HISTORY OF GREEN BUILDINGS:

- The Green Building movement was pioneered in Great Britain with the rating system called BREEAM (which was first launched in 1990. This system was later adopted in the U.S when the US Green Building Council was formed.
- LEED (Leadership in Energy and Environmental Design) was loosely adopted from the BREEAM system and came into existence sometime in March 2000.
- In India, this movement was adopted by the Confederation of Indian Industry (CII) in the early part of this decade. They formed the Indian Green Building Council which is actively involved in promoting the Green Building concept in India.
- LEED India, also known as Leadership in Energy and Environmental Design India, is a green building rating system developed by the Indian Green Building Council (IGBC) in partnership with the U.S. Green Building Council (USGBC).
- The Leadership in Energy and Environmental Design (LEED-INDIA) Green Building Rating System is a nationally and internationally accepted benchmark for the design, construction and operation of high performance green buildings.

(Cont…)

- It promotes a whole-building approach to sustainability by recognizing performance in key areas:
  - Sustainable site
  - Water efficiency
  - Energy efficiency and renewable energy
  - Conservation of materials and resources
  - Indoor environmental quality
  - Regional Priority
- LEED India was launched in India in 2003 and since then has grown exponentially.
- This has created a large network of smaller stakeholders which includes the construction industry comprising corporate, government & nodal agencies, architects, developers, builders, products manufacturers and most interestingly green building consultants whose profession was almost unheard of a decade ago

WHAT IS GREEN BUILDING ?

Green building refers to both a structure and the application of processes that are ***environmentally responsible*** and ***resource-efficient*** throughout a ***building's life-cycle***: from planning to design, construction, operation, maintenance, renovation, and demolition.

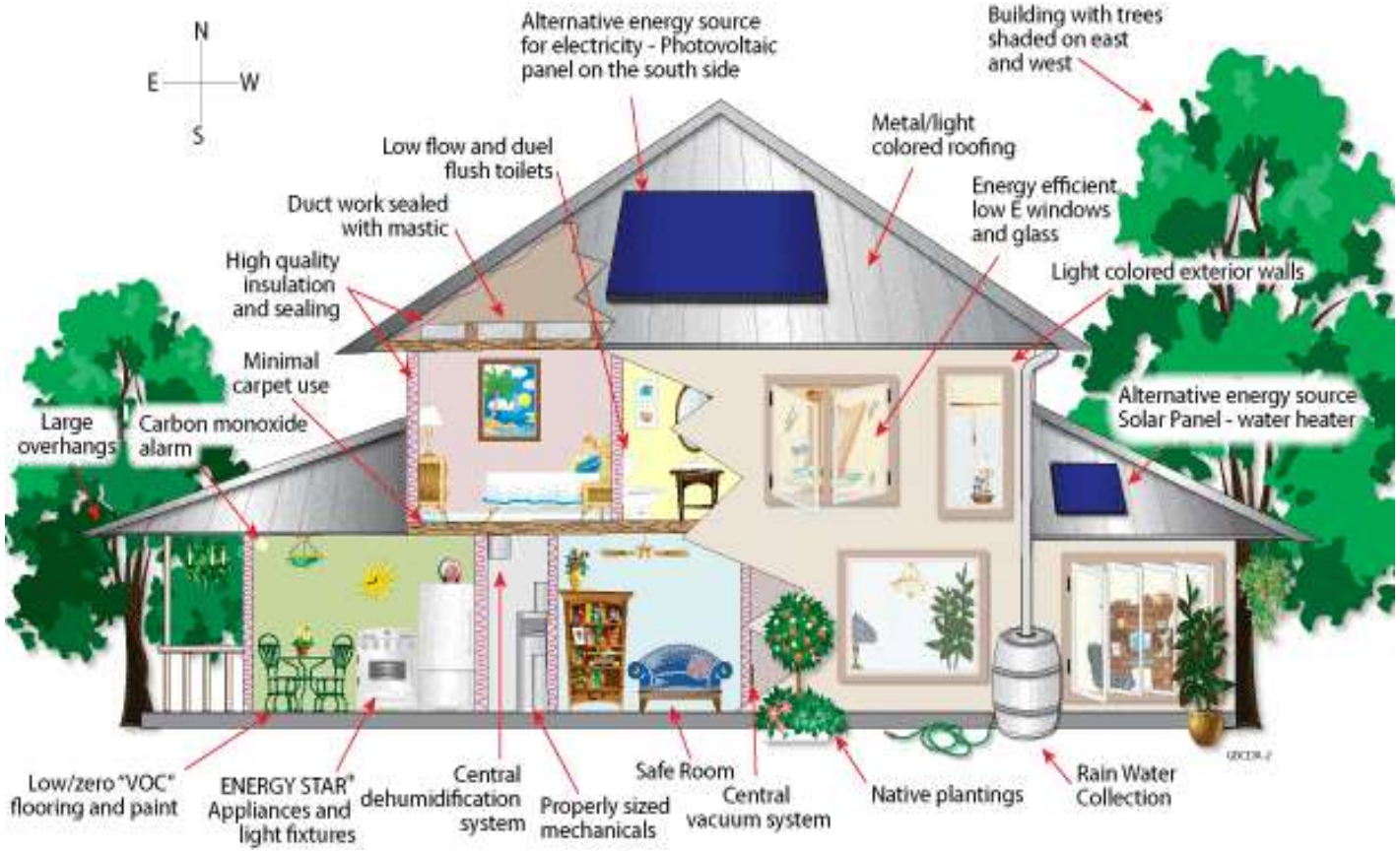
(or)

