium for daylighting
  - Use large interior windows to increase daylighting penetration
- **Hot Water Loads**
  - Use water-efficient faucets
- **Photovoltaics**
  - Use building-integrated photovoltaics (PV) to generate electricity on-site
- **Heating Systems**
  - Use direct-gain passive solar heating
- **Lighting Controls**
  - Use modulating photoelectric daylight sensors
  - Use occupancy sensors
- **HVAC Distribution Systems**
  - Use variable frequency drives for fans
- **HVAC Controls and Zoning**
  - Provide sufficient sensors and control logic

Materials & Resources

Diversion of Construction & Demolition Waste

- From the beginning of the project, EPA wanted to emphasize waste reduction and recycling. A construction waste management program was put in place, calling for sorting by category, including cardboard, paper, lumber, steel, aluminum, gypsum board remnants, and organic land-clearing matter. As a result, 82%, by weight, of the construction waste generated was recycled; this was verified by a tally of the hauler weight receipts.

Materials and Resources

Austin's angular city hall earned a gold LEED rating for its innovative design and energy-saving features. Most of the building materials were chosen for their high degree of recycled content. On the plaza, a large solar panel generates 9 kilowatts a day and shades seating during outdoor events. Photo by Douglas Fails, TCEQ

Green Products Used

- Photovoltaic Collectors
- Recycled-Content Carpet Tile
- Recycled-Content Gypsum Board
- Recycled-Rubber Athletic Flooring
- **Design for Adaptability to Future Uses**
- The computer equipment areas use raised access floors, which provide a great deal of flexibility with regard to connectivity and room reconfiguration.

Green Strategies

- **Job Site Recycling**
  - Designate a recycling coordinator
  - Require that subcontractors keep their wastes separate
- **Post-Consumer Recycled Materials**
  - Specify heavy steel framing with highest recycled content
  - Specify carpet made with recycled-content face fiber
- **Pre-Consumer Recycled Materials**
  - Use recycled-content rubber flooring

energy Appalachian STATE UNIVERSITY

Indoor Environment

Green Strategies

- **Visual Comfort and The Building Envelope**
  - Incorporate light shelves on the south facade
- **Visual Comfort and Interior Design**
  - Place primarily unoccupied spaces away from daylight sources
- **Direct Exhaust from High-source Locations**
  - Provide local exhaust ventilation for rooms with high-emitting sources
- **Reduction of Indoor Pollutants**
  - Use only very low or no-VOC paints
  - Use only very-low-VOC carpet adhesives
- **Isolation of Indoor Pollutants**
  - Wait three or more days after painting to install carpet
- **Ventilation During Construction**
  - Purge the building of VOCs during furniture installation prior to move-in

Chicago Center for Green Technology

Overview

- Location: Chicago, IL
- Building type(s): Commercial office, Industrial, Assembly, Other
- Renovation of a 1952 building
- 40,000 sq. feet (3,720 sq. meters)
- Project scope: 2-story building
- Urban setting
- Completed January 2003
- Rating: U.S. Green Building Council LEED-NC, v.1.0--Level: Platinum

Narrative

Designed by Chicago-based Farr Associates Architecture and Urban Design, the building uses solar and geothermal energy, a rooftop garden, and a natural habitat to filter storm water. The city invested $9 million in clean-up costs and another $5.4 million toward construction and renovation. The 1952 building is surrounded by a 17-acre site that was formerly the Sacramento Crushing Corporation, a construction materials recycler. The company was closed in 1996 after 600,000 cubic yards of waste were discovered on the site. The money for the Chicago Center for Green Technology came from a settlement with the Commonwealth Edison Company.

Environmental Aspects

- Environmental features of the building include: solar panels, rainwater collection for irrigation, recycled building materials, smart lighting, a green roof, and a geothermal exchange system. The building's tenants also reflect an environmental ethic; Spire Corporation (a solar panel production company), GreenCorps Chicago (a community gardening and job-training program), and a Chicago Department of Environment satellite office are housed here.
- The Center achieved a U.S. Green Building Council LEED (Leadership in Energy and Environmental Design) Platinum rating. LEED addresses environmental construction and operation through five categories: site design, energy efficiency, materials and resources, indoor environmental quality, and water efficiency.

