



Green Building & Sustainable Construction (TCM 5330)

Innovation in Design & Construction



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How to achieve points for innovative design and construction?

ACHIEVE EXEMPLARY PERFORMANCE:
Employ a strategy that greatly exceeds the requirements of an existing LEED credit.

Use of Energy Management Systems

Provide Acoustic Comfort

Develop an Educational Program

EMPLOY INNOVATIVE STRATEGIES:
Develop a solution specific to a particular location, condition, or region that has considerable sustainable benefits.

INVOLVE A LEED PROFESSIONAL:
Seek the expertise and knowledge of a LEED Accredited Professional.

AP+

PRACTICE INTEGRATED DESIGN:
Emphasize connections and communication between professionals, systems and concepts throughout the life of a project.



How can a project earn an “Innovation in Design” credit?

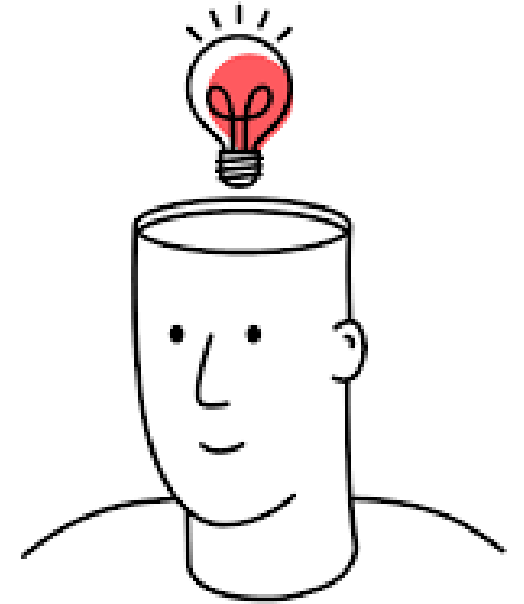
There are two primary ways to earn an Innovation in Design credit:

1. **Show innovation in Design**
2. **Show exemplary performance.**



Innovation in Design

- As the building design and construction industry introduces new strategies for sustainable development, opportunities for additional environmental benefits will continue to emerge.
- Opportunities that are not currently addressed by LEED may include environmental solutions specific to a particular location, condition, or region.



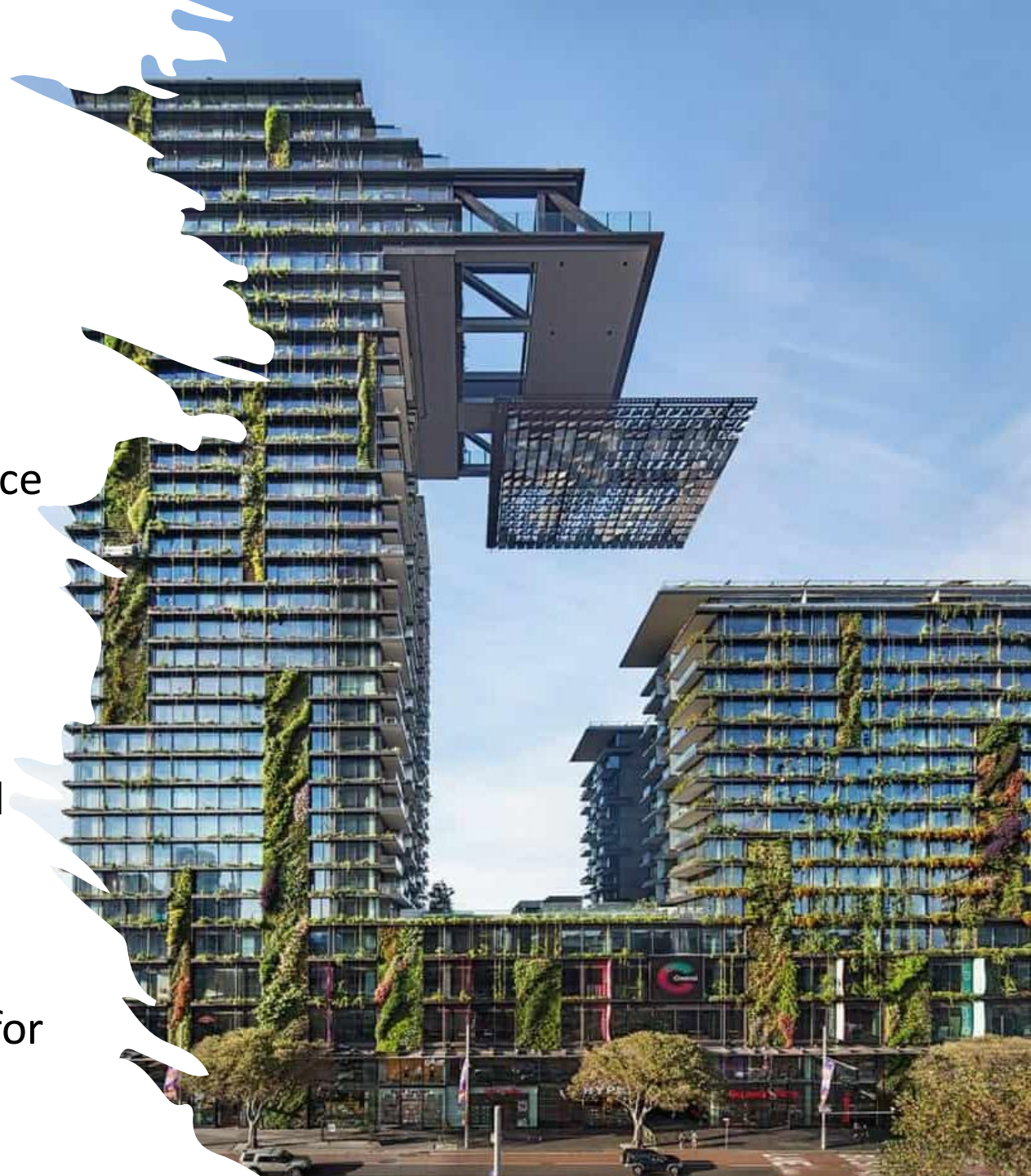
What does LEED mean by “Regional Priority?”