A green building is defined as one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier space for occupants compared to conventional buildings.

- It is an environmentally sustainable building, designed constructed and operated to minimize total environmental impacts.
- A green building aims to lower environmental impacts, maximize social and economic value over a building life cycle.

OBJECTIVES OF GREEN BUILDINGS:

- **Reducing Environmental Impact:** To minimize the consumption of resources such as the energy, water, and raw materials. They also strive to reduce greenhouse gas emissions, waste generation, and pollution, thereby contributing to a more sustainable and healthier planet.
- **Energy Efficiency:** Using innovative design techniques, insulation, energy-efficient appliances, lighting, and HVAC systems to significantly lower energy consumption. This reduces reliance on non-renewable energy sources and helps combat climate change.
- **Water Conservation:** Green buildings incorporate water-efficient fixtures, rainwater harvesting systems, and water recycling technologies to minimize water consumption. This helps conserve a precious resource and reduces the strain on local water supplies.
- **Improved Indoor Air Quality:** Green buildings prioritize indoor air quality by using low-emission materials, proper ventilation systems, and natural lighting. This creates a healthier and more comfortable indoor environment for occupants, leading to increased productivity and well-being.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Alternative energy source for electricity - Photovoltaic panel on the south side
Building with trees shaded on east and west
Metal/light colored roofing
Low flow and duel flush toilets
Duct work sealed with mastic
Energy efficient low E windows and glass
High quality insulation and sealing
Light colored exterior walls
Minimal carpet use
Large overhangs
Carbon monoxide alarm
Alternative energy source Solar Panel - water heater
Low/zero "VOC" flooring and paint
ENERGY STAR" Appliances and light fixtures
Central dehumidification system
Properly sized mechanicals
Safe Room
Central vacuum system
Native plantings
Rain Water Collection

(Cont…)

- **Optimal Site Selection and Land Use:** Sustainable buildings are often located in areas that minimize environmental impact, such as previously developed sites or areas with easy access to public transportation. Promotes responsible land use to preserve green spaces and biodiversity.
- **Materials Selection:** Green buildings use eco-friendly and recycled materials whenever possible. The goal is to reduce the demand for new resources, lower waste generation, and decrease the environmental impact of construction and demolition.
- **Waste Reduction:** Through efficient design and construction practices, green buildings aim to minimize construction waste and encourage recycling. This reduces the amount of waste that ends up in landfills.
- **Longevity and Durability:** Green buildings are designed to have a longer lifespan and require less frequent maintenance and repairs. This minimizes the need for replacement materials and reduces the overall environmental impact over the building's lifetime.

(Cont…)

- **Renewable Energy Integration:** Many green buildings incorporate renewable energy sources such as solar panels, wind turbines, and geothermal systems. This not only reduces the building's reliance on fossil fuels but also contributes excess energy back to the grid.
- **Occupant Health and Well-being:** Sustainable buildings prioritize the health and well-being of occupants by providing ample natural lighting, good ventilation, and comfortable indoor temperatures. These factors can lead to increased occupant satisfaction, productivity, and overall quality of life.
- **Cost Savings:** While the initial investment in green building technologies and materials can be higher, the long-term operational and maintenance cost savings often outweigh these costs. Energy and water savings, along with potential tax incentives, contribute to financial benefits over time.

GREEN BUILDINGS WITHIN THE INDIAN CONTEXT

Green buildings in India are gaining significant traction due to increasing awareness of environmental issues, energy efficiency, and sustainable practices. The concept of green buildings focuses on reducing the environmental impact of construction and operations while improving the health and productivity of occupants.

