

UNIT-1**GREEN BUILDINGS**

Definition: A Green building or sustainable building is a structure which is designed, constructed, operated, or reused in an ecological and energy-efficient manner. A Green Building is one which uses less water, optimises energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants as compared to a conventional building.

Green building is the only answer through creating healthier and more resource-efficient models of construction, renovation, operation, and maintenance. Green Architecture and sustainable buildings are considered a modern trend in architectural thinking which manipulates the relationship between the building and the environment.

Generally, office buildings are one of the highest types of buildings in energy consumption compared to other building types. so it's very important for an architect to implement specific strategies in order to decrease energy consumption, especially in this type of building, by using renewable energy sources such as solar energy, wind energy, and other sources which contribute to electric energy rationalization.

Green Building refers to a structure and building process that is environmentally responsible and resource-efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation and demolition. This requires close cooperation of the design team, the architects, the engineers and the client at all project stages. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability and comfort.

The concept of Green building integrates a variety of strategies during the period of Design, Construction, Maintenance, and Operation of buildings. Construction is an element of civilization which is increasing continuously and thereby requires lots of natural or manmade materials to fulfill the demand. Manufacturing of construction materials like Cement, Conventional brick, steel, etc. These materials produce a large amount of CO₂ and other greenhouse gases which are hazardous or toxic in nature and cause environmental and health-related problems. So it is today's demand to acquire good construction practice and energy efficient material which helps in less production of greenhouse gases and save energy.

Generally there are 4 elements of green building and that shows the main points required to be considered while designing any building.

1. Smart Design
2. Energy efficiency
3. Eco Materials
4. Water Conservation



Typical Features of Green Buildings

A green building includes environmental considerations in each stage of the building construction and focuses on the design, construction, operation, and maintenance phases.

Green buildings typically incorporate superior air quality, abundant natural light, access to views, and noise control which benefits building occupants, making these buildings better places to work or live.

some of the most highlighted features of Green Buildings are

1. Air tightness and vapour barrier in building walls and surfaces
2. Waste reduction
3. Enthalpy recovery of exhaust air
4. Low solar heat gain coefficient of glass
5. Daylight-controlled lighting systems
6. Occupancy sensors
7. Water-efficient fittings
8. Rain-water harvesting
9. Materials recovery facility (MRF)
10. Vegetation
11. Site sustainability
12. Geothermal Heating and Cooling
13. HEPA (High-efficiency particulate arrestance)
14. CO₂ Controlling ventilators
15. VSD (Variable Speed Drives)
16. Use of solar panels
17. Solar thermal collectors
18. Greywater/Blackwater Recycling
19. LED
20. Wind Turbines

1.Air tightness and vapour barrier in building walls and surfaces

Walls that are able to keep out moisture and humidity from outside will make the building naturally cooler. Because of this, air-conditioning systems will not have to work so hard to cool down the building and thus lowers electricity costs.



2.Waste Reduction

Pollution control measures adopted and implemented on the project sites during construction activities, Green buildings aim to reduce the amount of material being sent to landfills during construction.



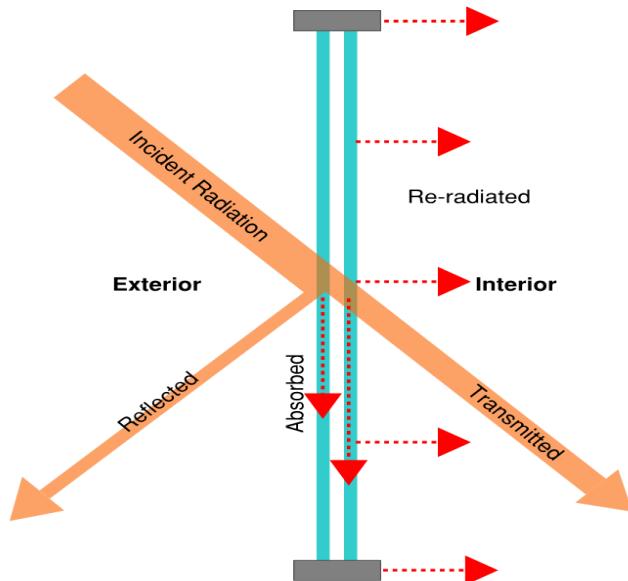
3.Enthalpy recovery of exhaust air

A device called an enthalpy wheel recovers cooled air from the inside and uses the coolness of this “spent” air to cool fresh air from outside.



4.Low solar heat gain coefficient of glass

Solar heat gain coefficient (SHGC) is the amount of solar radiation that enters through glass and is released as heat inside a building. The lower the SHGC, the less solar heat it transmits, and the cooler the building. This also lowers electricity costs because air-conditioning systems don't have to do all the work.

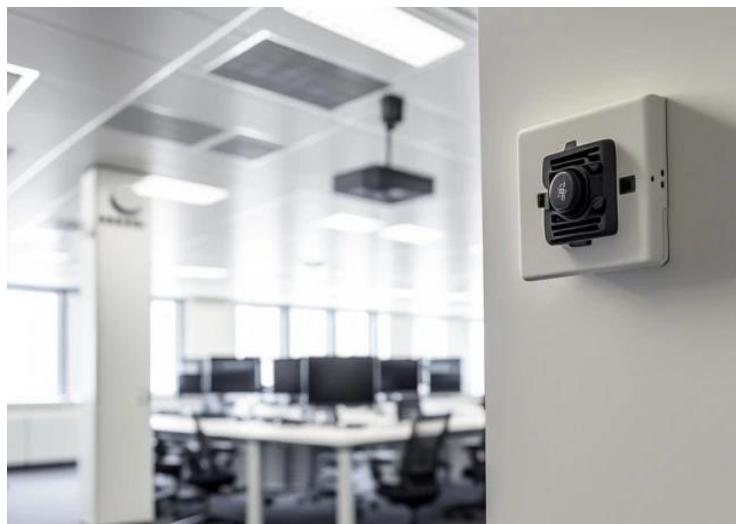


5.Daylight-controlled lighting systems

This type of lighting system has sensors that can detect daylight. During the day, the sensor switches off the lights since there is enough light from the sun. When the sun sets, the system will switch the lights on. This way, the use of artificial lighting during the daytime is reduced.

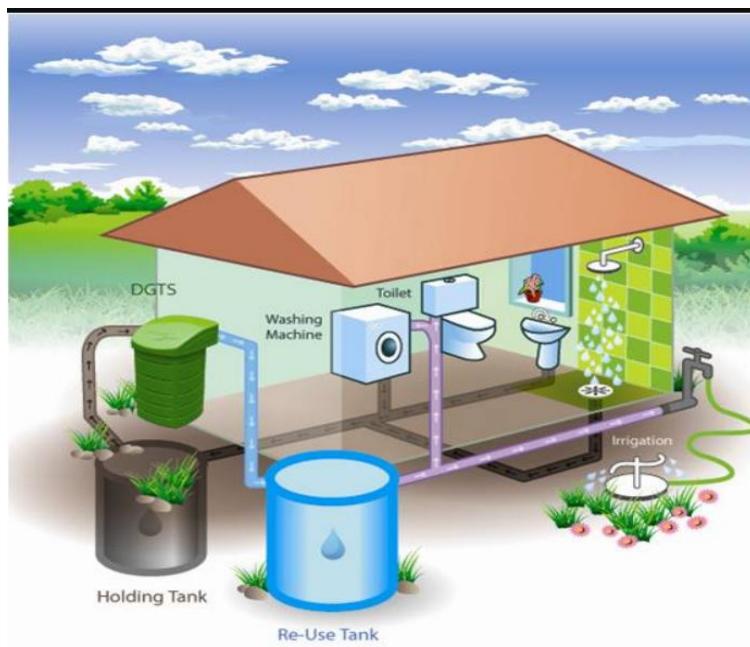
6. Occupancy sensors

This lighting system only turns on when it senses people in the room. This technology can also be found in escalators that activate only when there are people riding on them. The process also dehumidifies the air from outside. This is a cost-efficient way to improve indoor air quality and lessen energy consumed by air-conditioning systems.



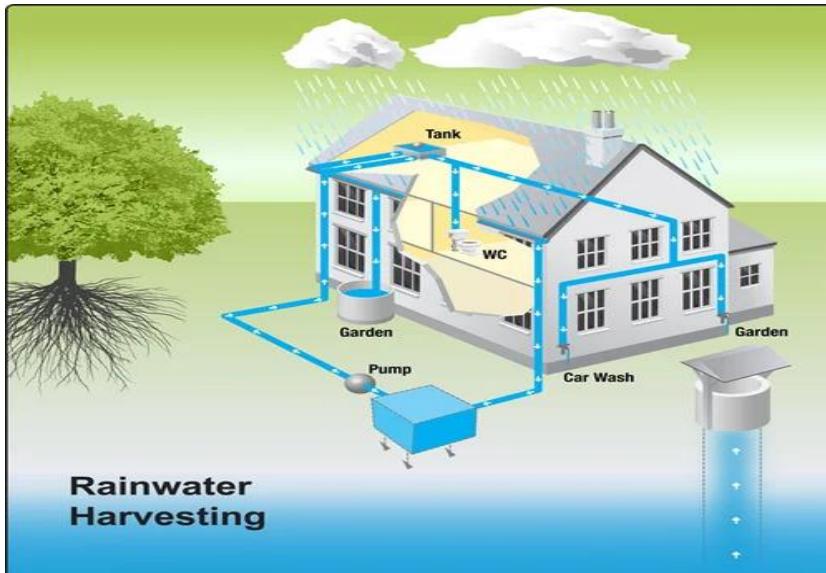
7. Water-efficient fittings

The latest faucets and flush mechanisms use less water to do the same thing.



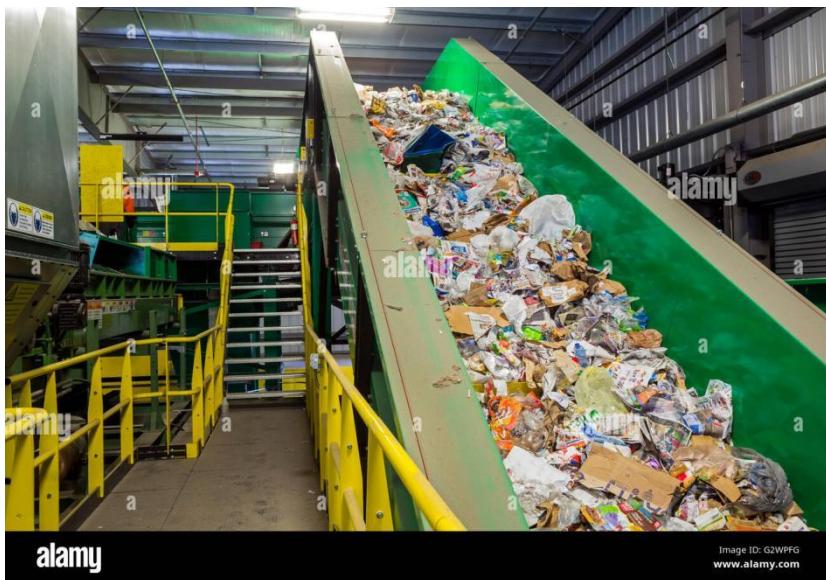
8. Rain-water Harvesting

A structure catches rainwater and then stores it in big containers. The water can then be used to water plants, flush toilets, or supply cooling towers.



9. Materials recovery facility (MRF)

An MRF is where the building's garbage is segregated into biodegradable, recyclable, non-recyclable, and special or hazardous waste. Biodegradable waste can be composted and used as fertilizer for the building's plants.



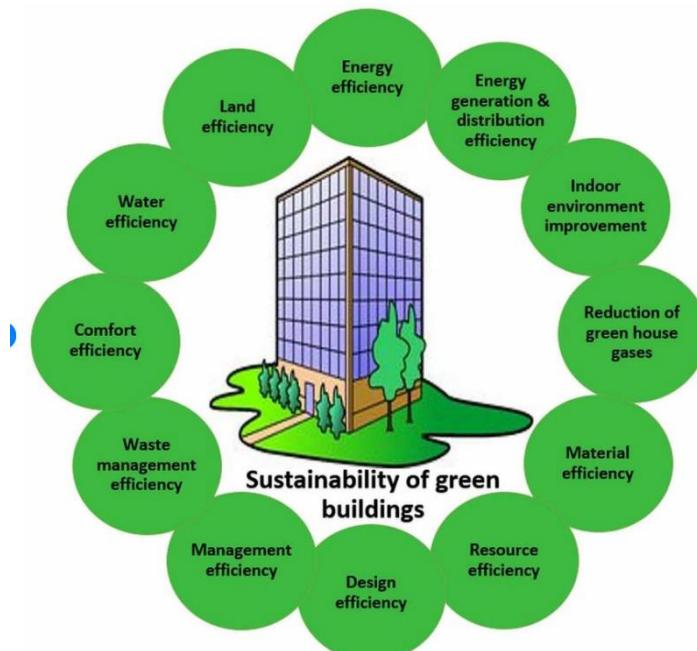
10. Vegetation

A significant portion of the building's unpaved area is devoted to vegetation. This helps reduce the heat urban island effect—when concrete surfaces so common in urban areas absorb heat from the sun and radiate it to the surroundings. Plants also help absorb some rainwater which would otherwise go to sewers and drainage, later on contributing to flooding.