- Regional Priority in LEED context focuses on addressing local environmental challenges.
- USGBC identifies specific LEED credits as Regional Priority Credits (RPCs) for different areas.
- RPCs guide projects to focus on sustainability efforts that meet local environmental needs.
- Projects earn additional points by achieving these region-specific credits.
- RPCs encourage regionally relevant sustainable building practices.
- Projects can identify which credits have regional priority by checking the USGBC website



How to qualify for “Innovation in Design” credit?

- Innovative strategies expand the breadth of green building practices and introduce new ideas.
- They are distinct from exemplary performance innovation credits in that they address environmental issues not addressed elsewhere within the LEED rating system.
- For instance, incorporating educational outreach programs qualify for this credit.
- Educational outreach programs are intended to educate building occupants about the building’s features and the benefits of green building in general. These concepts aren’t addressed elsewhere within the LEED rating system, so this strategy is a likely candidate for an Innovation in Design credit for innovative strategies.



What is a quick way to figure out if an initiative in design qualifies for “Innovation in Design” credit?

- Eligible innovative strategies aren’t addressed within the LEED rating system or reference guides, but are instead evaluated via the CIR process.
- If the issue in question has never been addressed, a Credit Interpretation Request (CIR) is typically required to evaluate the strategy.



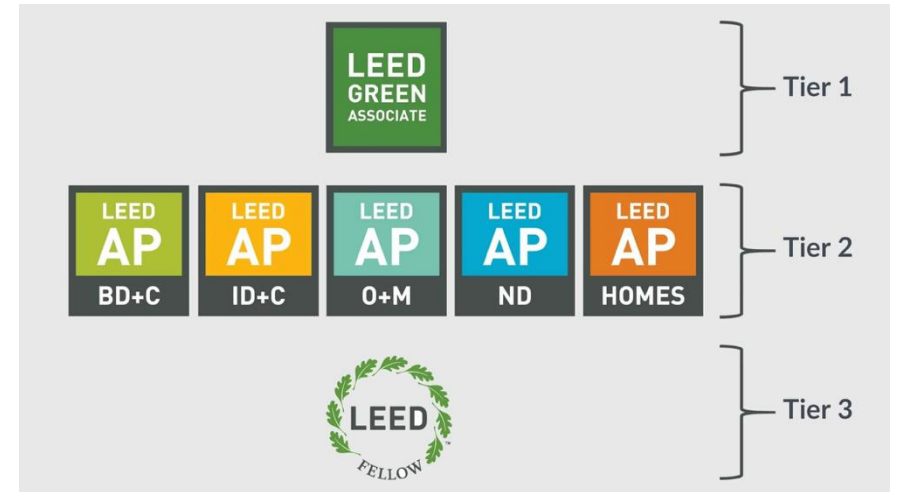
Exemplary Performance

- Project teams can earn exemplary performance points by implementing strategies that result in performance that greatly exceeds the level or scope required by an existing LEED prerequisite or credit.
- Exemplary performance opportunities are noted throughout the LEED reference guides.
- For example, if a project demonstrates a 45% reduction in potable water use, it is eligible for an Innovation in Design credit.



Who is a LEED Accredited Professional?

- A LEED Accredited Professional (LEED AP) is a credential awarded by the Green Building Certification Institute (GBCI), which signifies an individual's thorough understanding and expertise in the strategies, principles, and standards of the Leadership in Energy and Environmental Design (LEED) rating systems.
- The LEED AP designation demonstrates a professional's ability to support the green building design, construction, and operations processes, and to contribute to the goal of creating more sustainable and energy-efficient buildings.



What are the different categories of LEED AP?

There are several specializations within the LEED AP credential, each focusing on different aspects of green building and sustainability, such as Building Design + Construction (BD+C)



Obtaining a LEED AP credential involves passing a rigorous exam that tests the candidate's knowledge and understanding of LEED processes, sustainable practices, and the ability to apply these practices in real-world scenarios. This credential is widely recognized across the globe and is often sought after by professionals in the architecture, engineering, and construction industries who are committed to advancing their expertise in sustainable building practices.

Evolution of Sustainable Design: Late 20th Century to Present

How sustainable construction has evolved over the years.



Late 20th Century Milestones

- The 1970s energy crisis highlights the need for energy-efficient buildings.
- Introduction of green certifications (e.g., LEED, BREEAM) in the 1990s, setting benchmarks for sustainable construction.

21st Century Innovations

- Smart technology integration for energy efficiency and improved environmental quality.
- Green roofs, living walls, and urban green spaces becoming standard in many new constructions.

Global Impact and Policies

- International agreements (e.g., Paris Agreement) influencing sustainable construction standards.
- National and local regulations increasingly mandating green building practices.

The Future of Sustainable Construction

- Focus on net-zero buildings and carbon neutrality.
- Integration of renewable energy sources (solar, wind) directly into building designs.
- Evolution towards circular economy principles in construction materials and processes.