1. Key Features of Green Buildings in India:

- ***Energy Efficiency:*** Use of energy-efficient lighting, HVAC systems, and appliances.
- ***Water Management:*** Rainwater harvesting, efficient plumbing fixtures and wastewater recycling process/methods.
- ***Materials:*** Use of locally sourced, recycled, and sustainable building materials.
- ***Indoor Environmental Quality:*** Improved ventilation, use of non-toxic materials and ample natural light or natural sun light.
- ***Waste Management:*** Effective waste segregation, recycling, and disposal systems.

2. Rating Systems:

- **IGBC (Indian Green Building Council):** The IGBC Green Building Rating System is a widely used certification in India. It includes various categories like IGBC Green Homes, IGBC Green Factories, and IGBC Green Townships.
- **GRIHA (Green Rating for Integrated Habitat Assessment):** GRIHA is a national rating system endorsed by the Ministry of New and Renewable Energy (MNRE), focusing on sustainable building practices.
- **LEED (Leadership in Energy and Environmental Design):** While LEED is a global standard, it is popular in India, many buildings seeking certification to align with international standards.

3. Government Initiatives:

- **National Mission on Sustainable Habitat:** Part of India's National Action Plan on Climate Change, it promotes energy efficiency, sustainable urban planning & waste management.
- **Energy Conservation Building Code (ECBC):** Introduced by the Bureau of Energy Efficiency (BEE), this code sets minimum energy performance standards for buildings.
- **Incentives and Regulations:** Some state governments offer incentives like additional Floor Space Index (FSI) for green buildings, tax rebates, and faster approvals.

4. Challenges and Opportunities:

- ***Awareness and Education:*** Increasing awareness among builders, architects and the consumers about the benefits of green buildings.
- ***Cost:*** Higher initial costs can be a barrier, though long-term savings and government incentives can offset these.
- ***Skilled Workforce:*** Need for training and development of a skilled workforce proficient in green building practices.
- ***Policy Implementation:*** Ensuring robust implementation and monitoring of green building policies and codes.

5. Case Studies and Examples:

- ***CII-Sohrabji Godrej Green Business Centre, Hyderabad:*** One of the first LEED Platinum-rated buildings in India.
- ***ITC Green Centre, Gurgaon:*** A pioneering green building with a Platinum LEED rating, known for its energy and water efficiency.
- ***Indira Paryavaran Bhawan, New Delhi:*** India's first net-zero energy building, demonstrating advanced green building technologies.

GREEN BUILDING RATINGS IN INDIA

1. *Green Rating for Integrated Habitat Assessment (GRIHA)*

- GRIHA is India's own rating system jointly developed by **TERI** (The Energy & Resources Institute) and the Ministry of New & Renewable Energy, Government of India.
- Common wealth Games Village, New Delhi, Fortis Hospital, New Delhi, CESE (Centre for Environmental Sciences & Engineering) Bldg, IIT Kanpur have received GRIHA ratings
- It is a green building design evaluation system where buildings are rated in a three-tier process. It contains 34 evaluation criteria with 100 points, Criteria's are categorized into
  - **Site Planning** involves optimizing the location, orientation, and design to minimize environmental impact and maximize energy efficiency and sustainability.
  - **Water Conservation**
  - **Energy Efficiency** including energy embodied & construction and renewable energy
  - **Waste Management** including waste minimization, segregation, storage, disposal and recovery of energy from waste and
  - **Environment for good health** and wellbeing.

2. Leadership in Energy & Environmental Design India (LEED India)

- LEED is an internationally recognized green building certification system, providing **third-party verification** that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most:
  - Sustainable site
  - Energy savings,
  - Water efficiency,
  - CO_2 emissions reduction,
  - Improved indoor environmental quality and
  - Stewardship of resources and sensitivity to their impacts.
- The Indian Green Building Council has adapted LEED system and has launched LEED India version for rating of new construction.

3. Bureau of Energy Efficiency (BEE)

- BEE developed its own rating system for the buildings based on a 1 to 5 star scale.

  More stars mean more energy efficiency.

- The ECBC (Energy Conservation Building Code) provides design norms for:
  - **Building envelope:** Thermal performance requirements for walls, roofs, and windows
  - **Lighting system:** Day lighting, and lamps and luminaire performance requirements
  - **Cooling systems:** Air conditioning, HVAC system, including energy performance of chillers and air distribution systems.
  - **MEP systems:** Electrical system and Water heating and pumping systems, including requirements for solar hot-water systems.
- BEE has developed the Energy Performance Index (EPI).
- The unit of Kilo watt hours per square meter per year is considered for rating the building and especially targets air conditioned and non-air conditioned office buildings.