11. Site Sustainability

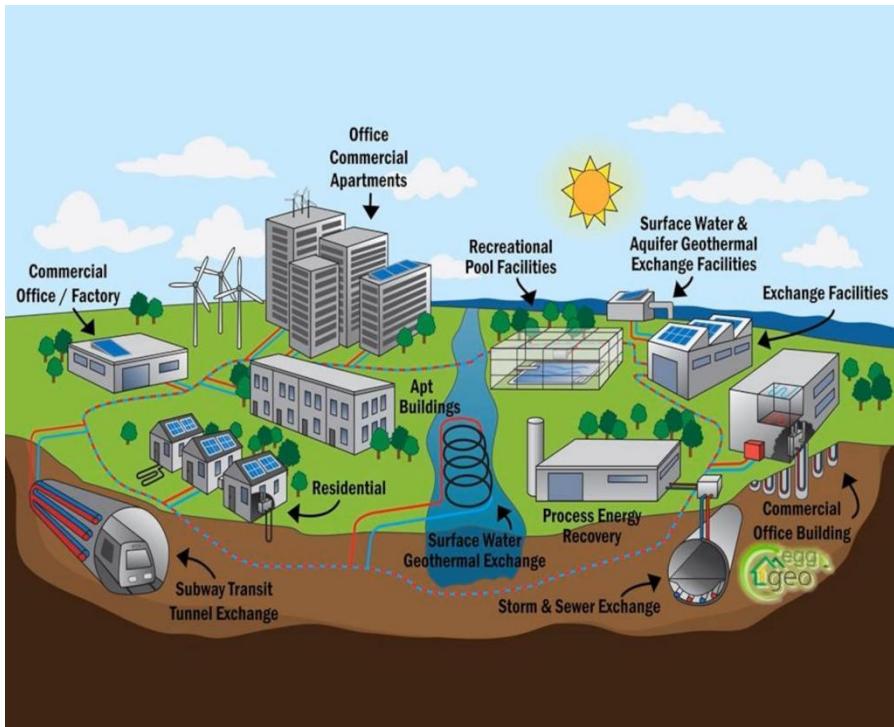
The building's design, construction, and operation practices should have minimum impact on ecosystems and water resources.



12. Geothermal Heating and Cooling-

The underground is an excellent heat sink in summer and an excellent heat source in winter. Geothermal heat pumps take advantage of this providing heating and cooling for buildings

with a lower kWh consumption than other methods. Indoor heating and cooling are provided normally with hydronic piping, air-handling units, and air ducts.



13. HEPA (High-efficiency particulate arrestance)

HEPA stands for high-efficiency particulate arrestance. HEPA filters are among the best available, capturing 99.97% of particles with a size of 0.3 microns or more. These filters remove many pollutants and allergens from the air, improving indoor air quality.



14. CO₂ Controlling Ventilators

Since human metabolism produces carbon dioxide, occupancy can be correlated with the CO₂ concentration in the air. Ventilation can be controlled with CO₂ sensors, reducing airflow in proportion to occupancy to achieve energy savings.



15. VSD(Variable Speed Drives)

Variable speed drives(VSD) are devices that modify the voltage and frequency supplied to a motor, allowing it to operate below-rated rpm. VSDs are very useful in motors that drive fans and pumps since these devices are often subject to part-load conditions. They are also known as variable frequency drives (VFD).

16. Use of solar panels

Solar panels are among the most promising building upgrades if you have plenty of rooftop areas available. They normally come with a 10-year warranty for manufacturing defects and a 25-year warranty for energy generation, in addition to having simple maintenance needs.

The payback period of solar panels only represents a small fraction of their service life. Simple maintenance. The main requirement is keeping panel surfaces clean and free of shadows. May be eligible for incentives from the government or utility companies.



17. Solar thermal collectors

Solar radiation is used directly for domestic hot water instead of electricity generation. With this building upgrade, you can rely less on your gas-fired water heater. There may be a slight pumping cost in taller buildings since water has to reach the rooftop, but it is much less than the ongoing cost of a water heater. However, Solar thermal collectors also harness sunlight.

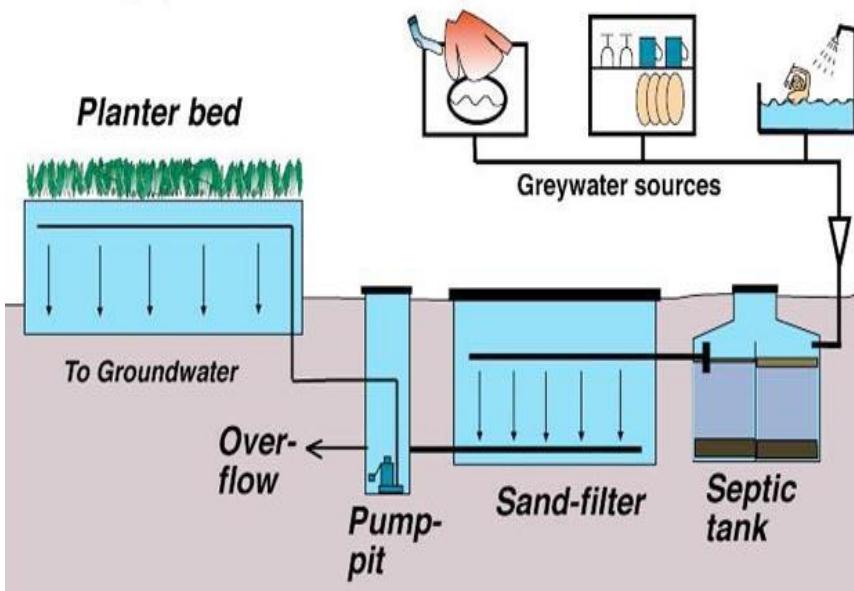


18. Greywater/Blackwater Recycling-

The concepts of greywater and blackwater are used to describe water that has already been used in plumbing fixtures. Blackwater includes water from all fixtures, while greywater excludes the water discharged from toilets.

Although greywater is polluted with cleaning agents and grease, it can be collected and reused for purposes such as flushing toilets or outdoor watering. Blackwater can also be recycled for some purposes, but it requires special treatment.

Advanced greywater treatment



19. LED

LED uses over 30% less power consumption than fluorescent, over 50% less than HID, and over 80% less than incandescent. LED also Reduced the cooling load for AC and refrigeration equipment. LEDs have a long service life and almost no maintenance is required.



20. Wind Turbines

A single wind turbine results in a lower cost per kilowatt. Electricity generation is enhanced with a taller tower since airflow is more stable as height increases. Smaller turbines are closer to the ground and susceptible to the turbulence caused by trees and constructions.



Benefits of Green Buildings:

Following are the benefits of Green Building:

1. Reduction of natural resource consumption
2. Reduction of operating costs
3. Health, comfort and safety for all residents
4. Energy optimization and reduction of energy consumption
5. Increased productivity of the occupants
6. Better indoor air quality (IAQ has a tremendous impact on human health)
7. Green Building encourages companies to benefit from the Green corporate image and to leave a very positive impression on customers, employees, business partners and shareholders.

Sustainable Site Selection:

The Site on which we build can influence each and every aspect of the building we choose. In this article, you can learn about various aspects to consider in site selection.

The primary goals for green buildings in selecting a site are

1. Protecting sensitive sites
2. Preserving undeveloped sites
3. Restoring and Reusing previously developed sites
4. Reducing impact on flora and fauna
5. Promoting connection to the community
6. Minimizing transportation impacts both the environment and energy use.

1. Site Selection Criteria

- The site selection and site plan must fulfill the regulations and guidelines of UDPFI(Urban Development Plan Formulation and Implementation) , Eco-sensitive zone regulations, Coastal zone regulations, and any other specific local bye-laws.
- Minimizing land disturbances by selecting previously disturbed lands; sites that are close to public transportation, community and work centers, and services such as pumping water and transporting electricity.
- Minimize long-term impacts on the community.
- Creating neighbourhoods with compactness, connectivity, and walkable streets.
- Climate zones (cold /hot/mixed) and Local Hydrology will have an impact on building design. The same type of building will be designed in a different way depending on outdoor temperature, outdoor humidity, and solar radiation.

The design varies in various aspects such as:

- Wall materials and assembly
- Size and orientation of windows
- Heating system selection
- Methods for controlling moisture
- Type of vegetation available for landscaping.
- Encouraging using less polluting modes of transportation.

2. Protection of Sensitive sites – Site Selection

- Site selection and Protect sensitive sites. These include

- Prime farmland
 - Parkland
 - Flood hazard areas
 - Habitat for endangered or threatened species
 - Primary dunes
 - Old-growth forests
 - Wetlands and other water bodies (50'-100' buffer space)
 - Conservation areas
- Not developing or undergoing any construction activities within these sites and also including buffer zones surrounding them.

3. Preservation and Restoration



Green Field

Brown field

1. Greenfields are defined as previously undeveloped sites.
2. Brownfields are abandoned industrial and commercial sites that have perceived levels of contamination.
3. Greyfields are previously developed sites that are not contaminated and have a visible development and infrastructure
4. Restoring and Reusing Brownfields to prevent/limit the development of Greenfields.
5. Developing Greyfield and promoting urban density

4. Protection of Natural Features

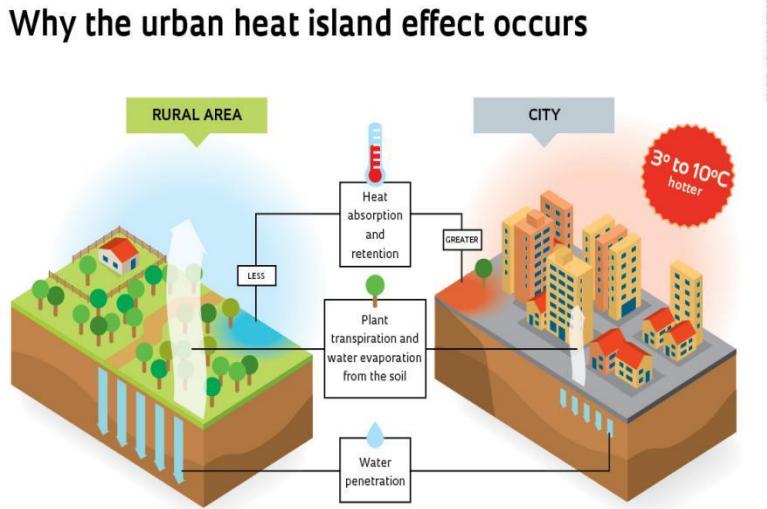
1. Minimize Site disturbance.
2. Protecting the Site's soil conditions.
 - Retaining soils in place.
 - Stockpiling and reusing soils.
 - Restoring soils during construction.
 - Revegetation of disturbed soils.
 - Measures to prevent soil runoff during construction.
3. Protection of vegetation present on site.

5. Heat Island Reduction

The heat Islands are generated by the raised levels of temperatures from hardscapes and buildings, particularly in urban areas. It refers to the absorption and retention of incoming

solar radiation by the buildings and hard pavements surrounding them. When this heat is released into the atmosphere, heat islands are formed having higher temperatures in urban areas, compared to rural areas.

Why the urban heat island effect occurs

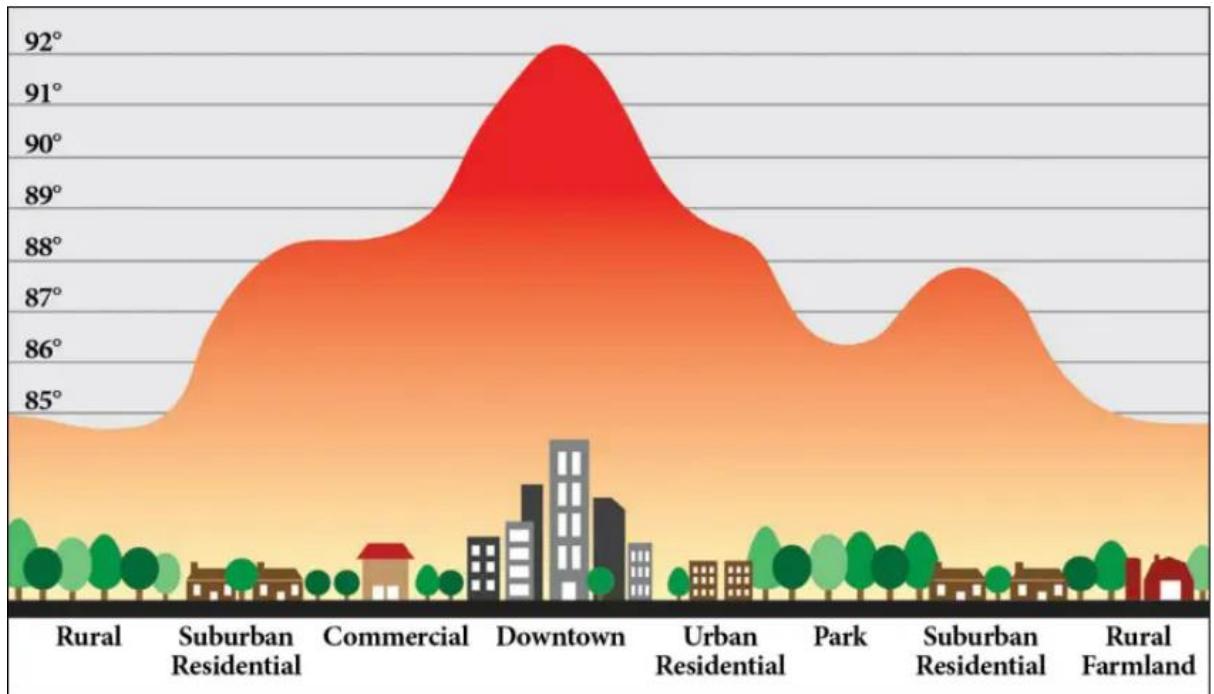


Effects of Higher Temperatures/heat Islands:

1. Increased energy consumption for cooling during summers.
2. Elevate emissions of air pollutants and greenhouse gases.
3. Contribute to heat exhaustion.
4. Heat-related Mortality.
5. Stressing aquatic ecosystems due to raised temperatures of water in streams, lakes and ponds, rivers, etc.\

Ways to Reduce the Heat Island Effect:

1. Using light-colored roofing having high solar reflectance.
2. Installing green roofs/Vegetated roofs.
3. Including pavement with non-heat-absorbing materials.
4. Planting trees
5. Providing landscapes
6. Shade Parking surfaces.