Sustainable construction has evolved from indigenous practices to a sophisticated, technology-driven approach that balances human needs with ecological stewardship. Ongoing innovation and regulatory support are essential for shaping a sustainable built environment for future generations.

Examples of Innovative Green Building Materials

Introduction to new, eco-friendly building materials and technologies.

Bamboo

- Rapidly renewable resource with high strength-to-weight ratio.
- Ideal for flooring, cabinetry, and structural elements.

Recycled Plastic and Composite Materials

- Made from recycled plastics and wood fibers.
- Used in decking, fencing, and as structural components.
- Reduces landfill waste and dependency on virgin materials.

Hempcrete

- Lightweight, biodegradable material made from hemp fibers and lime.
- Excellent insulation properties, regulates humidity.
- Carbon-negative: absorbs more CO₂ than it emits during production.

Cross-Laminated Timber (CLT)

- Engineered wood that rivals the strength and performance of concrete and steel.
- Reduces carbon footprint and speeds up construction times.
- Suitable for walls, roofs, and floors in mid to high-rise buildings.

Technological Innovations

- Smart windows that adjust transparency to save on heating and cooling.
- Photovoltaic glass to integrate solar power generation directly into buildings.
- Self-healing concrete that extends the life of infrastructure.



Recycled and Reclaimed Materials

Using recycled content in construction projects.

- **Recycled materials:** Previously used materials processed into new products to prevent waste of potentially useful materials.
- **Reclaimed materials:** Materials salvaged from previous projects or structures, used again without substantial modification.
- **Importance:** Reduces consumption of raw resources, minimizes waste, and lowers greenhouse gas emissions.

Common Recycled and Reclaimed Materials in Construction

- Metals (steel, aluminum)
- Concrete
- Bricks
- Wood and timber
- Glass
- Plastics
- Asphalt pavement



Challenges of Using Recycled and Reclaimed Materials



- Quality and Performance: Ensuring recycled materials meet structural and safety standards.
- Availability and Sourcing: Locating reliable sources of high-quality recycled materials.
- Regulatory and Compliance Issues: Navigating building codes and standards that may not fully accommodate recycled materials.

Best Practices for Integration of Recycled and Reclaimed Materials

- **Material Selection:** Assess the suitability of recycled materials for specific applications within the project.
- **Supplier Partnerships:** Develop relationships with suppliers who can consistently provide high-quality recycled materials.
- **Certification and Standards:** Utilize materials certified by recognized standards (e.g., LEED, BREEAM) to ensure compliance and sustainability goals are met.
- **Innovative Design:** Encourage architects and engineers to design with recycled and reclaimed materials in mind, exploring creative uses and applications.

Green Insulation Options

Exploring sustainable insulation materials and innovative techniques

- **Definition of Green Insulation:** Insulation solutions that minimize environmental impact, utilizing materials that are renewable, have low embodied energy, and are highly efficient in reducing energy consumption in buildings.

Importance of Sustainable Insulation:

- Reduces energy consumption for heating and cooling, lowering carbon footprint.
- Promotes healthier indoor air quality by avoiding harmful chemicals.
- Encourages the use of renewable and recycled materials.



Common Sustainable Insulation Materials

- **Sheep's Wool:** Naturally fire-resistant, excellent moisture regulation, and provides superior thermal and acoustic insulation.
- **Cork:** Harvested from the bark of cork oak trees without harming the tree, providing good thermal and acoustic performance.
- **Recycled Denim:** Made from post-consumer recycled jeans, non-toxic, and provides good thermal insulation and sound absorption.
- **Hemp:** Rapidly renewable, absorbs CO2 during growth, and offers good thermal insulation and moisture control.



Innovative Techniques in Green Insulation

Advanced Green Insulation Technologies:

Aerogel Insulation: Utilizes silica aerogels, one of the lightest solid materials, providing excellent thermal insulation with minimal thickness.



Vacuum Insulation Panels (VIPs): Offers very high thermal resistance in a very slim profile, ideal for applications where space is limited.