- The Reserve Bank of India's buildings in Delhi and Bhubaneshwar, the CII Sohrabji Godrej Green Business Centre and many other buildings has received BEE 5 star ratings.

4. Indian Green Building Council (IGBC) Green Building Rating System:

- The IGBC offers various rating systems for different building types, including Green Homes, Green Building, Green Factory Buildings, Green Schools, Green Townships, and Green Interiors.
- These rating systems evaluate aspects such as
  - Site planning
  - Energy efficiency
  - Water conservation
  - Indoor environmental quality
  - Materials and resources and innovation.

RELEVANCE OF GREEN BUILDINGS

Green buildings are crucial for sustainable development, encompassing environmental, economic, social, and technological aspects.

a) Environmental Relevance

Green buildings promote energy efficiency, reducing reliance on fossil fuels and lowering greenhouse gas emissions. They conserve water through efficient fixtures and rainwater harvesting, addressing water scarcity. By minimizing waste through recycling and sustainable materials, they reduce landfill impact and carbon footprint.

b) Economic Relevance

Green buildings offer significant operational savings in energy and water bills and reduced maintenance costs. Their market value and rental rates are higher due to sustainable features. Government incentives such as tax breaks and grants further reduce financial barriers to adopting green practices.

c) Social Relevance

Occupants of green buildings benefit from improved health and well-being due to better indoor air quality, natural lighting, and thermal comfort. These buildings enhance community spaces, fostering social interaction and overall well-being. They also serve as educational models, promoting awareness and adoption of sustainable practices.

d) Technological Relevance

Green buildings drive innovation by integrating advanced technologies and sustainable materials, fostering research and development. They are adaptable to changing environmental conditions and future needs, incorporating smart technologies for efficient resource management and building performance.

e) Specific Relevance to India

In India, rapid urbanization necessitates sustainable urban development to ensure livable and resilient cities. Green buildings address resource constraints like water and energy shortages, crucial for India's growth. They contribute to climate change mitigation and adaptation, enhancing resilience against extreme weather events.

TYPES OF ENERGY

- The word energy is derived from the Greek, ***en (in)*** and ***ergon (work)***.
- Energy is defined as ***'the capacity to do work'*** – that is, the capacity to move an object against a resisting force. The scientific unit of energy is the ***joule***.
- The concept of energy reveals the common features in processes as diverse as burning fuels, propelling machines and charging batteries.
- Energy can be broadly classified into the following

1. Kinetic Energy
2. Potential Energy
3. Based on sources (*Refer UNIT-II for classification based on sources*)
    - Renewable energy source
    - Non-renewable energy source

a) Kinetic Energy

- ***Mechanical Energy****:* Energy of moving objects (e.g., a car, a spinning turbine).
- ***Thermal Energy****:* Energy from the motion of particles within an object, experienced as heat.
- ***Electrical Energy****:* Energy of moving electrons or charged particles, used to power devices.
- ***Radiant Energy****:* Energy carried by electromagnetic waves (e.g., sunlight, X-rays).
- ***Sound Energy****:* Energy carried by sound waves, created by vibrating objects.

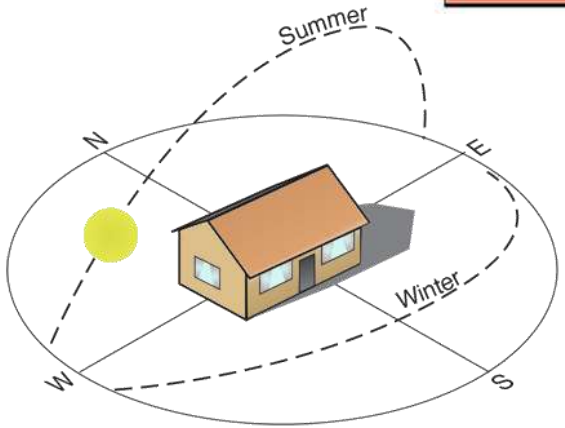
b) Potential Energy

- ***Gravitational Energy****:* Energy due to an object's position in a gravitational field (e.g., water in a dam, can be used to generate electricity).
- ***Elastic Energy****:* Energy stored in stretched or compressed objects (e.g., springs, rubber bands).
- ***Chemical Energy****:* Energy stored in chemical bonds, released during the reactions (e.g., batteries, fossil fuels).
- ***Nuclear Energy****:* Energy stored in atomic nuclei, released through fission or fusion.