6. Site Waste Management

Manage the waste generated during site construction. It includes:

1. Debris such as
 - o Rocks
 - o Soil
 - o Vegetation
2. Any other hazardous materials present

Strategies Include

1. Prevent debris from moving to landfills.
2. Restrict debris transported to sensitive sites such as wetlands.
3. Reusing materials onsite itself.
4. Recycling debris offsite.



5.

7. Greener forms of Transportation

One of the factors in the site selection process is transportation, proximity, and other facilities.

1. Proximity to public transportation.
2. Onsite Traffic Signs.
3. Providing facilities of transportation that emit fewer carbon emissions.
 - o Installing Bicycle racks.
 - o Facilities for storing and covering bicycles.
 - o Providing pedestrian paths.
 - o Sidewalks for walking and biking.
4. Vehicles serving Carpools.
5. Encouraging Electric vehicles and providing electric charging stations.



8. Minimizing Light Pollution

Light pollution is the presence of artificial light in the outdoor environment.

Impacts of Light Pollution:

1. Disrupts the habitat of nocturnal wildlife.
2. Interferes with normal plant growth cycles.
3. Conceal the night sky; interferes with the ability to view the night sky, stars, and planets.
4. Causes light trespass – Spill of light into neighbouring properties.
5. Safety Hazard – Produces glare while driving.
6. Assists Intruders – Increase security risks.
7. Wastes energy – impacts environmental and economic concerns.



Strategies to Reduce Light Pollution:

1. Select light fixtures that minimize spillage, and focus light downward rather than upward.
2. Providing accent lighting for pathways instead of higher pole-mounted lighting.
3. Eliminating Uplighting.
4. Installing fixtures downwards.
5. Locating outdoor amenities close to the main building.
6. Motion sensors and time schedules keep exterior lights on most of the time.
7. Eliminating exterior lighting wherever possible.
8. Reducing lighting near windows.

9. Site Strategies and Energy Use in Site Selection

1. A building on an exposed hilltop utilizes more energy than a building surrounded by trees or adjacent buildings.
2. Trees, structures, fencing, and other forms of shielding help reduce wind velocity downwind of the barriers.
3. Site planning not only refers to landscaping and natural features, but also exterior equipment such as air-conditioning condensers, cooling towers, and pad-mounted transformers.
 - o Unlike buildings, these equipment's operate more efficiently when not blocked by vegetation or structures.
4. Energy use rises by 20% or more by various risks such as-
 - o Air blockage by vegetation or other obstructions.

- Contamination of heat exchangers by dust or pollen
 - Recirculation of exhausted air.
5. Locating an outdoor unit in an enclosed or partially enclosed location will cause air recirculation and its high energy use.

Ways to reduce Increased Energy Use :

1. Maintaining clearance between the units and buildings or vegetation.
2. Locating units where outgoing air does not recirculate back into the units.

10. Storm and Site Water Conservation

1. One of the important goals of green projects is to mitigate the negative environmental effects of stormwater runoff and reduce the use of outdoor use of potable water on the site.
2. Impervious surfaces, buildings, and conventional storm drainage systems prevent rainwater from percolating into the soil.
3. Surface runoff (also known as overland flow) is the flow of water occurring on the ground surface when excess rainwater, stormwater, meltwater, or other sources, can no longer sufficiently rapidly infiltrate the soil. (Wikipedia)



Effects of Storm Water Runoff:

1. Soil erosion
2. Habitat damage
3. Flooding
4. Water Pollution
5. Groundwater Aquifer depletion
6. Physical and chemical depletion of water resources.
7. Transfers surface contaminants along the same path.

Strategies to Reduce Storm Water Runoff:

Quantity of Storm Water Runoff:

1. Reducing hardscapes for parking.
2. Minimizing on-site parking by encouraging public and non-motor vehicle transportation.
3. Providing on-site percolation facilities.
4. Replacing Impervious surfaces with permeable methods such as
 - o Pervious pavers,
 - o Porous asphalt,
 - o Pervious concrete
 - o Vegetated Landscapes
5. Rainwater harvesting methods on site.
6. Reuse of stormwater for landscapes and flushing toilets.

Quality of Storm Water Runoff:

Advantages:

1. Improved on-site water quality.
2. Improves water quality in downstream rivers and lakes, etc.
 - o Thereby benefiting flora and fauna

Strategies to improve Quality of Storm Water Runoff

1. Proper management of water quantity and its velocity.
 - o Reduces containments, such as pesticides, biological waste, garbage, and sediments.
2. Integrate pest management to minimize the use of pesticides.
3. Minimize on-site vehicles and contaminants to them such as oil, grease, dirt, etc., carried by tires.
4. Reduce onsite sources of pollutants – including pesticides, fertilizers, animal waste, finishes for outdoor structures, etc.
5. Minimize artificial landscaping that requires chemicals.

11. Transported Water

Water is supplied by a municipal water system or well water that is sourced from an underground aquifer and treated on-site.

Impacts of Using Transported Water:

1. Depletion of Potable Water Resources.
2. Use of water treatment chemicals.
3. Energy use and Power requirements for pumps.
4. Excess and unnecessary use of water increases surface runoff.

Strategies to Reduce Using Transported Water:

1. Employing water Efficiency measures.
2. Using non-potable water wherever possible such as for landscaping, flushing, etc.
3. Landscaping with native plant species that require fewer water resources.
4. Installing efficient irrigation methods such as Drip irrigation.
5. Selecting smaller fountains with fewer surface areas and with low flow rates.
6. Metering of water use helps to monitor the usage of water.

12. Other Site Issues

Trees and vegetation, which are helpful for shading and protection from the energy effects of the Sun, can also adversely contribute to humidity and other environmental problems if located adjacent to buildings.

Trees can also threaten a building's structure with their roots and branches.

Leaves and small branches can protrude into the windows.

Strategies to overcome the above problems:

1. Providing a buffer zone between the building and trees/vegetation.
2. Promote indoor environmental quality by protecting buildings from dirt and moisture.
 - o Installing walk-off mats at entrances.
 - o Textured paving materials instead of gravel.
3. Proper selection of landscaping materials and plants.



UNIT-II

ENVIRONMENTAL FRIENDLY BUILDING MATERIALS AND TECHNOLOGIES

Natural Material like Bamboo:

Bamboo is a versatile and sustainable natural material that has been used by humans for various purposes for centuries. Here are some key points about bamboo.

Renewable Resource: Bamboo is a highly renewable resource as it is a fast-growing grass that can reach maturity in just a few years. It can be harvested without killing the plant, and new shoots will continue to grow from the root system.

Strength and Durability: Bamboo has impressive strength-to-weight ratio, making it a durable material for construction and various other applications. It is known to be stronger than many types of wood and can withstand heavy loads.

Flexibility: Bamboo is known for its flexibility, which makes it suitable for applications that require bending or shaping. It can be easily cut, bent, and manipulated to create various products.

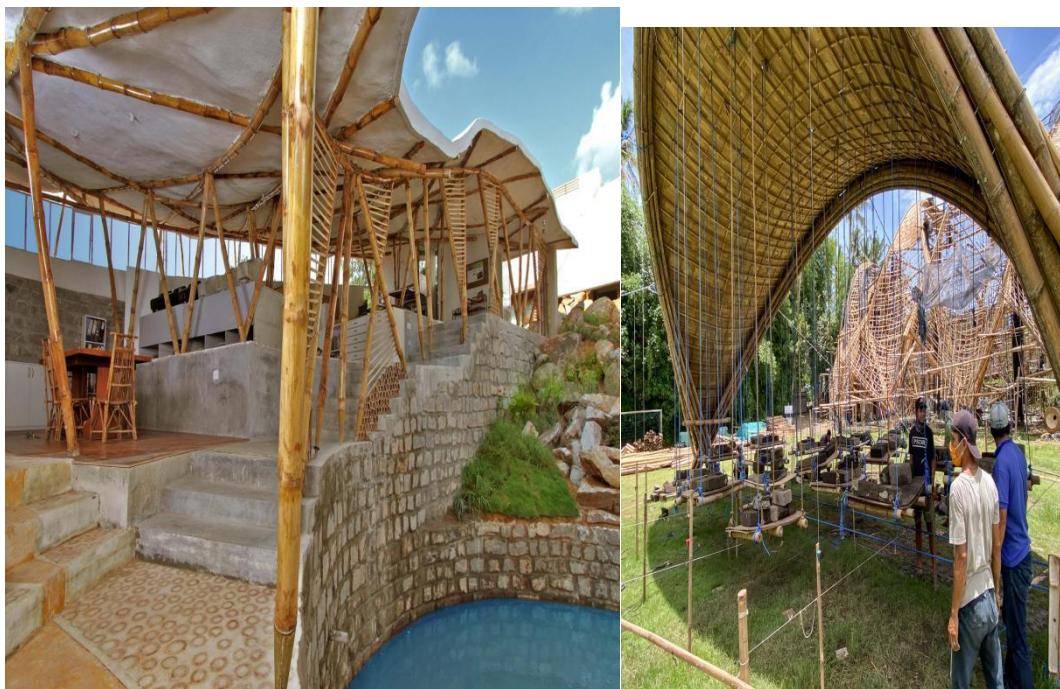
Environmental Benefits: Bamboo is considered an eco-friendly material due to its rapid growth and minimal environmental impact. It requires no pesticides or fertilizers for growth, and its extensive root system helps prevent soil erosion.

Versatility: Bamboo can be used in a wide range of applications. It is commonly used for building materials such as flooring, furniture, and structural components. Additionally, bamboo can be woven or processed into textiles, paper, kitchenware, and even used in traditional crafts.

Aesthetic Appeal: Bamboo has a unique and aesthetically pleasing appearance that adds a natural and organic touch to any setting. Its light color and distinctive grain patterns make it popular in interior design and decor.

Sustainability: Bamboo is considered a sustainable alternative to traditional materials like wood or plastic. Its rapid growth and ability to regenerate make it an attractive choice for reducing deforestation and promoting environmental sustainability.

Despite its many benefits, it's important to note that not all bamboo products are necessarily sustainable or environmentally friendly. The manufacturing and treatment processes used can impact its sustainability. It's advisable to look for bamboo products that are responsibly sourced and produced using environmentally friendly methods.



Natural Material like Timber:

Timber, or wood, is another natural material with a wide range of applications. Here are some key points about timber

Natural and Renewable Resource: Timber is derived from trees, which are natural and renewable resources. Trees can be harvested sustainably, with proper management and replanting practices, ensuring a continuous supply of timber.

Strength and Durability: Wood is known for its strength and durability. Different wood species have varying levels of strength, but overall, timber is widely used in construction, furniture making, and other applications where structural integrity is required.

Thermal and Acoustic Insulation: Wood has excellent thermal and acoustic insulation properties. It can help regulate indoor temperatures, reduce energy consumption, and provide soundproofing benefits when used in buildings.

Aesthetically Pleasing: Wood is valued for its natural beauty and warmth. It has a wide variety of grain patterns, colors, and textures, which can enhance the visual appeal of furniture, flooring, and other wooden products.

Versatility: Timber can be used in a diverse range of applications. It is commonly used in construction for framing, flooring, doors, windows, and paneling. Additionally, it is used for furniture, cabinetry, crafts, paper production, and more.

Carbon Storage: Trees absorb carbon dioxide from the atmosphere and store it in their wood fibers. Using timber in construction or other applications helps sequester carbon, mitigating the greenhouse effect and combating climate change.

Environmental Considerations: The sustainability of timber depends on responsible forestry practices. Sustainable forest management, including reforestation and responsible harvesting, ensures the long-term health and viability of forests.

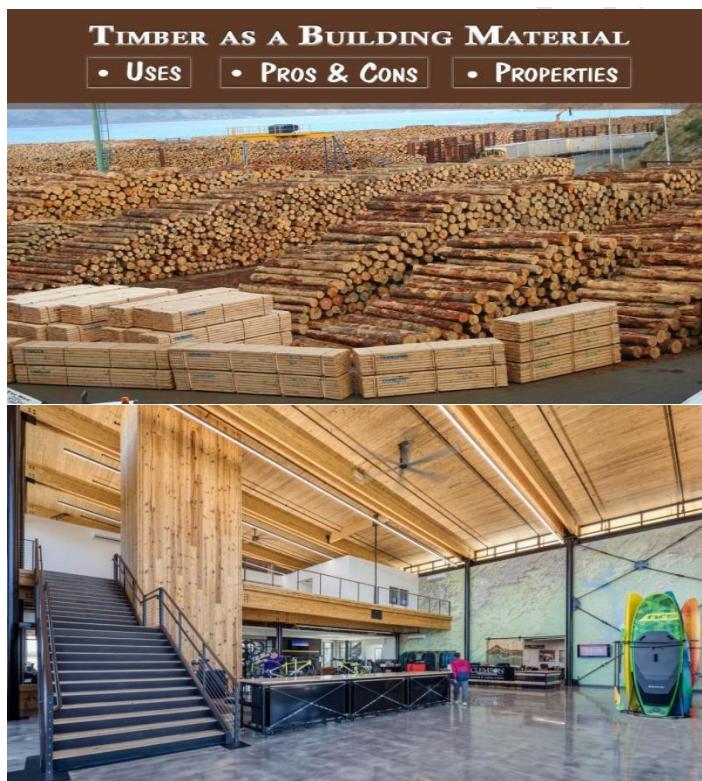
It's worth mentioning that timber products should be sourced from responsibly managed forests with appropriate certifications, such as the Forest Stewardship Council (FSC) or the Programme for the Endorsement of Forest Certification (PEFC). These certifications provide assurance that the timber comes from sustainably managed sources.

It's also important to consider alternative materials and methods, such as reclaimed or recycled wood, to further reduce environmental impact and promote sustainability in the use of timber.



TIMBER AS A BUILDING MATERIAL

- USES
- PROS & CONS
- PROPERTIES



Natural Material like rammed earth:



Rammed earth is a natural building material that has been used for centuries in various parts of the world. Here are some key points about rammed earth

Composition: Rammed earth is a mixture of soil, gravel, sand, and a small amount of cement or stabilizers (such as lime) for improved strength and durability. The soil mixture is compacted in layers within a formwork to create solid walls.