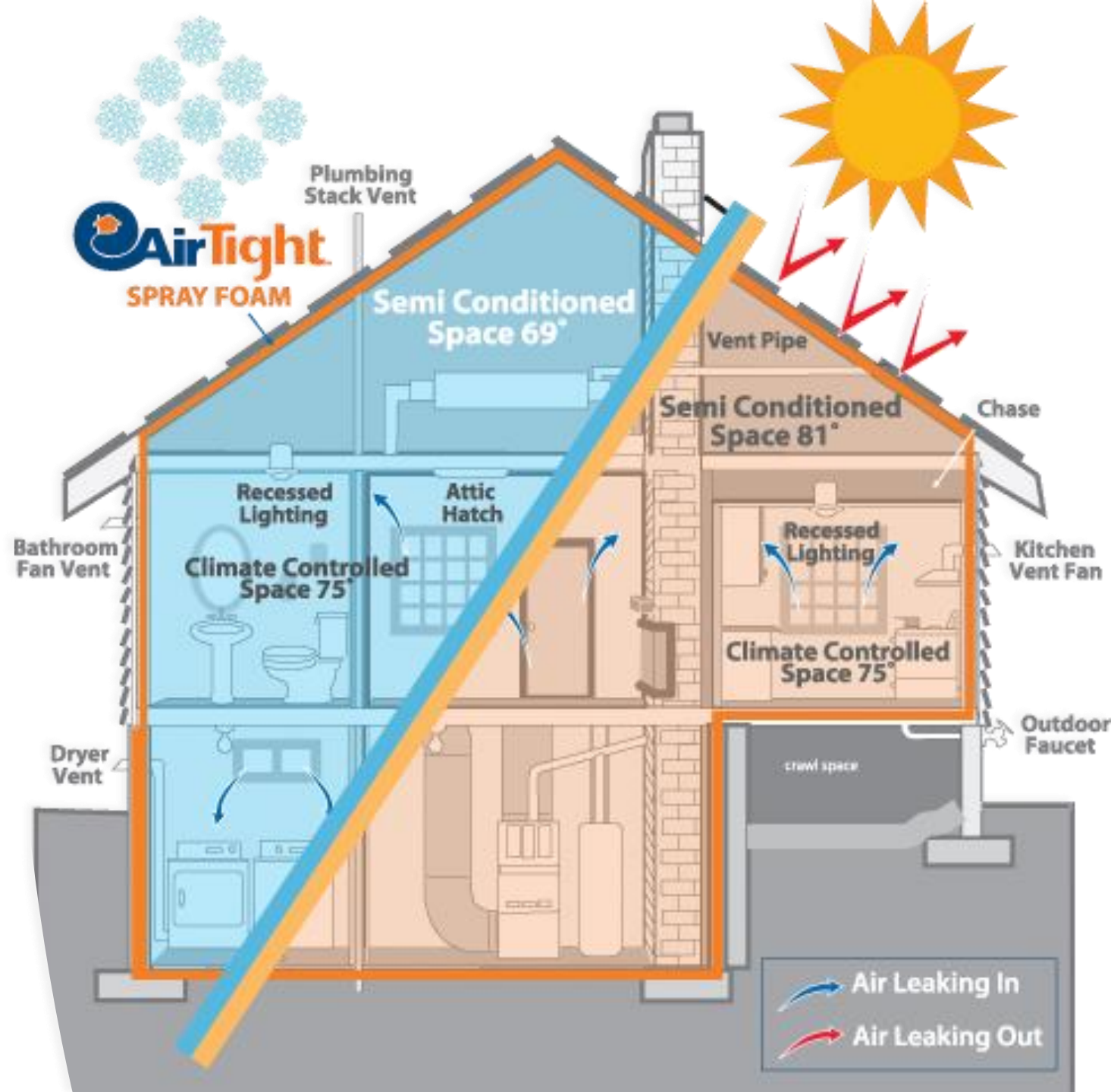
Phase Change Materials (PCMs): Absorb and release thermal energy to maintain comfortable indoor temperatures, reducing reliance on mechanical heating and cooling systems.



Integration of Green Insulation with Building Design

Integration with Building Design:

- Passive House Standards: Emphasizes to dramatically reduce energy consumption for heating and cooling.
- Green Roofs and Living Walls: Incorporate vegetation which provides natural insulation, enhances biodiversity, and manages stormwater.





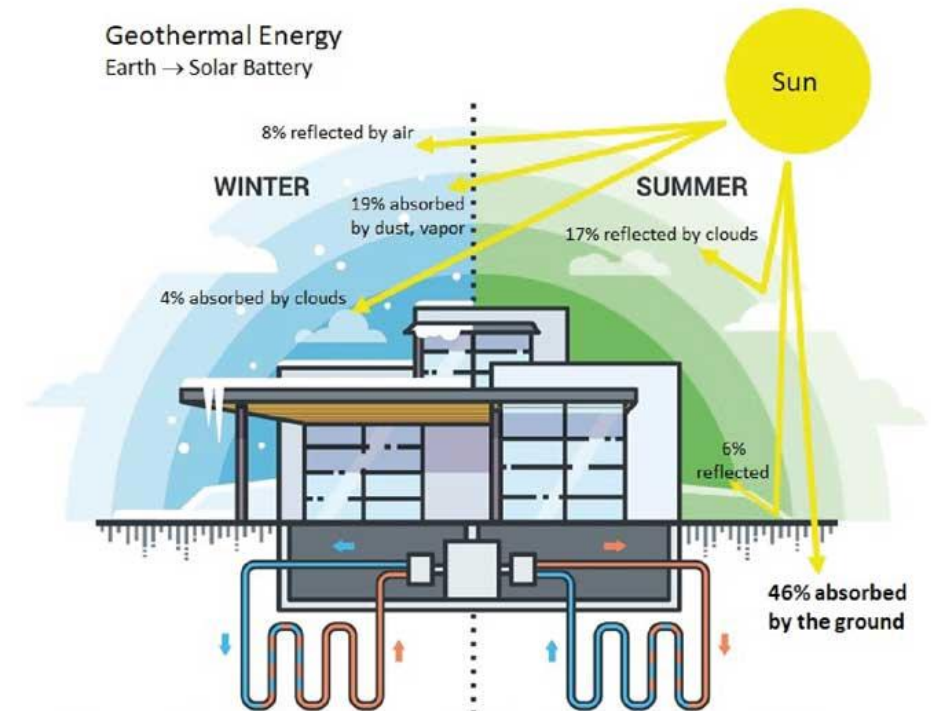
Renewable Energy Technologies in Construction Wind turbines

- **Wind Turbines in Construction**
- Definition: Devices that convert kinetic energy from wind into electrical power.
- Application: On-site small wind turbines for buildings, large-scale wind farms for utility grid supply.
- Benefits:
 - Renewable and inexhaustible source of energy.
 - Can be combined with other renewable sources for a more sustainable energy solution.
 - Tax incentives and rebates in many regions.
- Challenges:
 - Site-specific based on wind availability.
 - Potential noise and aesthetic concerns for residential areas.