ENRGY EFFIECINCY AND POLLUTION CONTROL

1. Design and Orientation:

- Optimize the building's design & orientation to maximize natural light and reduce the need for artificial lighting.
- Consider passive solar design principles to harness natural heat and ventilation.
- Use shading devices, such as awnings or louvers, to minimize direct sunlight and reduce cooling loads.



2. Energy-Efficient Lighting:

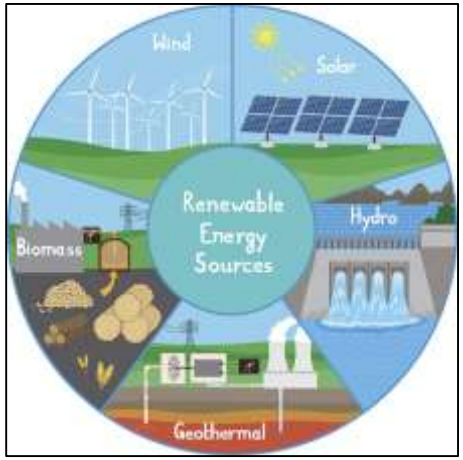
- Install energy-efficient lighting systems, such as LEDs, which consume less energy and have a longer lifespan than traditional bulbs.
- Incorporate occupancy sensors and daylight sensors to automatically adjust lighting levels based on occupancy and natural light availability.

3. Heat and Cooling Systems:

- Use high-efficiency HVAC (Heating Ventilation & Air conditioning) systems that meet or exceed energy efficiency standards.
- Occupancy sensors, variable-speed drives, automated ventilation control, heat exchangers, and efficient motors—can reduce energy consumption by adjusting the levels of heating and cooling to maintain a healthy and comfortable environment.

4. Insulation and Sealing:

- Insulate the building's envelope, including walls, roof, and windows, to minimize heat transfer and improve energy efficiency.
- Seal air leaks and use weather stripping to prevent drafts and enhance thermal comfort.
- An insulation blanket for a water heater will pay for itself in a year or less and will reduce heat loss by 25-40 percent.



5. Renewable Energy Sources:

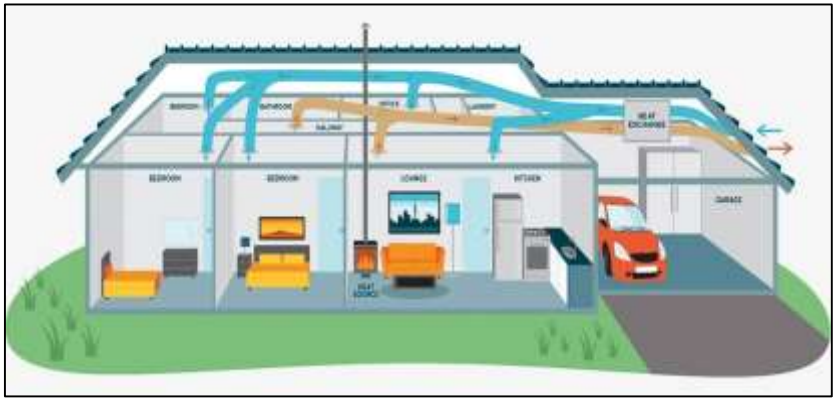
- Install renewable energy systems like solar panels or wind turbines to generate electricity.
- Consider incorporating geothermal systems for heating and cooling, utilizing the constant temperature of the earth.
- Likewise Hydro power, Biomass, Wind e.t.c, can be used for various purposes in Green buildings.

6. Energy-Efficient Appliances and Equipment:

- Install energy-efficient appliances, such as refrigerators, dishwashers and washing machines e.t.c, that carry the ENERGY STAR label has to be used.
- By checking for Energy Star label on products and equipment, you can reduce your energy bill by 30 percent and your electric lighting charges by 40 percent while cutting pollution.

7. Water Conservation:

- ❑ Implement water-efficient fixtures and appliances, such as low-flow faucets, showerheads, and toilets.
- ❑ Capture and reuse rainwater for landscaping or non-potable uses like flushing toilets or irrigation and Rainwater harvesting techniques.



8. Indoor Air Quality (IAQ):

- ❑ Use low-VOC (volatile organic compounds) materials, paints, and furniture to improve indoor air quality.
- ❑ Install effective ventilation systems to provide fresh air circulation and reduce the concentration of pollutants indoors.