Sustainability: Rammed earth is considered an environmentally friendly and sustainable building material. It utilizes locally available soil, reducing the need for transportation and minimizing the carbon footprint associated with construction.

Thermal Properties: Rammed earth has excellent thermal mass properties, meaning it can absorb, store, and release heat slowly. This helps regulate indoor temperatures, resulting in reduced energy consumption for heating and cooling.

Durability: Rammed earth structures can be long-lasting and durable when properly constructed. The compression and compacting process increases the strength of the material, and with proper maintenance, rammed earth walls can withstand weathering and erosion.

Aesthetics: Rammed earth has a unique and distinctive appearance. The natural color variations in the soil give the walls a warm and earthy aesthetic, creating a connection with the natural surroundings.

Sound Insulation: Rammed earth has good sound insulation properties due to its density and mass. It can help reduce external noise, creating a more peaceful indoor environment.

Low Maintenance: Rammed earth structures generally require minimal maintenance. However, protective measures like appropriate roof overhangs and surface treatments can be applied to protect the walls from excessive moisture or erosion.

Design Flexibility: Rammed earth can be used for both load-bearing and non-load-bearing walls. It can be shaped, curved, or combined with other construction techniques to create unique architectural designs.

It's important to note that rammed earth construction requires skilled craftsmanship and proper design considerations, including soil selection, stabilization techniques, and proper moisture management. Consulting with experienced professionals in rammed earth construction is recommended to ensure successful and durable results.



Natural materials like stabilized mud blocks:

Stabilized mud blocks (SMBs), also known as compressed earth blocks (CEBs), are a type of natural building material made from a mixture of soil, sand, and stabilizers. Here are some key points about stabilized mud blocks.

Composition: Stabilized mud blocks are typically made from a blend of locally available soil, sand, and stabilizers. The stabilizers can include cement, lime, fly ash, or other additives that improve the strength and durability of the blocks.

Sustainability: Stabilized mud blocks are considered an eco-friendly and sustainable construction material. They utilize locally sourced soil, reducing the need for transportation and minimizing the environmental impact associated with traditional building materials.

Strength and Durability: The addition of stabilizers enhances the strength and durability of the blocks, making them suitable for load-bearing applications. The compressive strength of stabilized mud blocks can be comparable to that of conventional fired bricks.

Thermal Properties: Stabilized mud blocks have good thermal properties, providing insulation against heat transfer. They can help regulate indoor temperatures, resulting in reduced energy consumption for cooling and heating.

Sound Insulation: Similar to rammed earth, stabilized mud blocks offer good sound insulation properties due to their density. They can reduce external noise, creating a quieter indoor environment.

Aesthetics: Stabilized mud blocks have a natural and earthy appearance, adding a unique aesthetic to the building. The variation in color and texture of the blocks contributes to a warm and visually appealing finish.

Low Embodied Energy: Stabilized mud blocks have a low embodied energy compared to conventional building materials such as fired bricks or concrete. The manufacturing process involves minimal energy consumption, as it relies on locally available resources and simple production techniques.

Cost-Effectiveness: Stabilized mud blocks can be a cost-effective alternative to traditional building materials, especially in regions where soil resources are abundant. They can help reduce construction costs while providing a durable and sustainable solution.

It's worth noting that proper soil selection, mix design, and construction techniques are crucial for the successful use of stabilized mud blocks. Consulting with experts or professionals experienced in working with stabilized mud blocks is advisable to ensure optimal results and long-term durability of the structures.



Natural materials like hollow blocks:

Hollow blocks, also known as concrete blocks or cinder blocks, are typically made from a mixture of cement, sand, and aggregates. However, if you are looking for natural alternatives to these conventional materials, there are a few options you can consider. Here are some natural materials that can be used to create hollow blocks

Woodcrete Blocks: Woodcrete is a type of material made by combining wood particles or fibers with a binding agent, such as cement or lime. Woodcrete blocks are lighter in weight compared to traditional concrete blocks and provide better insulation. They are commonly used for non-load-bearing walls in construction.

Bamboo Blocks: Bamboo is a versatile and sustainable material that can be used to create hollow blocks. It is lightweight, durable, and has excellent tensile strength. Bamboo blocks can be made by binding bamboo strips or fibers together using natural resins or adhesives. They are commonly used in regions where bamboo is abundant.

Rammed Earth Blocks: Rammed earth is an ancient construction technique where a mixture of soil, clay, sand, and a small amount of cement is compacted within a formwork. Rammed earth blocks can be created by compressing this mixture into a hollow block shape. They offer good thermal mass and insulation properties and are environmentally friendly.

Hempcrete Blocks: Hempcrete is a bio-composite material made from the inner core of the hemp plant mixed with lime and water. It can be used to create lightweight and insulating blocks. Hempcrete blocks are known for their excellent thermal regulation and moisture-wicking properties.

Stabilized Earth Blocks: Stabilized earth blocks are made by mixing soil, sand, and stabilizers like lime, cement, or other natural binders. These blocks are compressed and allowed to cure, creating a sturdy and sustainable building material. Stabilized earth blocks have been used for centuries and are known for their thermal insulation and low environmental impact.

It's important to note that the availability and suitability of these natural materials may vary depending on your location and specific project requirements. Consulting with local experts or architects who specialize in sustainable construction would be beneficial to determine the best natural material option for your hollow blocks.



Natural material like lime and lime:

Lime is a versatile material used in construction, particularly for its binding properties. Here are some natural alternatives related to lime:

Clay: Clay is a natural material widely used in construction. It can be mixed with water and formed into blocks or bricks, which can then be used in building walls. Clay has excellent thermal insulation properties and is abundant in many regions.

Adobe: Adobe is a traditional building material made from a mixture of clay, sand, water, and organic materials such as straw or grass. The mixture is then shaped into

blocks and dried in the sun. Adobe blocks provide good thermal mass and are commonly used in arid regions.

Chalk: Chalk is a soft, porous sedimentary rock composed primarily of calcium carbonate. It can be crushed into a powder and mixed with water to create a lime-like substance called slaked lime. Chalk can also be used as a natural building material itself, particularly for creating walls or foundations.

Gypsum: Gypsum is a mineral composed of calcium sulfate. It can be processed into a powder called gypsum plaster or plaster of Paris. When mixed with water, gypsum plaster hardens into a solid material suitable for creating walls and other structures. Gypsum has good fire-resistant properties.

Limestone: Limestone is a sedimentary rock primarily composed of calcium carbonate. It can be quarried and processed into lime products, such as quicklime or hydrated lime. Limestone itself can also be used as a natural building material, particularly for creating walls or facades.

These natural materials share some properties with lime and can be utilized in construction projects as binders, insulators, or building blocks. However, it's important to consider factors such as availability, local building regulations, and specific project requirements when choosing the most suitable natural material for your needs. Consulting with local experts or architects knowledgeable in natural building materials is recommended for guidance.



Natural Materials Like Pozzolana Cements:

Pozzolana cements are a type of cementitious material that contains natural pozzolans. Pozzolans are natural materials or industrial by-products that can react with calcium

hydroxide (lime) in the presence of water to form cementitious compounds. These compounds contribute to the strength and durability of the cement.

Historically, pozzolans were first used by the ancient Romans, who mixed volcanic ash with lime to produce a hydraulic cement that could set underwater. This type of cement was used in the construction of structures like the Roman aqueducts and the Pantheon.

There are two main types of pozzolana cements:

Natural Pozzolana Cement: This type of cement is produced by blending natural pozzolans, such as volcanic ash, pumice, or diatomaceous earth, with a specific amount of Portland cement or lime. The resulting mixture exhibits hydraulic properties, meaning it can set and harden even in the presence of water.

Fly Ash Pozzolana Cement: Fly ash is a by-product of coal combustion in thermal power plants. It is a widely used industrial pozzolan due to its high silica and alumina content. When mixed with lime or Portland cement, fly ash reacts with the calcium hydroxide to produce additional cementitious compounds, enhancing the strength and durability of the final product.

Pozzolana cements offer several benefits, including reduced heat of hydration, enhanced workability, improved resistance to chemical attacks, and lower overall carbon footprint due to the partial replacement of clinker with natural or industrial pozzolans.

However, it's worth noting that the specific properties of pozzolana cements can vary depending on the type of pozzolan used and the proportions in the cement mix. Additionally, proper quality control measures are essential to ensure the desired performance and consistency of pozzolana cements in construction applications.



Materials from Agro and Industrial waste:

Agro and industrial waste materials are increasingly being utilized as sustainable alternatives in various applications, including construction, agriculture, energy production, and more. These materials offer several benefits, such as reducing waste and environmental impact, conserving natural resources, and providing cost-effective solutions. Here are some examples of how agro and industrial waste materials are being used:

Construction Materials: Agro and industrial waste materials can be used as partial replacements for traditional construction materials like cement, sand, and aggregates. For instance:

Rice husk ash and sugarcane bagasse ash can be used as pozzolanic materials in concrete, similar to natural pozzolans, to improve its strength and durability.

Fly ash, a by-product of coal-fired power plants, is commonly used as a partial substitute for cement in concrete to reduce its carbon footprint.

Bioenergy Production: Agro waste materials, such as crop residues, wood chips, and animal manure, can be converted into bioenergy through processes like anaerobic digestion and gasification. This helps generate renewable energy while reducing the amount of waste that would otherwise end up in landfills.

Agriculture and Soil Improvement: Some agro waste materials, like rice husk and straw, can be used as mulch or organic amendments in agriculture to improve soil

fertility, water retention, and crop yields. These materials can also be composted to create organic fertilizers.

Packaging Materials: Agro waste, such as corn husks and sugarcane bagasse, can be used to manufacture biodegradable and compostable packaging materials as a more eco-friendly alternative to traditional plastics.

Textiles and Clothing: Agricultural waste fibers, like pineapple leaves (Piña) and banana stems, can be processed and used to produce sustainable and biodegradable textiles and clothing.

Biodegradable Disposable Products: Industrial waste materials, such as pulping residues from the paper industry or biodegradable plastics, can be used to create disposable cutlery, plates, and packaging.

Land Restoration: Some agro and industrial waste materials can be used for land restoration and reclamation purposes, such as stabilizing eroded soils or enhancing degraded land.

It's important to note that the suitability and application of agro and industrial waste materials depend on factors like local regulations, availability of waste sources, processing methods, and the specific needs of the target application. Proper treatment, processing, and quality control are essential to ensure the safety and effectiveness of these materials in various applications.



Materials from Ferro-cement and Ferro concrete:

Ferro cement and ferro concrete are composite materials that combine cement or concrete with a mesh of steel or iron reinforcement. Both materials are commonly used in construction due to their high strength, durability, and versatility. Let's explore the components and properties of each material:

Ferro Cement: Ferro cement is a thin, strong composite material made by layering a cement mortar mix over a mesh of closely spaced steel or iron wires. The wire mesh provides tensile strength, while the cement mortar provides compressive strength. The combination of these materials results in a material that can withstand bending and stretching forces, making it suitable for various construction applications.

Components:

Cement: It acts as the binding agent and provides compressive strength to the material.

Sand: Mixed with cement to form the cement mortar mix.

Steel or Iron Mesh: The reinforcing material that imparts tensile strength to the ferro cement.

Properties:

High strength-to-weight ratio: Ferro cement is lightweight but has excellent strength and rigidity.

Crack resistance: The closely spaced mesh helps distribute and control cracking.

Flexibility: It can be molded into various shapes, making it ideal for creating complex structures.

Good resistance to fire and weathering.

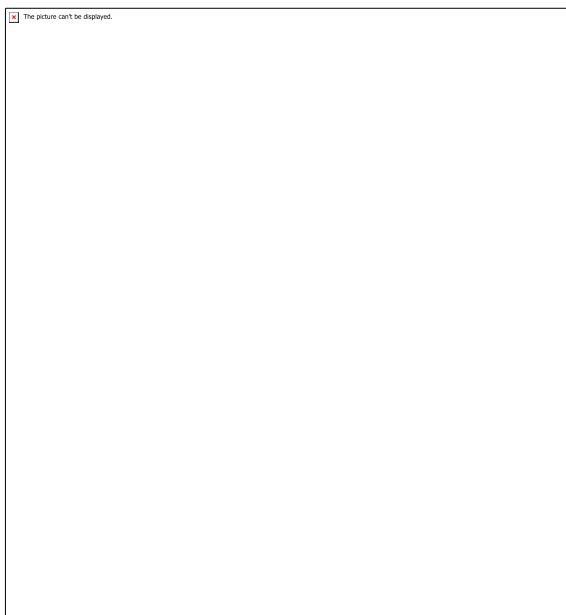
Excellent resistance to corrosion due to the steel or iron reinforcement.



Applications:

1. Boat and shipbuilding: Ferro cement boats are known for their strength and low cost.
2. Water tanks and reservoirs.
3. Architectural elements like domes, vaults, and decorative elements.
4. Housing and small buildings.
5. Infrastructure repairs and rehabilitation.

Ferro Concrete: Ferro concrete, also known as reinforced concrete, is a composite material composed of concrete (cement, sand, and aggregates) and embedded steel reinforcement (rebars or mesh). The steel reinforcement provides tensile strength to the concrete, which is strong in compression but weak in tension. The combination of concrete and steel reinforcement results in a material that can efficiently handle both compression and tension forces.



Components:

Cement: As the binding agent in the concrete mix.

Sand: Mixed with cement to form the concrete mix.

Aggregates: Usually gravel or crushed stone, added to the concrete mix to provide bulk and reduce the cost.

Steel Reinforcement: Steel bars or mesh that provide tensile strength and prevent cracking and failure due to tension.

Properties:

1. High compressive strength: Concrete is an excellent material for withstanding compressive forces.
2. Tensile strength: The steel reinforcement improves the material's tensile strength significantly.
3. Versatility: It can be used in various construction applications and structural elements.
4. Durability: Ferro concrete is highly durable and can withstand weathering and corrosion with proper design and construction.