Owner & Occupancy

- Owned by Chicago Department of Environment, Local government
- Occupants: Corporation, for-profit
- Typically occupied by 35 people, 50 hours per person per week; and 100 visitors per week, 2 hours per visitor per week
- Spire Solar Corp, GreenCorps Chicago (community gardening and job skills program), City Department of Environment satellite office, and others will be housed in the building.

Land Use & Community

The building is located within 1/2 mile of a Metra Rail station and within 1/4 mile of two bus lines. Bike storage is provided along with showers and changing facilities for bicycle commuters. Recharging stations are provided for electric vehicles in the rear parking lot. Preferred parking is provided for carpools.

The brownfield site, which had been turned into a dumping ground for construction and demolition materials, was cleaned by the city at a cost of nine million dollars. Much of the material accumulated on the site was recycled or salvaged for reuse.

Green Strategies

- **Property Evaluation**
  - Investigate property for possible contaminants (e.g., toxic or hazardous wastes, dumps)
- **Responsible Planning**
  - Ensure that development fits within a responsible local and regional planning framework
- **Support for Appropriate Transportation**
  - Provide showers and changing areas for bicycle and pedestrian commuters
  - Provide storage area for bicycles
  - Provide access to public transportation
  - Provide vehicle access to support car and vanpooling
  - Provide for electric vehicle charging
- **Property Selection Opportunities**
  - Look for opportunities for infill development
  - Select brownfield sites for development
  - Select already-developed sites for new development

energy Appalachian STATE UNIVERSITY

Site Description
Lot size: 160,000 ft2
Building footprint: 40,000 sq ft (3,720 sq meters)
Previously developed land, Brownfield site, Wetlands, Preexisting structure(s)

Green Strategies

- **Ecosystem Restoration**
  - Replant damaged sites with native vegetation
- **Runoff Reduction**
  - Use planted swales instead of curbs and gutters
  - Design a green roof system
- **Landscape Plantings**
  - Landscape with indigenous vegetation
- **Low-Water-Use Fixtures**
  - Use low-flow toilets
- **Managing Stormwater**
  - Disconnect roof leaders and storm drains from conventional infrastructure
  - Design a constructed wetland for pollutant removal from stormwater
- **Rainwater Collection**
  - Collect and store rainwater for landscape irrigation
- **Integration with Site Resources**
  - Use light-colored pavement to reduce heat island effect
- **Low-Impact Siting**
  - Select building sites that make use of existing infrastructure

Energy

The building and its mechanical, electrical, and plumbing systems are being commissioned to ensure they are installed and functioning per the original design intentions. The building surpasses ASHRAE 90.1 by 40%, which means that the Center uses 40% less energy than a minimally code-compliant building of the same size. These energy savings are expected to save approximately $29,000 per year.

Energy

Green Strategies

- **Ground-coupled Systems**
  - Use ground-source heat pumps as a source for heating and cooling
- **Solar Cooling Loads**
  - Shade south windows with exterior louvers, awnings, or trellises
- **Daylighting for Energy Efficiency**
  - Use large exterior windows and high ceilings to increase daylighting
  - Use skylights for daylighting
- **High-performance Windows and Doors**
  - Optimize energy performance of glazing systems
- **Lighting Controls**
  - Use modulating photoelectric daylight sensors
- **HVAC Controls and Zoning**
  - Provide sufficient sensors and control logic