Renewable Energy Technologies in Construction

Geothermal heating

- **Geothermal Heating Systems in Construction**
- Definition: Systems that use the stable underground temperature to heat and cool buildings.
- Application: Residential, commercial, and industrial buildings.
- Benefits:
 - High efficiency and low operational costs.
 - Reduced dependency on fossil fuels.
 - Minimal environmental impact.
- Challenges:
 - High upfront installation cost.
 - Feasibility depends on geological conditions.



Key Technologies for Water Conservation Technologies

Rainwater harvesting

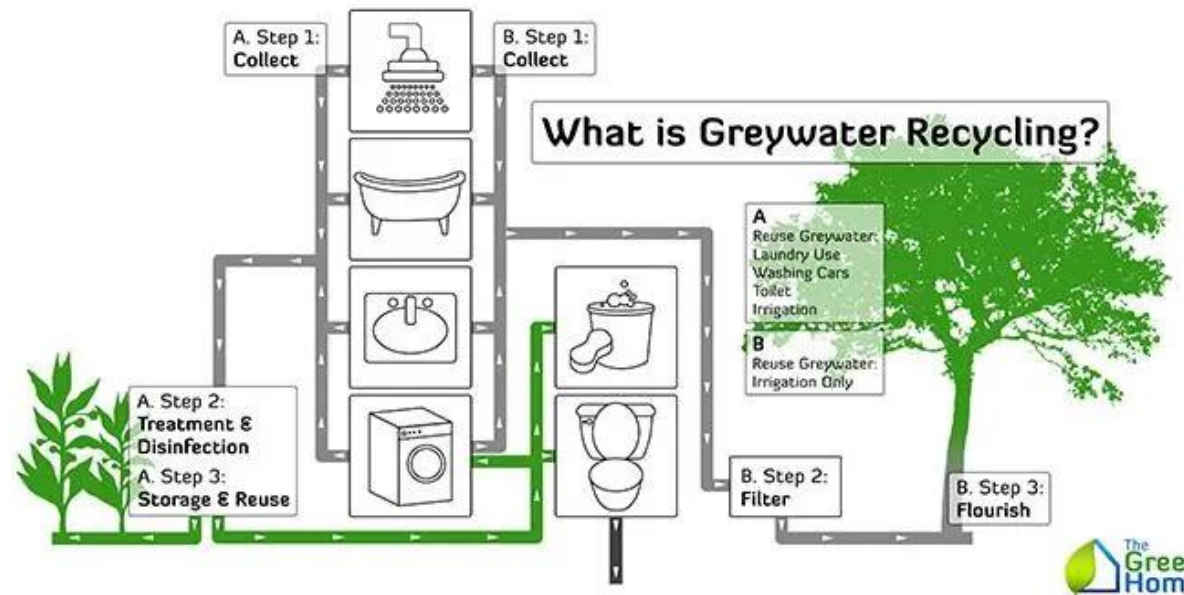
- **Rainwater Harvesting:** Collection and storage of rainwater for reuse onsite, rather than allowing it to run off.
 - **Benefits:** Reduces demand on municipal water supply, mitigates flooding and erosion, and conserves natural resources.
 - **Applications:** Irrigation, flushing toilets, and in some cases, potable uses after treatment.



Key Technologies for Water Conservation Technologies

Greywater systems

- **Greywater Systems:** Utilize wastewater from baths, sinks, washing machines, and other kitchen appliances (except toilets) for reuse.
 - **Benefits:** Significantly reduces freshwater usage, less strain on septic tanks or treatment plants, and landscape irrigation without utilizing potable water.
 - **Applications:** Irrigation, toilet flushing, and laundry, depending on treatment level.



Considerations for Implementation of Water Conservation Technologies

- **Local Regulations and Standards:** Compliance with health and safety standards is crucial.
- **System Design and Capacity:** Based on water demand, rainfall patterns, and greywater production.
- **Cost vs. Benefit Analysis:** Initial setup costs versus long-term savings and environmental impact.



Green Roofing

Benefits of vegetated roofs

Environmental Impact Reduction

- Decreases urban heat island effect by absorbing heat
- Reduces greenhouse gas emissions through carbon sequestration
- Enhances biodiversity by providing habitat for wildlife

Stormwater Management

- Absorbs and retains rainwater, reducing runoff and alleviating pressure on sewer systems
- Improves water quality by filtering pollutants

Energy Efficiency

- Provides natural insulation, reducing the need for heating in winter and cooling in summer
- Leads to significant energy savings and lowers utility bills

Roof Longevity

- Protects roofing materials from UV radiation and temperature fluctuations, extending roof lifespan
- Reduces maintenance costs over time

Aesthetic and Recreational Value

- Enhances building aesthetics, increasing property value
- Can be used as recreational or garden spaces, improving quality of life





Green Roofing

Challenges of vegetated roofs

- **Initial Costs and Installation**
 - Higher upfront costs compared to traditional roofing solutions
 - Requires specialized expertise for installation and design
- **Maintenance Requirements**
 - Needs regular maintenance, including watering, weeding, and repairs
 - Potential for pest issues if not properly managed
- **Structural Considerations**
 - Additional weight of soil and vegetation requires assessment of structural capacity
 - Waterproofing and drainage systems must be meticulously designed to prevent leaks
- **Climate and Vegetation Choices**
 - Plant selection must be appropriate for the local climate
 - Some regions may have limited options for suitable vegetation
- **Regulatory and Approval Process**
 - Must comply with local building codes and regulations
 - Obtaining permits can be complex and time-consuming

Green Walls

Benefits of vegetated walls



- **Improved Air Quality:** Green walls act as natural air filters, removing pollutants and particulate matter, leading to healthier indoor environments.
- **Energy Efficiency:** They provide natural insulation, reducing the need for heating in winter and cooling in summer, thereby lowering energy costs.
- **Noise Reduction:** Vegetated walls can absorb, reflect, and diffract sound, making them effective for noise reduction in urban settings.
- **Biodiversity Enhancement:** They support urban biodiversity by providing habitats for birds, insects, and other wildlife.
- **Aesthetic Appeal:** Green walls add visual interest and natural beauty to buildings, enhancing the wellbeing of occupants and increasing property value.
- **Stormwater Management:** They can absorb and retain rainwater, reducing runoff and mitigating the risk of flooding.