Applications:

1. Building structures: Columns, beams, slabs, foundations, and walls in residential and commercial buildings.
2. Bridges and highways.
3. Dams and other water-related structures.
4. Retaining walls.
5. Tunnels and underground structures.

Both ferro cement and ferro concrete have proven to be valuable construction materials, offering a balance of strength, durability, and affordability. Proper design, construction practices, and maintenance are crucial to ensure their long-term performance and structural integrity.

Materials from Alternative roofing systems:

Alternate roofing systems refer to non-conventional or innovative roofing materials and technologies used as alternatives to traditional roofing materials like asphalt shingles, clay tiles, or metal sheets. These materials often aim to offer improved energy efficiency, sustainability, or unique design options. Here are some examples of materials used in alternate roofing systems:

Green Roofs: Green roofs involve the installation of living vegetation, soil, and drainage layers on top of a waterproofing membrane. They provide numerous benefits, including improved insulation, reduced stormwater runoff, and enhanced aesthetics. Green roofs can be extensive (with low-maintenance plants) or intensive (with a wider variety of plants requiring more maintenance).

Solar Roofing Tiles: Solar roofing tiles or solar shingles are photovoltaic cells integrated into roofing materials. They generate electricity from sunlight and can be used as an alternate roofing option for energy-efficient and environmentally friendly buildings.

Thermoplastic Polyolefin (TPO) Membranes: TPO roofing is a single-ply roofing membrane made from a blend of polypropylene and ethylene-propylene rubber. It is lightweight, energy-efficient, and has excellent UV resistance, making it a popular choice for commercial and residential flat roofs.

Ethylene Propylene Diene Monomer (EPDM) Roofing: EPDM is a synthetic rubber roofing material commonly used in low-slope or flat roof applications. It is durable, weather-resistant, and has a long lifespan, making it a cost-effective alternative.

Cool Roofs: Cool roofs are designed to reflect more sunlight and absorb less heat than traditional roofs. They are typically made from reflective materials like white coatings, tiles, or shingles, which help reduce heat absorption and lower indoor cooling needs.

Metal Roofing: While metal roofing is not entirely an alternate roofing material, it has gained popularity as an eco-friendly and long-lasting option compared to traditional asphalt shingles. Metal roofs are often made from recycled materials and have excellent durability and recyclability.

Slate Alternatives: Natural slate is a traditional roofing material, but it can be heavy and expensive. Synthetic slate tiles made from polymer composites or recycled materials offer a lightweight and more cost-effective alternative.



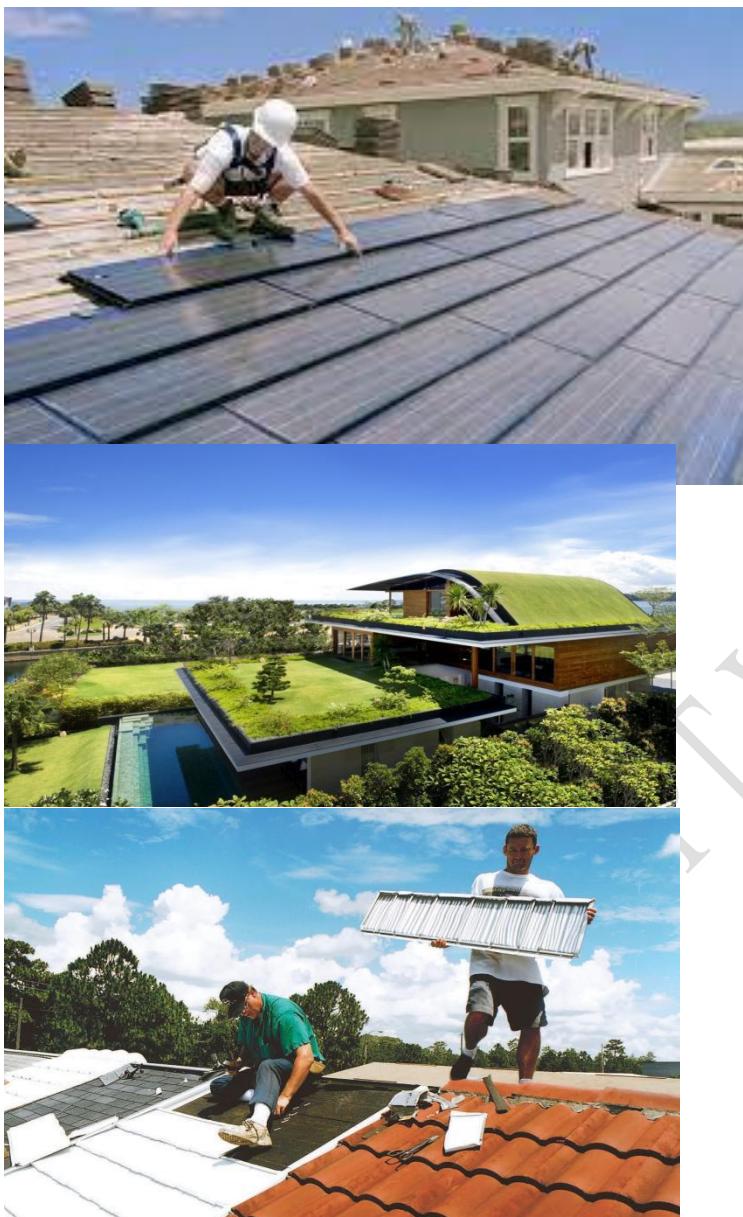
Thatched Roofing: Thatch is a traditional roofing material made from dried vegetation like straw, reeds, or grass. While it is less common in modern construction, thatched roofing can be used for eco-friendly and aesthetically unique applications.

Fiber Cement Roofing: Fiber cement roofing consists of a blend of cement, cellulose fibers, and sand. It is durable, fire-resistant, and can mimic the appearance of wood shakes or slate tiles.

Recycled Roofing Materials: Various recycled materials, such as recycled rubber, plastic, or wood, can be used to create eco-friendly and sustainable roofing options.

It's essential to consider the specific requirements, climate, and regulations of a particular location when choosing alternate roofing systems. Additionally, professional installation and regular maintenance are crucial to ensure the longevity and effectiveness of these roofing materials.

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Various paints reducing the Heat gain of the building:

Reducing heat gain in buildings is crucial for energy efficiency and maintaining a comfortable indoor environment, especially in hot climates. Various types of paints and coatings are available that can help achieve this goal. These heat-reflective or cool paints work by reflecting more sunlight and absorbing less heat than traditional paints. Here are some types of paints used for reducing heat gain in buildings:

Cool Roof Coatings: Cool roof coatings are designed to have high solar reflectance and thermal emittance, meaning they reflect a significant portion of the sun's rays and emit absorbed heat efficiently. These coatings can be applied over existing roofing materials, such as asphalt shingles, metal roofs, or concrete tiles, to turn them into cool roofs. Cool roof coatings come in various colors, including white, light gray, and reflective metallic shades.

Infrared-Reflective (IR) Paints: IR paints are formulated to reflect infrared radiation (heat) from the sun. They work by using specialized pigments or additives that help disperse heat away from the surface. These paints can be used on exterior walls and roofs to reduce heat absorption and lower the temperature inside the building.

Heat-Reflective Exterior Wall Paints: Heat-reflective exterior wall paints are designed to minimize heat absorption on building facades. They often have lighter colors and special additives to enhance solar reflectance. Applying these paints to exterior walls can help reduce heat transfer into the building and keep indoor spaces cooler.

Thermal Insulating Paints: Thermal insulating paints are formulated with materials that offer insulation properties. They typically contain hollow ceramic or glass microspheres, which create a barrier against heat transfer. These paints can be applied to interior walls and ceilings to reduce heat gain from the exterior environment.

Phase Change Material (PCM) Paints: PCM paints contain microscopic phase change materials that can absorb and release heat as the temperature fluctuates. During the day, when the temperature rises, the PCM absorbs heat, helping to keep the indoor environment cooler. At night, when the temperature drops, the PCM releases the stored heat, maintaining a more stable indoor temperature.

Cool Pavement Coatings: For buildings with surrounding paved areas, cool pavement coatings can be used on roads, parking lots, or driveways. These coatings have similar reflective properties to cool roof coatings, reducing the heat island effect and overall heat gain in the vicinity of the building.

When using heat-reflective paints and coatings, it's essential to follow the manufacturer's instructions for application and surface preparation to achieve the best results. These paints are one of many strategies that can be combined to create an energy-efficient and comfortable building. Proper insulation, shading, and ventilation are also crucial for maximizing the benefits of heat-reducing paints.



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UNIT-3 Energy and Resource conservation

Need for Energy Conservation:

There are several reasons why energy conservation is important and why we should make efforts to conserve energy:

- 1. Environmental Impact:** Energy production and consumption are major contributors to environmental issues such as air pollution, climate change, and resource depletion. By conserving energy, we can reduce the demand for energy generation, which often involves burning fossil fuels and emitting greenhouse gases. Energy conservation helps to mitigate climate change and minimize the environmental impact associated with energy production.
- 2. Climate Change Mitigation:** The excessive use of energy derived from fossil fuels releases large amounts of carbon dioxide and other greenhouse gases into the atmosphere, contributing to global warming and climate change. By conserving energy, we can reduce greenhouse gas emissions and limit the rate of global temperature rise, helping to mitigate the impacts of climate change.
- 3. Resource Conservation:** Many sources of energy, such as fossil fuels (coal, oil, and natural gas), are finite and non-renewable. Conserving energy helps to extend the lifespan of these resources, ensuring their availability for future generations. Additionally, extracting and processing these resources can have detrimental environmental impacts, so reducing energy consumption can help minimize the need for resource extraction.
- 4. Energy Security:** Dependence on imported energy resources can leave a country vulnerable to supply disruptions and price fluctuations. By conserving energy and diversifying energy sources, countries can enhance their energy security, reduce dependence on foreign energy, and promote domestic energy production from renewable sources.
- 5. Cost Savings:** Energy conservation can lead to significant cost savings for individuals, households, businesses, and governments. By using energy-efficient technologies and practices, we can reduce energy bills and operational costs. Energy conservation also promotes the development and adoption of energy-efficient technologies, which can stimulate economic growth and job creation.
- 7. Sustainable Development:** Energy conservation is a crucial aspect of sustainable development. By using energy more efficiently and responsibly, we can meet our present needs without compromising the ability of future generations to meet their own needs. Energy conservation is aligned with the principles of sustainable development, promoting a balance between economic growth, social well-being, and environmental protection.

Overall, energy conservation plays a vital role in mitigating climate change, preserving natural resources, enhancing energy security, and promoting sustainable development. It is a collective responsibility that requires individual actions, policy support, technological advancements, and a shift towards cleaner and more efficient energy sources.

Various forms of Energy used in Buildings:

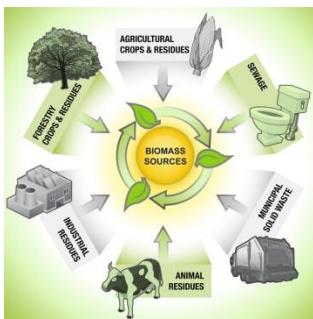
Buildings utilize various forms of energy to meet their operational needs. Here are some common forms of energy used in buildings:

- 1. Electricity:** Electricity is a primary form of energy used in buildings for lighting, powering appliances and electronics, heating and cooling systems, and running various equipment.
- 2. Natural Gas:** Natural gas is commonly used as a source of energy for heating buildings, providing hot water, and fueling stoves, ovens, and other cooking appliances. It is also used for running boilers and furnaces.

3. Heating Oil: In some regions, heating oil is used as an alternative to natural gas for space heating, especially in areas where natural gas infrastructure is limited. It is typically stored in tanks and used in oil-fired boilers or furnaces.

4. Renewable Energy: Buildings are increasingly incorporating renewable energy sources to reduce their environmental impact. These can include solar power through photovoltaic (PV) panels installed on rooftops or as solar farms, wind energy through small-scale wind turbines or grid-connected wind farms, and geothermal energy by harnessing heat from the ground.

5. Biomass: Biomass refers to organic matter such as wood pellets, agricultural waste, or dedicated energy crops, which can be used to generate heat and electricity in buildings. Biomass boilers and stoves burn these materials to produce heat, and in some cases, they can be converted into biogas for electricity generation.



6. District Heating and Cooling: In urban areas, district heating and cooling systems supply thermal energy from a centralized plant to multiple buildings via a network of pipes. Heat can be generated through various means such as combined heat and power (CHP) plants, waste heat recovery, or renewable sources. This approach can be more energy-efficient and reduce individual building energy consumption.

7. Propane: Propane is a liquefied petroleum gas (LPG) commonly used in buildings for space heating, water heating, cooking, and backup power generation in areas without access to natural gas pipelines.

8. Hydroelectric Power: In regions with nearby water sources like rivers or dams, hydroelectric power can be harnessed to generate electricity. Large-scale hydroelectric power plants supply power to the grid, which is then used in buildings.

9. Tidal Power: In coastal areas, tidal power generation systems can be utilized to convert the kinetic energy of tides into electricity. This source is less common but has the potential to contribute to a building's energy needs.



It's important to note that the specific energy sources used in buildings can vary depending on factors such as geographical location, local infrastructure, building size and purpose, energy regulations, and the availability of different energy resources.

Embodied energy of Materials:

The embodied energy of materials refers to the total energy consumed throughout their lifecycle, including the extraction of raw materials, manufacturing, transportation, and disposal. It is a measure of the energy required to produce, process, and deliver a material or product.

Embodied energy can be divided into two categories:

- 1. Direct embodied energy:** This includes the energy used in the extraction, processing, and manufacturing of materials. It involves the energy consumed in activities such as mining, refining, and manufacturing processes like casting, molding, and shaping. It also takes into account the energy used in transportation to move materials from one location to another.
- 2. Indirect embodied energy:** This encompasses the energy used to produce the inputs required for the material's manufacturing, such as the energy used to create machinery, tools, and infrastructure. It also considers the energy consumed in the production of fuels and electricity.