Materials and Resources

- **Diversion of Construction & Demolition Waste**
- 84% of all construction waste was diverted from the landfill.
- **Green Products Used**
- Cork Flooring
- Green Roof Systems
- Natural Linoleum Flooring
- Non-Petroleum Flexible Pavement
- Reclaimed Lumber and Timbers
- Recycled-Content Acoustical Ceiling Panels
- Recycled-Content Cellulose Insulation
- Recycled-Glass Ceramic Tiles
- Recycled-Plastic Restroom Partitions
- Zero-VOC Interior Acrylic Latex Paint

Materials and Resources

Green Strategies

Protection of Global Ecosystem

- Avoid rigid or blown foam insulation made with an HCFC blowing agent

- **Building Deconstruction**
  - Reuse existing structure
- **Recycling by Occupants**
  - Specify recycling receptacles that are accessible to **the occupants**
- **Toxic Upstream or Downstream Burdens**
  - Use wood treated with less-toxic preservatives than the standard CCA or ACZA
- **Post-Consumer Recycled Materials**
  - Prefer insulation with high recycled content
- **Pre-Consumer Recycled Materials**
  - Use recycled-content rubber flooring
- **Transportation of Materials**
  - Prefer materials that are sourced and manufactured within the local area

Materials and Resources


Green Roof at Chicago Center for Green Technology

Green Strategies

- **Protection of Global Ecosystem**
  - Avoid rigid or blown foam insulation made with an HCFC blowing agent
- **Building Deconstruction**
  - Reuse existing structure
- **Recycling by Occupants**
  - Specify recycling receptacles that are accessible to the occupants
- **Toxic Upstream or Downstream Burdens**
  - Use wood treated with less-toxic preservatives than the standard CCA or ACZA
- **Post-Consumer Recycled Materials**
  - Prefer insulation with high recycled content
- **Pre-Consumer Recycled Materials**
  - Use recycled-content rubber flooring
- **Transportation of Materials**
  - Prefer materials that are sourced and manufactured within the local area

Indoor Environment

- All asbestos was removed from the building.

Smoking is not permitted in the building.

A construction indoor air quality management plan, involving protecting ducts from contamination and cleaning ducts prior to occupancy, was designed and implemented by the contractor. Low-VOC materials were used exclusively in the construction of the building.

Green Strategies

- **Outdoor Pollution Sources**
  - Research previous uses of the site
- **Identification of Indoor Pollutants**
  - Check old vinyl flooring and pipe insulation for asbestos
- **Reduction of Indoor Pollutants**
  - Use only very low or no-VOC paints
  - Use only very-low-VOC carpet adhesives
- **Ventilation During Construction**
  - Provide temporary filters on any permanent air-handling devices used during construction
- **Building Commissioning for IEQ**
  - Use a comprehensive commissioning process to ensure that design intent is realized
- **Facility Policies for IEQ**
  - Recommend a non-smoking policy for the building

energy Appalachian STATE UNIVERSITY

LEED and Cost Effectiveness

- LEED projects typically involve:
  - Additional construction costs
  - Savings on energy and water costs
  - Changes in the cost of operation and maintenance
- It is important to be able to present the economic analysis to show whether the savings will pay for the additional costs

Measures of Cost Effectiveness

Example Green Building

Extra Cost: $225,000.00

Energy Savings: $30,000.00

Water Savings: $8,500.00

Operation and Maintenance Savings: $5,000.00

- Payback period =

$$\frac{\text{Additional Construction Costs}}{\text{Annual Savings}}$$

- Example = 225,000 / 43,500 = 5.2 years
- Hard to interpret in regard to % annual return
- Cannot incorporate annual % increases in fuel and operating costs

Measures of Cost Effectiveness

- Loan analysis
  - Assume the additional construction costs receive standard financing
  - Compare annual payments to annual utility and other savings
  - Method still does not incorporate % increases in energy costs; also only states annual savings
- Chart on next page calculates annual payments
- Example: 8% interest for 10 years