9. Miscellaneous:

- Turn off and unplug the unused appliances, equipment and lights.
- Do regular maintenance and checking of furnace, air conditioner and heat pump filters.
- By cleaning your heating, ventilation and air-conditioning equipment, your units will last longer, avoid costly down time and improve indoor air quality.
- Increase natural light. Paint exterior and interior walls in a light color so more light is reflected.
- During the day, open blinds to bring in natural light instead of turning on lights.
- Reduce paper usage. By double siding on copiers, reusing single-sided paper, using electronic mail and circulating documents with routing slips, an organization can save a significant amount of energy and natural resource
- Use public transportation or carpool. Not only does this save energy costs, but it extends the life of your vehicle.

BETTER BUILDINGS

- United States Department of Energy (DOE) started the Better Buildings Initiative in 2011. The program is part of DOE's Office Energy Efficiency and Renewable Energy.
- Better Buildings aims to make commercial, public, industrial, and residential buildings 20 percent more energy efficient over the next decade. Improving the energy efficiency of the nation's commercial buildings, responsible for 20% of the United States' energy use at that time.
- It saves billions of dollars on energy bills, reducing greenhouse gases & creating thousands of jobs.
- The Energy Department is currently pursuing strategies within 4 interrelated key areas to catalyze change and investment in energy efficiency.
  - Developing innovative, replicable solutions with market leaders
  - Making energy efficiency investment easier
  - Developing a skilled clean energy workforce
  - Leading by example in government.

Some key factors that to be considered for ***better building*** are:

1. **Planning and Design:** Thorough planning and thoughtful design are essential for a successful building project. This includes understanding the purpose of the building, its intended use, and the needs of the occupants. Consider factors such as functionality, aesthetics, space utilization, and energy efficiency during the design phase.

   Design the building to be ***accessible*** to all people., such as providing ramps, elevators, wider doorways and accessible restrooms to ensure easy access for individuals with disabilities.

2. **Quality Materials:** Using high-quality materials is vital for the durability and longevity of a building. Quality materials not only enhance the structural integrity but also reduce maintenance costs over time. Choose materials that are resistant to weathering, fire, pests, and other potential hazards.

3. **Energy Efficiency:** Building energy-efficient structures is not only environmentally friendly but also helps reduce long-term operating costs. Incorporate energy-efficient design elements such as proper insulation, efficient HVAC systems, energy-saving lighting, and the use of renewable energy sources like solar panels.

4. **Sustainable Construction:** Sustainable building practices aim to minimize the environmental impact throughout the entire construction process. Consider using eco-friendly materials, incorporating green building techniques, recycling and reusing materials, and implementing water-saving measures.

5. **Structural Integrity:** A structurally sound building is essential for the safety of its occupants. Ensure that the building adheres to local building codes and regulations. Qualified architects and engineers to design and oversee the construction to guarantee its structural integrity.

6. **Proper Ventilation:** Good indoor air quality is crucial for occupant health and comfort. Incorporate proper ventilation systems that provide fresh air circulation and minimize the buildup of pollutants and moisture, which can lead to mold and other issues.

7. **Safety and Security:** Adequate safety measures throughout the building, including fire safety systems, emergency exits, smoke detectors, and security systems. Ensure compliance with safety regulations and consider factors like slip-resistant surfaces and proper lighting.

REDUCING ENERGY CONSUPMTION

Reduction in energy consumption can be done at ***Building level*** and ***City level***

BUILDING LEVEL STRATEGIES:

- ***Energy-efficient systems:*** Install energy-efficient lighting, heating, ventilation, and air conditioning (HVAC) systems, and appliances to reduce energy consumption.
- ***Insulation and sealing:*** Insulate buildings to reduce heat loss in winter & heat gain in summer. Seal air leaks around windows, doors & ducts to prevent heated or cooled air from escaping.
- ***Renewable energy:*** Install on-site renewable energy systems like solar panels, wind turbines, or geothermal systems to generate electricity and reduce reliance on the grid.
- ***Smart building technologies:*** Implement smart meters, energy management systems, and automation to monitor and optimize energy use in real-time. These technologies can:
  - Monitor energy consumption
  - Detect energy waste
  - Optimize energy use
  - Automate energy-saving actions

- ***Green building materials:*** Use sustainable materials with low embodied energy and high recyclability, such as:
  - Recycled materials
  - Locally sourced materials
  - Sustainable wood products
  - Low-VOC (volatile organic compound) paints and finishes
- ***Passive design:*** Design buildings with natural ventilation, daylighting, and shading to reduce energy needs. This includes:
  - Orienting buildings to maximize natural light
  - Using natural ventilation instead of mechanical cooling
  - Incorporating shading devices to reduce summer heat gain
- ***Energy recovery:*** Install energy recovery systems to harness waste energy and reuse it, like
  - Heat recovery ventilation systems
  - Energy recovery wheels
  - Solar thermal systems