Embodied energy is typically measured in terms of primary energy, which is the energy obtained directly from natural resources before any conversion or transformation occurs. It is often expressed in units like joules (J) or mega joules (MJ) per unit of mass (e.g., MJ/kg).

Assessing embodied energy is crucial for evaluating the environmental impact of materials and products. By understanding the energy inputs involved in their production, it becomes possible to make informed decisions and prioritize materials with lower embodied energy to reduce the overall energy footprint and associated environmental consequence.

Energy used in transportation and Construction processes:

The energy used in transportation and the construction process can contribute significantly to the overall embodied energy of materials. Here's a breakdown of these two aspects:

- 1. Transportation energy:** Transporting materials from their source to the construction site requires energy, usually in the form of fuel for vehicles. This includes transporting raw materials from mines or forests to manufacturing facilities, moving finished products from factories to distribution centers, and delivering materials to the construction site.

The energy consumption in transportation depends on several factors such as distance, mode of transport (road, rail, air, or water), and the efficiency of the vehicles used. Long-distance transportation and modes that are more energy-intensive, like air freight, tend to have a higher energy impact. Conversely, shorter distances and efficient transportation options can help reduce energy consumption.

- 2. Construction process energy:** The construction process itself involves various energy-intensive activities, including site preparation, foundation work, building assembly, and finishing. These activities often require heavy machinery, tools, and equipment that consume energy.

The specific energy requirements during construction vary depending on factors such as the complexity of the project, the size of the structure, the construction methods used, and the energy efficiency of the equipment and machinery employed.

Efforts can be made to minimize energy consumption during the construction process by adopting sustainable construction practices, optimizing project planning and logistics, and using energy-efficient machinery and equipment. Additionally, utilizing renewable energy sources for powering construction activities can help reduce the environmental impact further.

Overall, considering and minimizing the energy used in transportation and the construction process are important aspects of managing the embodied energy of materials and promoting sustainable construction practices.

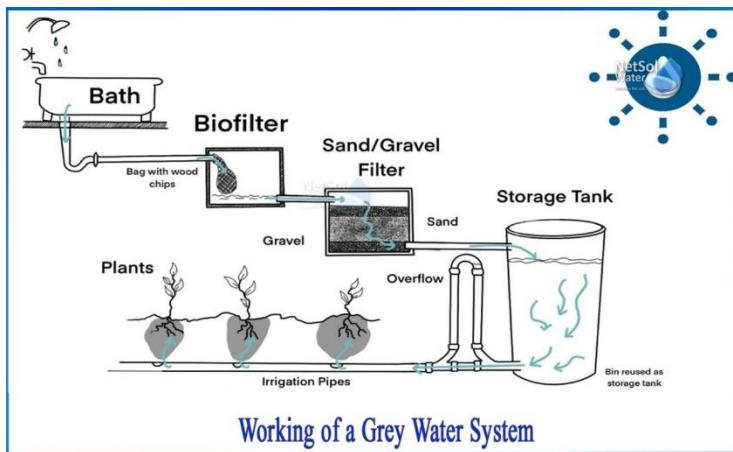
Water conservation systems in Buildings

Some common water conservation systems used in buildings:

1.Low-Flow Fixtures: Installing low-flow fixtures is a straightforward and cost-effective way to conserve water in buildings. These fixtures include low-flow faucets, showerheads, and aerators, which reduce water flow rates while maintaining adequate functionality. They can significantly reduce water consumption without compromising user comfort.

2.Rainwater Harvesting: Rainwater harvesting systems capture and store rainwater from rooftops or other surfaces for later use. The collected water can be used for non-potable purposes such as landscape irrigation, toilet flushing, and cleaning. Rainwater harvesting systems typically include collection surfaces, gutters, downspouts, filters, storage tanks, and distribution systems.

3.Greywater Recycling: Greywater recycling involves treating and reusing wastewater generated from sources such as sinks, showers, and laundry. Greywater recycling systems filter and disinfect the wastewater, making it suitable for non-potable applications like toilet flushing, landscape irrigation, and industrial processes. These systems help reduce freshwater usage and alleviate strain on municipal water supplies.



4.Dual-Flush Toilets: Dual-flush toilets provide users with two flushing options: a full flush for solid waste and a reduced flush for liquid waste. This system allows users to choose the appropriate amount of water needed, resulting in significant water savings over time.

5.Waterless Urinals: Waterless urinals eliminate the need for water in flushing. They utilize specialized trap systems that separate urine from odors and prevent them from entering the restroom. Waterless urinals save substantial amounts of water and also reduce maintenance costs associated with traditional urinals.



6. Smart Irrigation Systems: Smart irrigation systems use sensors and weather data to optimize landscape irrigation. These systems automatically adjust watering schedules based on factors such as soil moisture, rainfall, and evaporation rates, ensuring that plants receive the right amount of water without wastage.

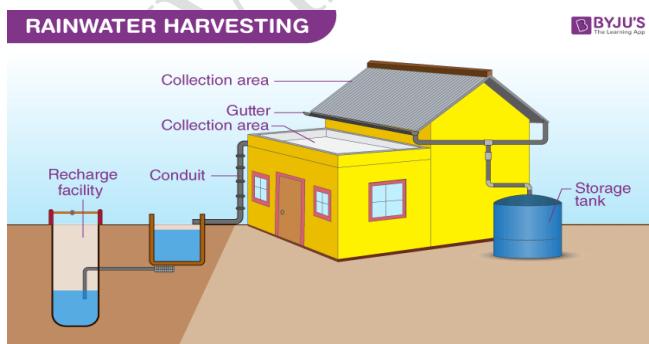
7. Submetering and Leak Detection: Installing submeters within a building allows for the monitoring and measurement of water usage in different areas or units. This helps identify high-water usage areas and detect leaks promptly, enabling timely repairs and water conservation.

Implementing these water conservation systems can contribute to significant water savings and promote sustainable water management practices in buildings. Additionally, promoting awareness and providing educational resources on water conservation can encourage occupants to adopt water-efficient behaviors.

*Water Harvesting in Buildings:

Water harvesting in buildings refers to the collection and utilization of rainwater or other sources of water within the building premises. It involves capturing and storing water for various purposes such as irrigation, toilet flushing, and other non-potable uses. Here are some common methods and technologies used for water harvesting in buildings:

1. Rainwater Harvesting: This method involves collecting rainwater from rooftops, directing it through gutters and downspouts, and storing it in tanks or underground reservoirs. The collected rainwater can be used for various purposes after proper filtration and treatment.



2. Greywater Recycling: Greywater refers to wastewater generated from activities such as bathing, laundry, and dishwashing. Greywater recycling systems capture and treat this water for reuse in non-potable applications like toilet flushing, landscape

irrigation, and washing machines. These systems typically employ filters and disinfection methods to ensure the water is safe for the intended use.



3. Condensate Recovery: Buildings equipped with cooling systems like air conditioners or dehumidifiers produce condensate, which is water that forms when warm air comes into contact with a cold surface. Condensate recovery systems collect and store this water for various non-potable applications, reducing the reliance on freshwater sources.

4. Stormwater Management: Buildings can incorporate stormwater management techniques to control and store rainwater runoff. This may include techniques like permeable paving, green roofs, and bioswales. These methods help reduce stormwater runoff, promote groundwater recharge, and enhance overall water sustainability.

5. Water-efficient Fixtures: Installing water-efficient fixtures such as low-flow toilets, faucets, and showers can significantly reduce water consumption within buildings. These fixtures are designed to use less water without compromising performance.

6. Dual Plumbing Systems: In some cases, buildings may have separate plumbing systems for potable and non-potable water. Non-potable water from rainwater harvesting or greywater recycling systems is used exclusively for non-drinking purposes, while the potable water supply is reserved for drinking, cooking, and other sanitary needs.

Water harvesting in buildings offers several benefits, including reduced demand on freshwater sources, lower water bills, and improved water conservation. However, it is important to consider local regulations, water quality requirements, and maintenance needs when implementing water harvesting systems in buildings.

Waste to energy management in residential complexes or gated communities

Waste-to-energy management in residential complexes or gated communities is an approach that aims to convert waste materials into usable energy, such as electricity or heat. It provides an environmentally sustainable solution for waste disposal while generating energy that can be used within the community. Here are some key aspects and considerations for waste-to-energy management in such settings



1. Waste Segregation: Proper waste segregation is crucial for effective waste-to-energy management. Residents should be educated and encouraged to separate their waste into different categories, such as organic waste, recyclables, and non-recyclables. This ensures that the waste can be efficiently processed for energy recovery.

2. Biogas Generation: Organic waste, such as food scraps and garden waste, can be converted into biogas through a process called anaerobic digestion. Biogas can be used for cooking, heating, or generating electricity within the residential complex. Establishing a biogas plant on-site can be a viable option for communities with a substantial amount of organic waste.

3. Composting: Composting is another method for managing organic waste. The compost produced can be used as a nutrient-rich soil amendment for community gardens or landscaping purposes. Encouraging residents to compost their organic waste reduces the overall waste volume and enhances sustainability.

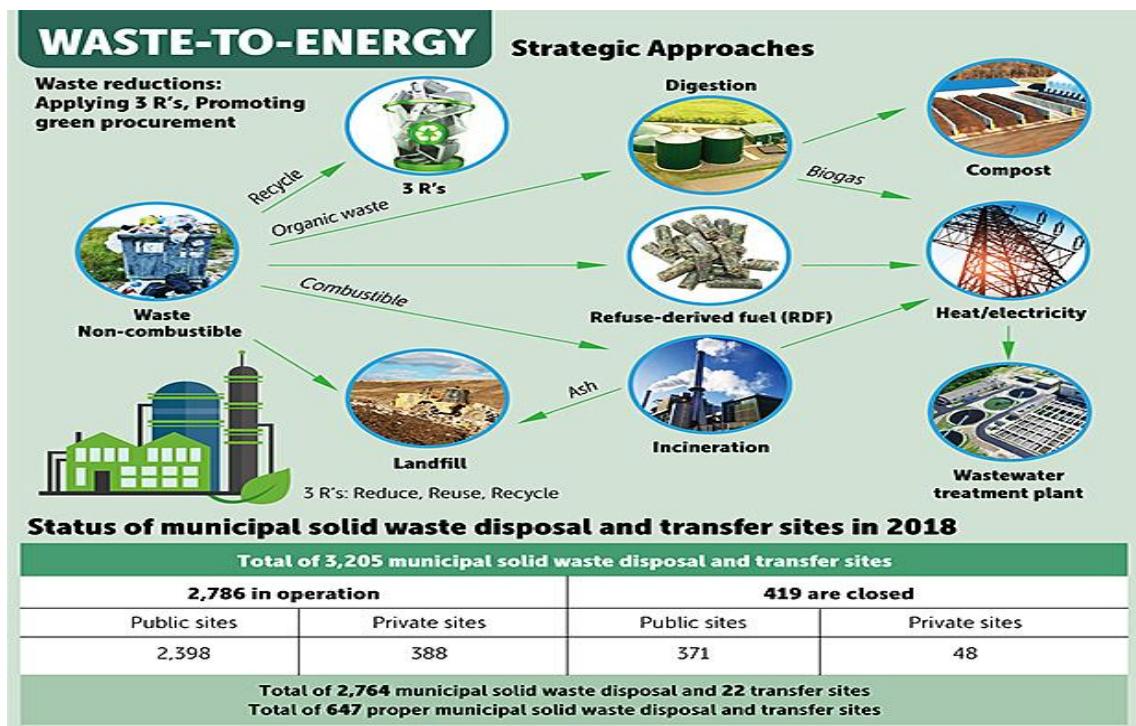
4. Waste-to-Energy Facilities: In larger residential complexes or gated communities, installing waste-to-energy facilities such as incinerators or gasification plants can be considered. These technologies convert non-recyclable waste into heat or electricity. However, such facilities require careful planning, environmental impact assessments, and compliance with local regulations to ensure proper air pollution control and ash disposal.

5. Collaboration and Partnerships: Waste-to-energy initiatives are often more successful when communities collaborate with local municipalities, waste management authorities, or private companies specializing in waste management. These partnerships can provide expertise, funding, and infrastructure support for implementing waste-to-energy projects.

6. Energy Distribution: If a waste-to-energy facility generates excess electricity, the community can explore options for distributing or selling it to the grid, thereby contributing to the local energy supply. Alternatively, the generated energy can be used to power common areas, streetlights, or shared facilities within the residential complex.

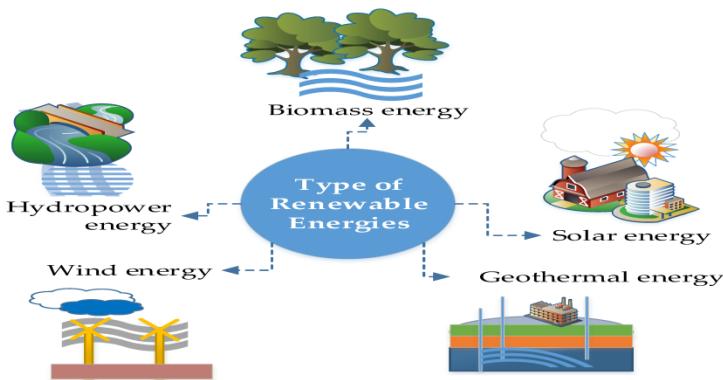
7. Monitoring and Evaluation: It is essential to establish a monitoring and evaluation system to assess the effectiveness of the waste-to-energy management approach. Tracking waste reduction, energy generation, and environmental impacts can help identify areas for improvement and optimize the system over time.

Remember that the specific waste-to-energy solutions and infrastructure will depend on factors such as the size of the community, waste composition, available resources, and local regulations. Engaging residents through awareness campaigns, incentivizing waste segregation, and promoting a culture of sustainability are crucial for the success of waste-to-energy management in residential complexes or gated communities.