Passive Solar Design Utilizing building orientation and design to reduce energy use.

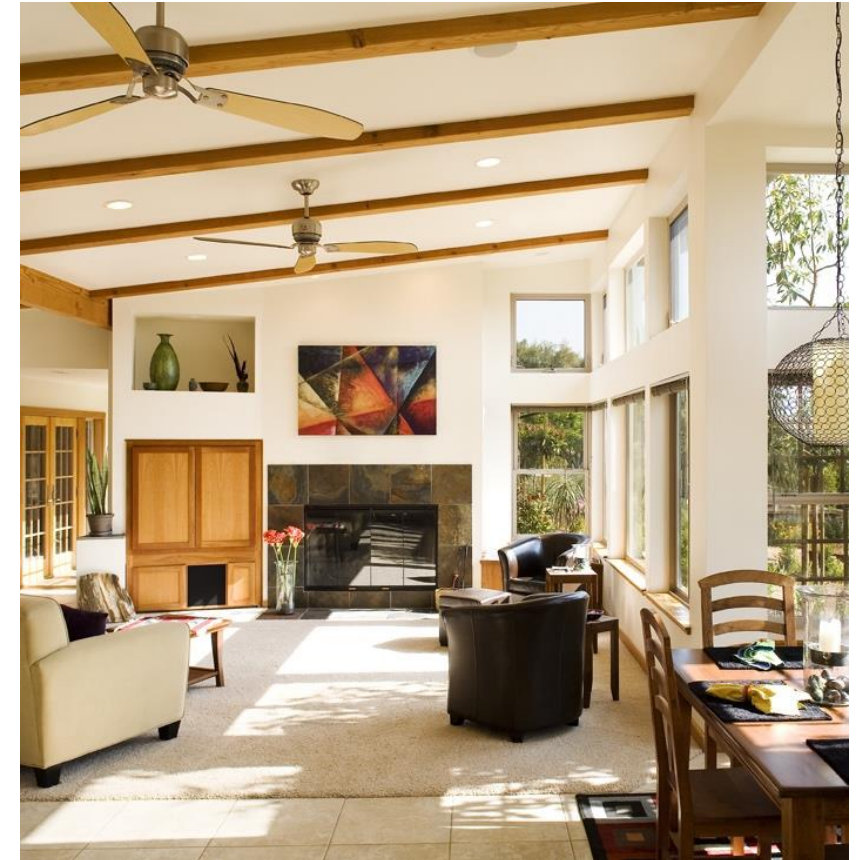
- Definition: An approach to building design that utilizes the sun's energy to naturally heat and light homes, reducing reliance on artificial heating and lighting.
- Objective: Maximize solar gain in winter and minimize it in summer to reduce energy use and enhance comfort.



Passive Solar Design

Key Principles of Passive Solar Design

- **Solar Orientation**
 - Optimal orientation of buildings with longer facades facing south (in the Northern Hemisphere) to capture maximum sunlight.
- **Thermal Mass**
 - Use of materials that absorb, store, and distribute solar energy (e.g., concrete, brick, stone) to stabilize indoor temperatures.
- **Insulation and Air Sealing**
 - High-quality insulation and tight construction to prevent heat loss and gain, crucial for maintaining energy captured or excluded by other means.
- **Window Placement and Glazing**
 - Strategic placement of windows to maximize solar gain in winter and minimize overheating in summer, often complemented by energy-efficient glazing to reduce heat transfer.
- **Shading Devices**
 - Incorporation of overhangs, louvers, and other shading structures to block excessive summer sun while allowing winter sunlight to penetrate interiors.



High-Performance HVAC Systems

Innovations in heating, ventilation, and air conditioning to improve energy efficiency.



- **Variable Refrigerant Flow (VRF) Systems**

- Adjusts refrigerant flow based on demand, significantly reducing energy usage.
- Enables individual temperature control in different zones, enhancing comfort and efficiency.

- **Smart HVAC Controls**

- Incorporates IoT (Internet of Things) for real-time monitoring and control.
- Utilizes advanced algorithms to learn user preferences and optimize system performance.

- **Geothermal Heat Pumps**

- Uses the earth's constant underground temperature to heat and cool buildings.
- Can reduce energy consumption by up to 60% compared to traditional systems.

- **Radiant Heating and Cooling Systems**

- Distributes heat and cool through floors or ceilings, providing uniform temperature distribution.
- Reduces energy consumption and improves indoor air quality by minimizing air movement.