Loan Multipliers

Interest Rate	Term (years)					
	3	5	10	15	20	30
6.00%	0.365	0.232	0.133	0.101	0.086	0.072
6.25%	0.366	0.233	0.135	0.103	0.088	0.074
6.50%	0.368	0.235	0.136	0.105	0.089	0.076
6.75%	0.369	0.236	0.138	0.106	0.091	0.078
7.00%	0.371	0.238	0.139	0.108	0.093	0.080
7.25%	0.372	0.239	0.141	0.110	0.095	0.082
7.50%	0.373	0.240	0.142	0.111	0.097	0.084
7.75%	0.375	0.242	0.144	0.113	0.099	0.086
8.00%	0.376	0.243	0.146	0.115	0.100	0.088
8.50%	0.379	0.246	0.149	0.118	0.104	0.092
9.00%	0.382	0.249	0.152	0.122	0.108	0.097
9.50%	0.384	0.252	0.155	0.125	0.112	0.101
10.00%	0.387	0.255	0.159	0.129	0.116	0.105
10.50%	0.390	0.258	0.162	0.133	0.120	0.110
11.00%	0.393	0.261	0.165	0.136	0.124	0.114
11.50%	0.396	0.264	0.169	0.140	0.128	0.119
12.00%	0.399	0.267	0.172	0.144	0.132	0.123

Steps:

1. Based on annual interest rate and term, find multiplier

2. Multiply additional construction costs by multiplier to find annual loan payments (compounded monthly)

energy Appalachian

Example: Loan Analysis

- Additional Construction Costs: -$225,000
- Loan Multiplier (from chart) x 0.146
- Annual Loan Payments -$32,850
- Annual Savings +$43,500
- Net Annual Savings (Costs) +$10,650

Measures of Cost Effectiveness

- Net Present Value
  - Compares total net benefits over time to the total additional construction costs
  - Allows for annual % increases and decreases in the future
  - Discounts future dollars
    - Time value of money
    - 10% discount rate assumes that $1,000 today has the same value as $1,100 in one year and $2,594 in ten years ($1000*(1+0.10)^{10}$)
    - While confusing to some, it is the correct way to relate future income and costs to the present

Finding the Present Worth of the Future Savings

- When conducting Net Present Value Analysis your have to calculate the Present Worth – value today – of the annual savings and costs
- You have annual savings on energy, water, and O&M that need to be converted into Present Worths
- Assume that your client has a minimum discount rate of 15% -- the minimum rate of return expected on investment
- To find the Present Worth for 20 years of savings, first use the chart on the following page to find the Annual to Present Worth Factor

Annual-to-Present-Worth Factors

Discount Rate	Time Period (years)				
	5	10	15	20	30
3.00%	4.580	8.530	11.938	14.877	19.600
5.00%	4.329	7.722	10.380	12.462	15.372
7.00%	4.100	7.024	9.108	10.594	12.409
10.00%	3.791	6.145	7.606	8.514	9.427
12.00%	3.605	5.650	6.811	7.469	8.055
15.00%	3.352	5.019	5.847	6.259	6.566
20.00%	2.991	4.192	4.675	4.870	4.979
25.00%	2.689	3.571	3.859	3.954	3.995
30.00%	2.436	3.092	3.268	3.316	3.332
35.00%	2.220	2.715	2.825	2.850	2.857

Net Present Value Analysis

- Remember, our total savings on energy, water, and O&M was $43,500 in the first year of operation
- The Present Worth of that savings at a 15% discount rate for 20 years would be:
  $43,500 * 6.259 = $272,266
- The Net Present Value is then:

  $272,266 - $225,000 (Additional Construction Cost) = $47,266
- The positive value means the investment is earning more than the 15% annual discount rate

Net Present Value (cont.)