CITY-LEVEL STRATEGIES:

- **Urban planning:** Design compact, walkable neighborhoods with mixed-use development to reduce transportation energy. This includes:
  - Mixed-use development (residential, commercial, recreational)
  - Dense, walkable neighborhoods
  - Pedestrian-friendly infrastructure (sidewalks, crosswalks, bike lanes)
  - Public transportation hubs
- **Public transportation:** Develop efficient public transportation systems to reduce reliance on personal vehicles. This includes:
  - Bus rapid transit (BRT) systems
  - Light rail or metro systems
  - Bike-sharing programs
  - Electric or hybrid public transportation vehicles

- ***Smart grids:*** Implement smart grid systems for managing the energy distribution and consumption, which includes the following
  - Advanced metering infrastructure (AMI)
  - Smart grid management systems
  - Energy storage systems (batteries, etc.)
  - Renewable energy integration
- ***Green infrastructure:*** It Incorporates aspects like Urban forests, Green roofs and walls, Green Corridors, Parks and gardens e.t.c., to reduce urban heat island effects.
- ***Energy-efficient lighting:*** Install energy-efficient street lighting and public lighting systems, like
  - LED lighting,
  - Smart lighting controls and
  - Energy-efficient lighting designs
- ***Waste-to-energy:*** Implement waste-to-energy systems to convert waste into energy. This includes: Incineration, Gasification and Anaerobic digestion systems.

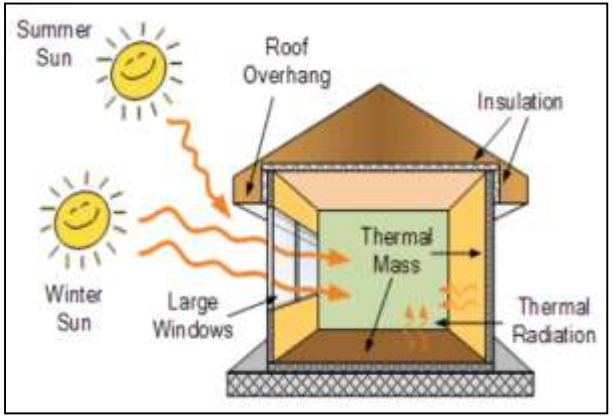
Miscellaneous:

- Adoption of BEE Guidelines, EC building code, Standards and specifications for buildings, energy and equipments
- Promoting the utilization of exhaust heat from incinerations plants and sewerage treatment
- Replace coal based power generation to natural gas/non polluting alternative fuels
- Observe strictly safety controls and instructions
- Check transmission and distribution losses
- Incentive decentralized power generation and energy conservation
- In regions where heating is important during winter months, the use of top-light solar passive strategies for spaces without an equator-facing façade can efficiently reduce energy consumption for heating, lighting and ventilation.

Passive techniques

a) Passive heating system:

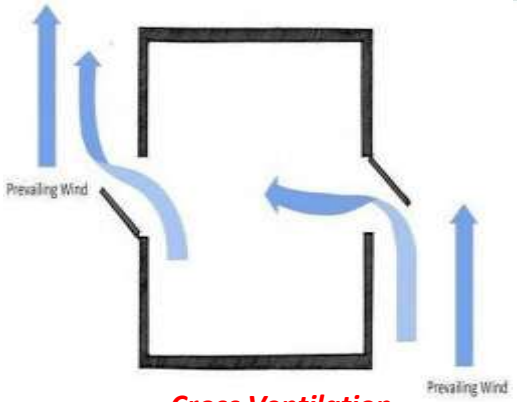
- High levels of insulation and air tightness are used to reduce heat loss from the building, and hence the need for heating during winter.
- Dense materials in the building construction creates ‘thermal mass’, which reduces temperature fluctuations by storing heat and releasing it later in the day, helping limit overheating during hot weather conditions.