Sustainable Practices in HVAC Design

- **Integration with Renewable Energy Sources**

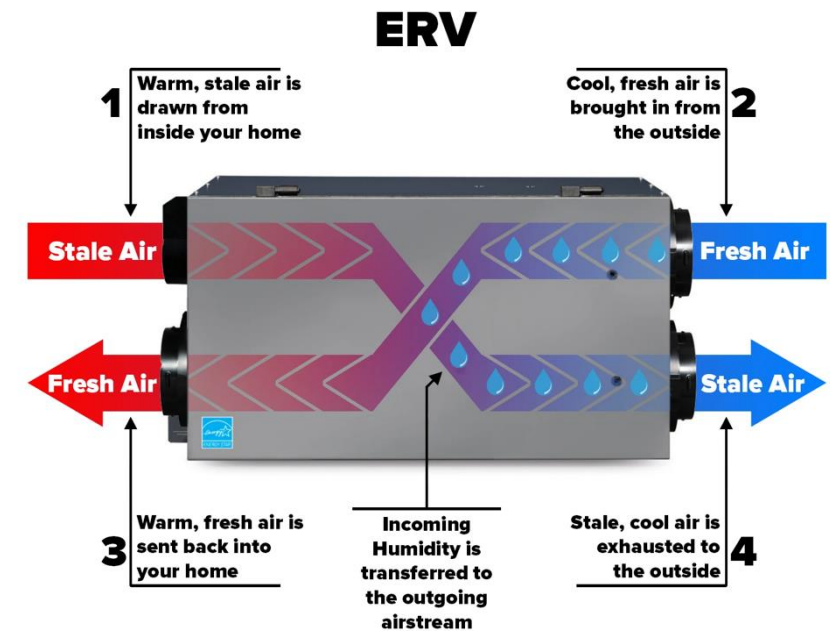
- Pairing with solar panels or wind turbines to power HVAC systems with renewable energy.
- Encourages the use of sustainable and inexhaustible energy resources.

- **Demand-Controlled Ventilation (DCV)**

- Adjusts ventilation based on occupancy and indoor air quality, reducing unnecessary energy use.
- Ensures fresh air delivery is optimized for occupant comfort and health.

- **Energy Recovery Ventilators (ERV)**

- Recovers energy from exhaust air to pre-treat incoming fresh air, minimizing energy loss.
- Improves energy efficiency while ensuring a constant supply of fresh air.



Sustainable Urban Planning and Community Design

Principles of designing sustainable communities and urban areas.

1. Density and Compactness

1. Promotes higher density urban development to reduce sprawl.
2. Encourages mixed-use buildings to minimize transportation needs.
3. Enhances efficiency in land use, reducing pressure on natural habitats.

2. Green Space and Natural Environment Integration

1. Protects and integrates natural environments within urban settings.
2. Utilizes green roofs, walls, and other infrastructures to support biodiversity.
3. Plans for public parks and green spaces to improve air quality and provide recreation areas.

3. Water Management and Conservation

1. Employs sustainable water use practices, including rainwater harvesting and greywater recycling.
2. Designs urban landscapes to support natural water cycles and mitigate flooding.
3. Encourages water-efficient landscaping and the use of native plant species.

4. Community Engagement and Social Equity

1. Facilitates active participation of community members in planning processes.
2. Ensures equitable access to resources, amenities, and opportunities.
3. Designs inclusive public spaces that cater to diverse populations.

5. Innovative and Adaptive Design

1. Encourages innovative solutions to urban design challenges.
2. Plans for flexibility and adaptability to future changes, including climate change.
3. Integrates smart technology to enhance efficiency and livability.

6. Policy and Governance

1. Develops policies that support sustainable urban development principles.
2. Ensures regulatory frameworks facilitate the implementation of sustainable practices.
3. Promotes partnerships between public, private, and community sectors.



Building Information Modeling (BIM) for Sustainability

How BIM can be used in planning and designing green buildings.

- BIM enhances teamwork across disciplines, integrating sustainable objectives from the start.
- **Energy Efficiency:** Enables early-stage simulations to optimize building energy use, focusing on natural light, insulation, and efficient HVAC systems.
- **Sustainable Materials:** Assists in selecting eco-friendly materials and reducing waste through precise quantity estimates.
- **Water Management:** Supports the design of systems for reduced water usage and sustainable management.
- **Lifecycle & Facility Management:** Promotes sustainability across a building's lifecycle, ensuring long-term operational efficiency.
- **Green Certification:** Aids in achieving certifications by documenting adherence to environmental standards.
- **Innovation & Visualization:** Facilitates the exploration of new sustainable technologies and solutions.
- **Stakeholder Engagement:** Improves communication on sustainable features through detailed visualizations.



Other Green Building Standards *(slide 1 of 2)*

Overview of sustainability certifications other than LEED.



- **BREEAM (Building Research Establishment Environmental Assessment Method)**

- Origin: United Kingdom, 1990.
- Focus: Comprehensive coverage including energy, water use, health and wellbeing, pollution, transport, materials, waste, ecology, and management processes.
- Application: Widely used in Europe, adaptable to international projects.



- **Green Star**

- Origin: Australia, by the Green Building Council of Australia.
- Focus: Design & As Built assessments, Interiors, Communities, and Performance of buildings.
- Application: Offers tools for a wide range of building sectors including office, retail, industrial, public buildings, healthcare, and education.

- **WELL Building Standard**

- Origin: International WELL Building Institute, focus on enhancing people's health and well-being through the built environment.
- Key Areas: Air, water, nourishment, light, fitness, comfort, and mind.
- Application: Applies to commercial and residential projects, with a strong emphasis on occupant health.



Other Green Building Standards *(slide 2 of 2)*

Overview of sustainability certifications other than LEED.

- **Passivhaus (Passive House)**

- Origin: Germany, a rigorous standard for energy efficiency in a building, reducing its ecological footprint.
- Features: Requires very little energy for heating or cooling.
- Application: Suited for residential, commercial, and educational buildings.