- We still have a bit of a problem – we haven't factored in the annual cost increases – *escalation rates* – for energy, water and O&M
- The next chart allows you to find the Annual-to-Present-Worth Factor for the discount rate and the escalation rate for annual savings and costs over a 20-year time horizon
- At the end of the section, there are charts for other time horizons

Annual-to-Present-Worth Factors with Escalation Rates – 20 years

Time Horizon ----->	20	years			
Discount	Annual Savings and Costs Escalation Rate					
Rate	1.0%	1.5%	2.0%	3.0%	4.0%	5.0%
3.00%	16.221	16.952	17.727	20.000	21.317	23.453
5.00%	13.503	14.068	14.665	15.965	17.419	20.000
7.00%	11.411	11.854	12.320	13.332	14.459	15.717
10.00%	9.096	9.409	9.739	10.450	11.238	12.112
12.00%	7.941	8.194	8.460	9.031	9.661	10.356
15.00%	6.610	6.798	6.994	7.414	7.874	8.379
20.00%	5.096	5.216	5.340	5.605	5.893	6.205
25.00%	4.108	4.189	4.273	4.451	4.642	4.847
30.00%	3.426	3.484	3.544	3.669	3.802	3.944
35.00%	2.932	2.975	3.019	3.111	3.208	3.311

Factor for Energy (1.5% escalation rate) = 6.798

Factor for Water and O&M (1% escalation rate) = 6.610

Net Present Value – Final Example

- Additional Construction Costs = -$225,000
- PW of Energy Savings:
  $30,000 * 6.798 = $203,940
- PW of Water Savings:
  $8,500 * 6.610 = $56,185
- PW of O&M Savings:
  $5,000 * 6.610 = $33,050
- Total PW of Savings = $293,175
- Net Present Value = $68,175

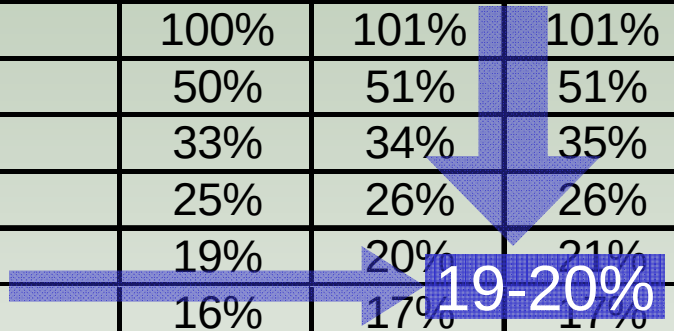
  (without factoring in escalation, it was $47,266)

Measures of Cost Effectiveness

- You were probably wondering – *What about that annual rate of return*?
- The following (and last) chart, allows you to take the payback period and escalation rates (have to assume one rate, though) and estimate the rate of return earned over the 20-year time horizon

Rate of Return

Time Horizon ----->	20	years					
Payback	Annual Savings and Costs Escalation Rate						
Period	0.0%	1.0%	1.5%	2.0%	3.0%	4.0%	5.0%
1	100%	101%	101%	102%	103%	104%	105%
2	50%	51%	51%	52%	53%	54%	55%
3	33%	34%	35%	35%	36%	37%	38%
4	25%	26%	26%	27%	28%	29%	30%
5	19%	20%	21%	21%	22%	23%	24%
6	16%	17%	17%	18%	19%	20%	21%
7	13%	14%	15%	15%	16%	17%	18%
8	11%	12%	12%	13%	14%	15%	16%
9	9%	10%	11%	11%	12%	13%	14%
10	8%	9%	9%	10%	11%	12%	12%
12	5%	6%	7%	7%	8%	9%	10%
15	3%	4%	4%	5%	6%	7%	8%
17	2%	3%	3%	3%	4%	5%	6%
20	0%	1%	1%	2%	3%	4%	5%



Example: Payback Period = 5.2 years

Escalation rates for the annual savings = 1% to 1.5%.

With interpolation, the annual rate of return = 20%.

Final Notes

- Net Present Value performs best at taking future price changes into account
- Rate of Return, with use of the escalation factor, is also an excellent measure
- Loan Analysis, while very useful, does not factor in future price changes
- Payback Period provides the least useful information
- Note – these methods as presented are simplified; they do not take tax effects, depreciation, and other financial impacts into account