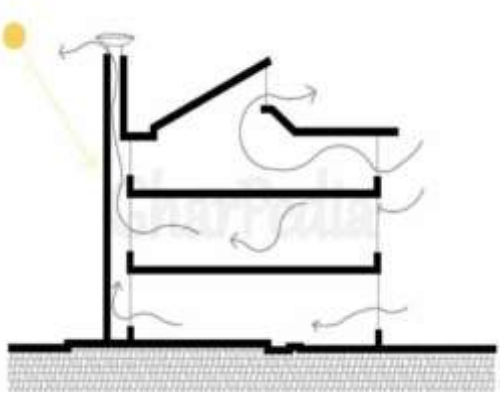
- Buildings can be designed to make the best use of sunlight by orientating them relative to south and arranging windows to maximize daylight and allow sunlight in during winter, but to limit direct sunlight penetration during summer when it can cause overheating.
- The use of high efficiency, low emissivity glazing allows high levels of daylight in whist reducing heat losses through windows.

b) Passive cooling system

- Passive design can use wind-driven and stack-driven natural ventilation to provide cooling in summer without the need for air conditioning.
- Natural Ventilation:
  - ***a. Cross Ventilation:*** Utilizing windows, doors, or vents placed on opposite sides of a room or building to allow cooler outdoor air to pass through, displacing warmer indoor air.
  - ***b. Stack or Chimney Effect:*** Warm air within a building rises and exits through higher openings or vents, drawing in cooler air from lower openings.
- To minimize heat losses during cold weather, airflow is reduced to the minimum needed to provide fresh air.



Cross Ventilation



Stack Ventilation

Renewables

- Renewable heating systems can be used to supply heating and hot water needs with the reduced greenhouse gas emissions, which includes the following
  a) Biomass boilers
  b) Active solar water heating and
  c) Ground source heat pumps

- Solar photovoltaic's can be mounted on or integrated in the building roof, to provide renewable electricity.
- Wind turbines can be included within the site as another means of providing renewable electricity or power generation.
- Energy efficiency brings health, productivity, safety, comfort and savings to home owner, as well as local and global environmental benefits.

LOW ENERGY DESIGN

- "Energy-Efficient Building" or "Low-Energy Building" refer to the building's energy performance.
- These terms put an emphasis on the building's envelope and its technical installations like,
  - Underlining thermal insulation,
  - Energy-efficient windows, and
  - Technical schemes (e.g., a heat-recovery ventilation system, solar panels, etc.) and
  - It also provides good indoor comfort.
- **Low energy buildings** are structures that are *designed* and *constructed* to *minimize energy consumption* and *reduce environmental impact*.
- A **low-energy building** is defined as "*A building that uses 25% less energy for space heating than stipulated in the building code, while a very low-energy building must use 50% less energy for space heating than stipulated in the building code".*

- In buildings energy is used in two forms basically, those are
  1. ***Energy-in-use:*** Energy is used in buildings to deliver comfortable conditions for occupants and to power appliances.
  2. ***Embodied energy:*** Energy is also used in the production of building materials and during construction.
- Low energy design can be done by following ways:
  - Low energy buildings use a mixture of *passive techniques* and *active systems* to deliver a comfortable environment with low energy use and low greenhouse gas emissions.
  - Passive techniques relate to the *shape of building* and the *materials* that it is built with, while active systems use *machinery* to provide services to the building which *minimize energy* use.
  - In addition, low energy use makes the adoption of *renewable energy technologies* more viable because less capacity is required to meet the building demand.
  - It's possible to reach the point where a building produces net zero greenhouse gas emissions in use, known as '*zero carbon in use*'.

- Embodied energy can also be reduced by using low-carbon building materials and construction methods.
- Natural ventilation is rapidly becoming a significant part in the design strategy for non-domestic buildings because of its potential to reduce the environmental impact of building operation, due to lower energy demand for cooling.
- Naturally ventilated building can readily provide a high ventilation rate. On the other hand, the mechanical ventilation systems are very expensive.
- However, a comprehensive ecological concept can be developed to achieve a reduction of electrical and heating energy consumption, optimize natural air condition and ventilation, improve the use of daylight and choose environmentally adequate building materials.

❑ The use of renewable energy resources could play an important role in this context, especially with regard to responsible and sustainable development.

- General principles of energy efficient building design or low energy design comprises are:
  - Integration of energy concept from project outset, demand and management
  - Compact shape and minimize power requirement
  - Day light design, Energy efficient lighting and ventilation
  - Space conditioning, site planning and landscape design
  - Shading, green roof and building envelope design
  - Fenestration and window/ openings design, glazing design
  - Efficient use of passive solar energy and renewable energy
  - Energy efficient and easy to use technical systems
  - Low water use sanitary ware and Low energy electrical appliances
  - Use of low embodied energy, recyclable construction materials
  - Increased insulation, elimination of thermal bridges wherever possible
  - Safety against fire and other hazards