UNIT-4 USE OF RENEWABLE ENERGY RESOURCES

Renewable energy is energy produced from sources like the sun and wind that are naturally replenished and do not run out. Renewable energy can be used for electricity generation, space and water heating and cooling, and transportation



Types of Renewable Energy Sources



Benefits of Renewable Energy Use

- Less global warming.
- Improved public health.
- Inexhaustible energy.
- Jobs and other economic benefits.
- Stable energy prices.
- Reliability and resilience

RENEWABLE ENERGY is sustainable, clean energy harvested from sources that do not deplete with use or are replenished on a human timescale. This is in contrast to non-renewable energy sources, like oil, coal and natural gas, which are derived from a finite resource. Solar and wind power are examples of renewable energy sources. Harvesting energy from the Sun and wind today will not result in less sunshine or wind tomorrow.

Wind energy is an underutilized renewable energy source. Many people are familiar with the idea of wind power, but not quite certain exactly what it is or how it is used. This brief introduction of wind power provides basics on what wind energy is, how it is harvested, and how it is stored for future use.



WHAT IS WIND POWER?

WIND POWER is the use of the wind's kinetic energy to generate electricity or mechanical power. The use of wind power to pump water and grind grain has been around for centuries. In a basic windmill, the force of the wind pushes against the front side of the sails of the windmill causing them to turn. This rotation is mainly caused by drag. The sails are attached to a horizontal windshaft so when the sails turn, the windshaft turns. This rotary motion is then converted into mechanical power and can turn the wheel of a grist mill or pump water.

When people talk about harvesting wind energy today however, they tend to be talking about converting the wind's kinetic energy into electricity. This is a similar process to the ancient windmill, except the mechanical power in the rotor shaft is used to rotate an electric generator, producing electricity.

HOW IS WIND ENERGY HARVESTED?

Harvesting wind energy for electricity operates on the same basic principles of older windmills. The specialty windmills that are used to convert wind energy into electricity are called wind turbines. There are two different types of wind turbines, horizontal-axis and vertical-axis. In vertical-axis wind turbines, the main rotor shaft (similar to the windshaft of older windmills) is set vertically, or perpendicular to the ground. In horizontal-axis wind turbines, the main rotor shaft is set horizontally and the blades are perpendicular to the ground. Most commercial wind turbines that are connected to the electrical grid are horizontal-axis wind turbines.

Modern horizontal-axis wind turbines are tall towers that typically have two or three blades. At the top of the tower is a weather vane which is connected to a computer. This keeps the turbine facing into the wind. Like with the windmill, the wind moves the blades of the wind turbines. Although, the blades of the turbine work more like the wing of an airplane than windmill sails. When the wind blows, a pocket of low pressure air is formed on the back side of the blade, accompanying an area of high pressure air on the front. This creates a pressure differential and an aerodynamic force known as lift. Lift causes the blades to spin which, in turn, spins the main rotor shaft that is connected to a generator. The electric generator converts the mechanical energy of the rotor shaft into electricity.



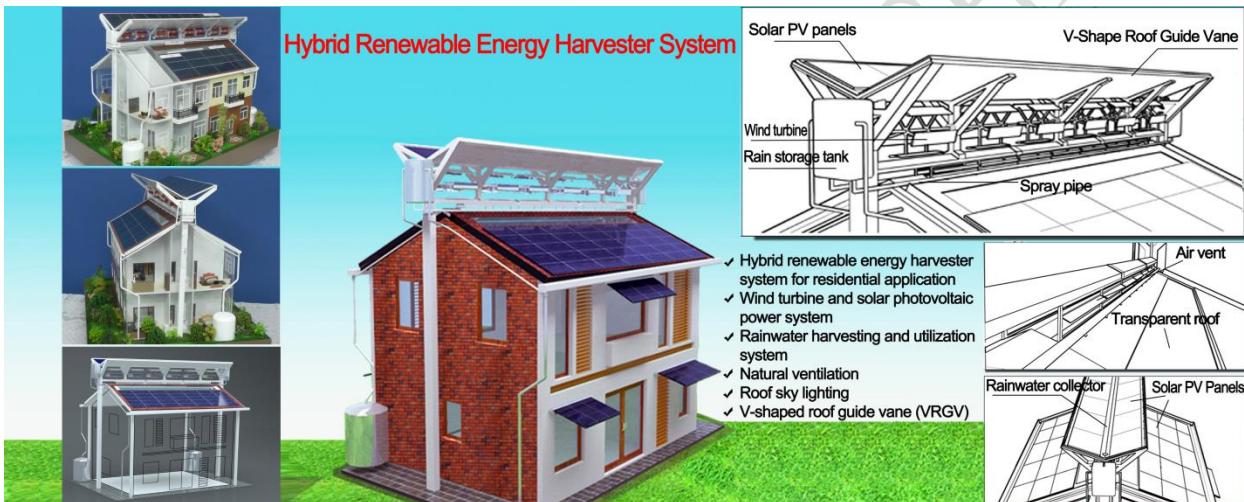
HOW IS WIND ENERGY STORED?

One of the challenges of wind power is the intermittent nature of the wind. Even in the optimum locations for wind harvesting, there is no way to guarantee the wind will be providing enough energy to meet the demand for electricity at any given time. Currently, wind energy is a supplemental source of energy for electrical power grids. Moving forward and away from finite energy sources will require a greater dependence on renewable sources like wind energy. In order to ensure consistent and reliable electricity, wind energy needs to be able to be stored. The wind itself cannot be stored, but there are few ways to store wind energy.

Many storage solutions for wind energy have a high initial cost. At the moment, it is far less expensive to keep wind energy as one piece of a varied and flexible energy grid than it is to store wind energy. According to the American Wind Energy Association, wind turbines currently produce enough electricity to power over 15 million homes in America. While impressive, the wind could power much more. In fact, the United States wind energy potential exceeds the nation's electricity needs by more than 10 times.

It is possible to meet America's electricity needs from renewable energy sources alone. With the right **ENERGY STORAGE TECHNOLOGY**, these needs could be met from only wind energy. In order to access this potential and move away from finite energy sources like fossil fuels, more wind energy storage solutions need to be explored. The development of future technologies capable of storing energy is essential to fully harness the power of abundant renewable energy sources.

Solar Energy Harvesting:



Solar Power is a cost-effective and clean source of electricity. It is also an excellent alternative to power produced by fossil fuels like coal, oil, and natural gas. Solar power uses the energy from the sun to generate electricity. Solar panels are either photovoltaic (PV) panels or concentrating solar power (CSP) panels. Photovoltaic panels convert sunlight directly into electricity. The most common form of photovoltaic panels is crystalline silicon solar panels. Crystalline silicon solar panels are made of thin silicon layers and stacked on top of each other because of the thinness.

In green building technologies, Solar Power can be utilized into two types,

- **Active solar energy** is a form of solar energy generated from the sun using mechanical and electrical means that we can use in the future. This form of solar energy can convert the sun's energy into useful energy for all kinds of practical benefits. It provides energy to individual consumers, electric power stations, industries, hospitals, hotels, airports, and many other types of buildings and infrastructure projects and establishments. Solar energy is highly efficient and generates a great deal of power. It can also supply excess surplus energy generated to the Grid.
 - **Passive solar energy** is a form of solar energy from the sun that requires no other energy or mechanical system. In this passive solar design, the windows and walls collect and store solar energy for the winter and transmit solar energy to the interior during the summer. Passive solar design is unlike active solar heating systems. It does not involve the use of mechanical and electrical devices.
- Passive solar design is a way of natural heating or cooling a building or a home. It works through the use of the sun's energy. It uses the sun's energy to heat the building during the winter and cool the building during the summer.

Potential of solar Energy in India:

India has undertaken ambitious targets under the Paris Agreement. India's climate action is dependent upon energy transition (in the electricity sector) by betting large on shift to solar energy. In 2014-15, the Government had set a target of producing 175 Gigawatt (GW) of renewable energy by 2022, with 100 GW of solar energy. The present installed capacity of solar energy is only 60% of the target. While, the Government is set to miss the ambitious target, nevertheless the progress in expansion of renewable and solar energy has been commendable. The installed renewable energy capacity has trebled from 38GW in 2014. The Government should take steps to address the challenges facing the sector and further enhance the pace of transition to clean energy.

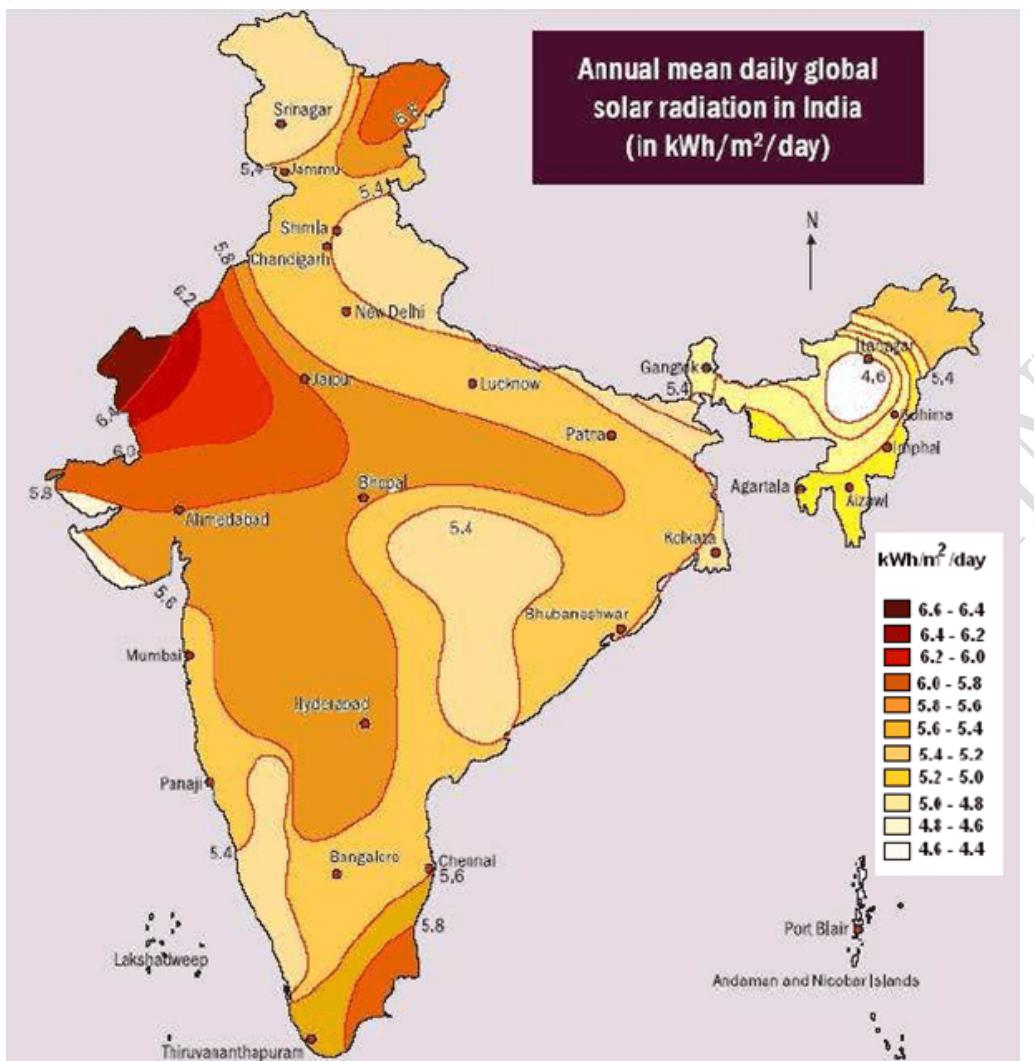
What are the Potential, Targets and Status of Solar Energy in India?

Potential

India is endowed with vast solar energy potential. India receives nearly 3000 hours of sunshine every year. About **5,000 trillion kWh per year** energy is incident over India's land area with most parts receiving **4-7 kWh per sq. m per day**. Solar photovoltaics power can effectively be harnessed providing huge scalability in India.

National Institute of Solar Energy has assessed India's **solar potential to be about 750 GW** assuming 3% of the waste land area to be covered by Solar PV modules.

Gujarat and Rajasthan have the highest solar energy potential.



Source: Ministry of New and Renewable Energy (MNRE)

Potential of solar Energy in world:

The world is facing an energy crisis. The supply of conventional resources such as coal, oil, and gas has become unpredictable due to rising geopolitical tensions. But the power demand refuses to abate.

It is unsurprising then, that countries are scrambling to build their renewable energy capacity.

One resource that leads this energy shift is **solar power**. It is the **3rd largest renewable energy resource**, after wind and hydropower. Solar energy's economic viability along with vast availability contributed to its unprecedented growth in recent years.

China- 392 GW

China's solar prowess is staggering. With a whopping **392 GW**, the country is the largest producer of solar energy in the world.

In the first six months of 2022, the nation has deployed **more than 30.88 GW of Solar PV systems**. Moreover, it has set goals to install 108 GW of solar power this year.

The nation is also the largest manufacturer of solar equipment. According to reports, China has invested over **50 billion USD**, in **new PV supply capacity since 2011**. This figure is ten times greater than the amount invested by the entire continent of Europe in the same industry.

China's share in all manufacturing phases of solar panels exceeds 80%. Today, subsidy-free solar power has become cheaper than coal in China

The United States of America- 135.7 GW

With **135.7 GW** of solar power capacity, the USA stands second in the list of top solar countries. From a measly capacity of 0.34 GW in 2008, the nation has come a long way in the solar domain.

Presently, **3% of the US's electricity** is sourced through solar power plants.

Moreover, US's solar potential is huge. According to a report by National Renewable Energy Laboratory, an area the size of Lake Michigan (around 22,000 sq. miles), covered with solar panels, would be enough to power the entire country. If the efficiency of the panels is raised, this area could be reduced by half.