- **Living Building Challenge (LBC)**

- Origin: International Living Future Institute.
- Philosophy: Create buildings that generate more energy than they consume and are symbiotic with their environment.
- Requirements: Net-zero energy, water, and waste, among other stringent environmental challenges.



- **EDGE (Excellence in Design for Greater Efficiencies)**

- Origin: Innovation by IFC, a member of the World Bank Group.
- Focus: Mainly on developing countries, aiming for minimum savings of 20% in energy, water, and energy used in materials.
- Application: Residential and commercial buildings.



Innovative Case Studies

Award-Winning Green Buildings: Examples of innovative green building projects around the world.

1.The Edge (Amsterdam, Netherlands)

Innovations: Energy-efficient design with extensive use of natural light, smart technology for space and energy management, and a large rooftop solar array.

2.Bosco Verticale (Milan, Italy)

Innovations: Vertical forests integrating 900 trees and over 2,000 plants, reducing urban heat island effect and improving air quality.

3.Pixel Building (Melbourne, Australia)

Innovations: Rainwater collection, solar panels, and wind turbines; façade designed to maximize natural light while minimizing heat gain.

4.Shanghai Tower (Shanghai, China)

Innovations: World's second-tallest building featuring a spiral form to reduce wind load; includes rainwater recycling, wind turbines, and a double-skin façade for energy efficiency.

5.Bullitt Center (Seattle, USA)

Innovations: Net-zero energy building with solar panels covering a footprint larger than the building itself, composting toilets, and rainwater-to-drinking-water system.

Challenges and Barriers to Green Construction *(slide 1 of 2)*

Discussing the obstacles to adopting sustainable construction practices



- **Initial Costs and Financial Barriers**

- Higher upfront investment compared to traditional construction.
- Perceived risk by investors and financial institutions.
- Lack of widespread understanding of long-term savings and value.

- **Regulatory and Policy Challenges**

- Inconsistent or lacking governmental policies and incentives.
- Complexity in obtaining permits for innovative green technologies.
- Variation in building codes and standards across regions.

- **Availability of Sustainable Materials and Technologies**

- Limited availability and higher cost of green materials in some regions.
- Challenges in sourcing locally to reduce carbon footprint.
- Technological innovation outpacing workforce skills and knowledge.

Challenges and Barriers to Green Construction *(slide 2 of 2)*

Discussing the obstacles to adopting sustainable construction practices



- **Knowledge and Perception Gap**

- General lack of awareness and understanding of green construction benefits.
- Misconceptions about the performance and durability of green buildings.
- Need for more education and training programs for industry professionals.

- **Stakeholder Resistance**

- Difficulty in aligning interests among developers, builders, and clients.
- Resistance to change and adoption of new practices.
- Lack of demand from clients due to insufficient knowledge about green alternatives.

- **Challenges in Measurement and Verification**

- Difficulties in quantifying the environmental impact accurately.
- Lack of standardized metrics and benchmarks for green construction.
- Challenges in verifying the sustainability claims of products and technologies.

Role of Government Policies in Sustainable Construction

Overview of regulations, incentives, and policies supporting green building.

- **Regulatory Measures**
- **Building Codes and Standards:** Adoption of green building standards (e.g., LEED, BREEAM) in construction codes.
- **Environmental Impact Assessments (EIA):** Mandatory EIA for projects to assess and mitigate negative environmental impacts.
- **Resource Efficiency:** Regulations on materials, energy, and water usage to promote efficiency.



Role of Government Policies in Sustainable Construction

Overview of regulations, incentives, and policies supporting green building.

Incentives for Green Building

- **Tax Benefits:** Reductions or exemptions for projects meeting sustainability criteria.
- **Grants and Subsidies:** Financial support for research and development in sustainable technologies and materials.
- **Expedited Permitting:** Faster approval processes for projects adhering to green building standards.



Role of Government Policies in Sustainable Construction

Overview of regulations, incentives, and policies supporting green building.

Impact and Outcomes

- **Encouraging Sustainable Practices:** Government policies play a pivotal role in promoting sustainable construction methodologies.
- **Reducing Environmental Footprint:** Through stringent regulations and incentives, the aim is to minimize the environmental impact of construction projects.
- **Economic Benefits:** Long-term savings and efficiency gains for businesses and society through sustainable construction practices.



Education and Training in Green Construction

Importance of educating architects, engineers, and contractors in sustainable practices.



Why Educate Architects, Engineers, and Contractors?

- **Foundation of Sustainable Development:** Professionals equipped with green construction knowledge are pivotal in driving the industry towards sustainability.
- **Innovation and Leadership:** Education fosters innovation, enabling professionals to lead in the design and construction of sustainable buildings.
- **Regulatory Compliance:** Understanding evolving regulations and standards is crucial for legal compliance and industry leadership.



Education and Training in Green Construction

Importance of educating architects, engineers, and contractors in sustainable practices.

Implementing Education and Training

- **Curriculum Development:** Incorporate sustainable construction principles across architecture, engineering, and construction management programs.
- **Continuing Education:** Offer workshops, certifications, and seminars for ongoing learning and adaptation to new green technologies and practices.
- **Collaboration and Partnerships:** Engage industry partners, government agencies, and non-profits to provide practical experiences and resources.

Watch the video

10 Innovative Green Building Materials to Watch in 2023

- Link:

https://www.youtube.com/watch?v=UMxcEQ61gZU&ab_channel=ARCH-Architecture

(you may also click on the YouTube Logo below)