The solar market in the US is also growing at a rapid rate. Sources claim that **solar jobs** have increased by **167%** in the nation.

Japan- 84.9 GW

A few years ago, Japan stood 4th in terms of solar power capacity. Now, with a cumulative capacity of **84.9 GW**, the nation is **occupying the 3rd spot**.

Solar Power accounted for **close to 10% of Japan's total electricity generation in 2021**. This is an excellent growth, compared to the mere 0.3% of the energy mix in 2010.

The nation is considered the **fastest growing in terms of promoting Solar PV**. Further, with **45% of the world's photovoltaic cells manufactured in Japan**, the country leads the world in the photovoltaic market.

Germany- 66.5 GW

Germany leads the European countries in renewable energy. As of 2021, the nation's solar capacity was **66.5 GW**. In the **first half of 2022, Germany added more than 3.8 GW** of capacity to the figure.

In 2021, solar power accounted for **10% of the country's electricity consumption**.

The Ukraine war has created tension between many European nations and Russia. Germany is also facing the consequences of this friction in the form of a shortage of gas. To manage this energy crisis, the German government is striving to introduce policies and expand the renewable energy capacity.

Recently the country floated a **tender to develop 1.5 GW of additional solar energy** to meet the rising power demand.

India- 63.3 GW

With an installed solar capacity of over **63.3 GW**, India is the **5th largest solar country** in the world. The country has **vast solar potential**, as most states of India receive sunshine for more than 300 days a year.

To harness this potential, the Indian government is constantly churning out policies and initiatives that encourage the shift to solar among the population. The nation is also determined to **reduce import dependence in the solar sector** and **build domestic manufacturing capabilities**.

In September 2022, the government of India approved the **Performance Linked Initiative (PLI) scheme for High-Efficiency Solar PV panels**. This decision aims to incentivize enterprises for sales of indigenously produced solar equipment and thus **strengthen the Atmanirbhar Bharat (Self-sufficient) initiative**.

***Construction and Operation of various Solar appliances**

1. Solar Water Heater

This refers to the solar water heaters used in residential buildings and commercial buildings that have been traditionally powered by electricity being powered by solar power at present. But, it is possible only if does require certain installation processes for you to harness the solar energy to power the heater. It includes setting up thermal panels in the roof, installing a tank to store water and using other accessories such as a circulating pump and thermal regulator. The panels in the roof absorb light from the sun's rays. It is converted into heat energy. This heats up the water in the tank when it is passed into the tank by means of the circulating pump. You may gain additional benefits in the form of reduced electricity bills if the hot water is used for the washing machine and dishwasher.



2. Solar Water Pumps



The solar water pumps are used as water lifting systems that can deliver drinking water. It can also be used to meet the irrigation requirements for agricultural purposes. The process of water lifting is done by the electricity that is generated from the panels placed to harness solar energy. You can use solar pumps to extract water from borewells, rivers, ponds and any other source of water. It can also be used to supply water for various purposes that are required. The solar panels that receive sunlight convert it into DC or direct current. If your motor cannot run on DC current, you may use the inverter. This would convert the DC current into AC or alternating current and this can be used to power the water pump. However, once the initial installation is done, it is easy to operate and incurs low maintenance costs too.

3. Solar Air Conditioner

Solar energy technologies have made it possible to power cooling systems effectively. You now have solar thermal hybrid air conditioners the compressors of which is powered by solar energy. Electricity is just used to operate the electric control components and to run the fans. You also have Solar PV hybrid airconditioners that are capable of switching between solar power and battery power as per the need of the hour. The solar AC is considered to be very efficient in terms of cooling as well as bringing down the expenses for electricity. Once the upfront installation costs are met, you can get ready to pay less for electricity generated from the grid. It is an environment-friendly airconditioner that emits very less carbon into the atmosphere.



4. Solar Water RO

Water purification systems are being increasingly sought out to ensure that you get pure drinking water that is free of harmful bacteria and dust particles. These systems, however, use electricity for the purification process. The solar-powered RO systems are a fine combination of best water purification technologies as well as solar technology to power them. The purification systems are powered by solar power rather than the power from the electric grid. This makes it perfect to be installed even in remote places that are off the grid-like army camps, remote villages, etc.



5. Solar phone

You need electric power to charge the batteries that power the cell phones. Samsung introduced a solar-powered cell-phone called GuruE1107 as early as 2009. The in-built solar cell in the backplate of the phone made use of solar energy to generate

electricity that was enough to charge the phone's battery. Though there haven't been any other solar cell phones in the market, you can surely expect more models in a short period of time.



6. Solar Charger

The primary purpose of the charger is to supply electricity to the batteries of products that feature chargeable batteries. A solar charger in contrast to the electricity produced from fossil fuels that are supplied by ordinary chargers supplies electricity produced from the light from the Sun's rays. You have cell phone chargers as well as multi-use solar chargers that can supply electricity for the operation of devices or charge the batteries in them. The products include drones, cameras, DSLR, laptops, tab, etc.



7. Solar Inverter

The inverter is an accessory that is used invariably with solar energy generation installations. It does the job of converting the variable DC current that is produced by means of the activation of electrons in the solar panels into usable alternating current. You might know that the battery of the inverter has to be charged to produce current when the grid current fails in the home or commercial buildings. The power for getting the battery charged is also got from the gridline current in an ordinary inverter or power inverter that you might be using. In a solar-powered inverter, the energy required to charge the battery is also received from solar energy.



8. Solar Cooker

The solar cookers are used to derive heat from the sun and use it to cook food materials and pasteurize drinks. Like the number of appliances that are used for cooking like the stove, oven, etc to suit the type of cooking, you also have solar panel cookers, parabolic solar stoves, and solar ovens to suit the cooking type. But, one of the major drawbacks of using a solar cookers is that the food loses its warmth quickly.



9. Solar Street Light

As the name implies, it refers to street lights that are powered by solar energy. The solar panels are generally mounted on the lighting structures or poles erected for the lights itself. The lights can be custom made and you can have different types of street lights.



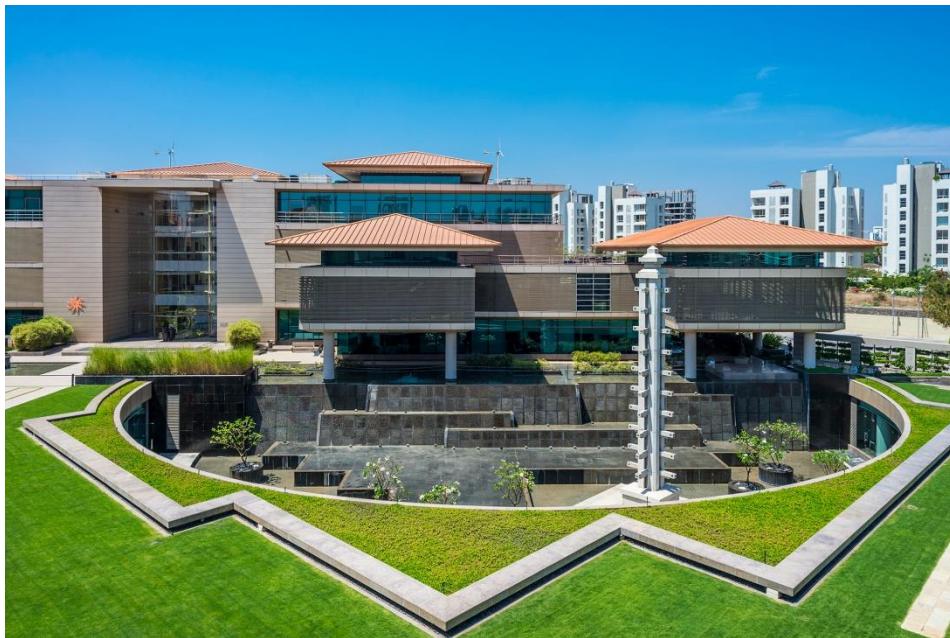
10.Solar Balloon:

The solar balloon is one of the recent developments in Solar energy technologies used for harvesting solar power. The balloons are meant to address the two problems that are usually considered in connection with solar energy like the necessity to use a battery to store energy for the night and not being able to harvest enough power when it is cloudy. The solar radiation creates heat that warms up the air inside the balloon. Since warm air would be less dense than cool air, the balloon floats higher and higher. These balloons act as solar panels deployed above the clouds and scientists estimate that the yield of energy from the balloons could be at least 3 times more than that you can produce with panels in the buildings, without having to worry about clouds too.

***Case studies of fully solar energy-based buildings in India***

The Suzlon One Earth Corporate Headquarters campus spread over ten acres of land in Hadapsar, Pune, India. However, the place conceived with a business and practical need to bring all trade verticals and corporate services under 1 roof. That although connected to each other would be independent sufficiently to be able to act as per their respective needs and requirements.

Case Study :1 of Suzlon One Earth Corporate Headquarters



- Location: Hadapsar, Pune, India.
- Site area: 4,53,930sq. feet
- Client –Suzlon Energy Ltd.
- Principal Architect –[Christopher Charles Benninger Architects](#)
- Landscape Architects –Ravi and Varsha Gavandi
- Interior Architects –Tao Architecture and Space Matrix
- Green Building Design and Certification –Environmental Design Solution

Project Typology

The campus is a Corporate Campus. Also, the occupancy profile of the campus twenty-four by seven global shared service providers and the think-tank' for the globe across all places. However, the headquarters changed from a strategic center to a global control headquarter.

Philosophy of Suzlon One Earth Corporate Headquarters

To be a corporation that serves communities with sufferable wind power on a commercial scale with a focus. On continuously growing efficiency and reliability of wind turbines. With a philosophy that emphasizes innovation, to drive every aspect; the company has turned the dream of a greener world into a sustainable and profitable business

About site

This location surrounded by large townships and IT parks. The site rests amidst a fast-growing suburb context. The Corporate Campus developed by M/s Vascon Hadapsar Venture. The Plot Area is approximately 45,392 sq.m. The built-up area shall be approximately 70865.58 sq.m. The Campus shall also accommodate approximately 2500 Suzlon Employees.

Concept of Suzlon One Earth Corporate Headquarters

- Low rise campus.
- Flexible and Adaptable.
- Functional and durable.
- Integration of inside and outside.
- A green building.
- Based on the regulations of Vaastu and even climatic reaction the building developed in such a manner.
- The southwest side of the structure put with an overload water tank and with minimum openings/windows.
- The center ‘Bramhasthal’ of the building is open to the sky to get enough light.
- The direction of the building is North-South direction.
- The water feature should be on the east side of the plot
- All sides of the structure have roads for better accessibility.
- The team was conscious of the reality that each of the Suzlon values should reflect and express itself in the campus design, interiors, landscape, and communication.
- The integrity seen in the campus design with connected buildings through some service elements.
- All the possible sides have peripheral routes and entry from them. (indirect access)
- The northeast part of the structure is low in elevation and has the highest openings.
- The entire plot divided into 2 parts with the corporate building placed on the eastern side and the learning center placed on the western side.

Architectural features of Suzlon One Earth Corporate Headquarters

- Suzlon One Earth derives its inspiration from big Indian historical campuses like Fatehpur Sikri and the Meenakshi Temple complex in Madurai.
- Both employ an inter-positioning of open and closed spaces that counteracts one another. Both have strong horizontal features that tie the complexes together and accent qualities that emphasize quadrants and sacred places, like the Gopura at Meenakshi.
- The Panch Mahal at Fatehpur Sikri, a multi-storied construction. That maintains its scale through the employment of modular construction, whose elements expressed, imparting the structure scale and proportions. In these recorded precedents, there are also water bodies and open courtyards, as in Suzlon One Earth.
- It is the need of the hour that architecture should borrow components of critical rationalism, with overhangs, louvers, pergolas, courtyards, water, and natural light permeation
- The design strategy started with the premise of creating a central meeting space, or Brahmasthan, with the sky as its ceiling.
- There is visible access to the big central gardens from everyplace. They act as visible connectors between all the floors.

- The Deepa Stambh, set in the middle of the Suzlon reflecting pool. The waterbody in the lineal basin links the Brahmasthal to a fountain toward the east. These auspicious elements protect the campus from unwanted influences and create a central focus and landmark. They carry very Indian elements within a very global, high-tech ambience.
- A big water body in the central court helps in enhancing the air quality and evaporative cooling. All the exterior landscape areas brought into the indoors along the perimeter of the structure bringing fresh air, nature, and natural light into the work areas so as to improve the productivity of occupants.



CIVIL ENGG DEPT VY

CII Sohrabji Godrej Case study: 2


CII Sohrabji Godrej Green Business Centre, Hyderabad

CII Sohrabji Godrej Green Business Centre, Hyderabad is one of the substantial examples of green buildings in the world. The design of this building includes the above three points along with few other features. This is the first LEED Platinum-certified building outside of the US. It is a commercial business building consists of an office area, research labs, and conference rooms. These are the three main functions of the building. However, the building deals with two significant concepts of architecture which are green architecture and passive architecture.

Most of us think that green building is having a greener area in a building. We simply refer every building as a green building which has roof gardens or vertical green wall or which comprises more percentage of green space than usual. But the fact is a green building or green architecture is something which is more than just vegetation. Let's get a glimpse of what actually green building is?

The following three qualities are the essential characters of green building.

- Location: Hyderabad
- Site area: 4.5 acres
- Built-up Area: 20,000 Sq. ft
- Architect: [Ar. Karan Grover](#)
- Building type: Commercial office building
- Award: LEED Platinum Rating

Also read: [Top 5 Examples of Sustainability in modern architecture forms in the world](#)

- Environment friendly – Efficiently using the natural resources, pollution reduction in its surroundings, and minimal generation of wastage comparatively.
- Economical – Using local materials which cut down the transportation rate also affordable

- Energy-saving – Using more daylight into the building and utilizing electricity efficiently.



CII – Sohrabji Godrej Green Business Centre, Hyderabad.

Green elements of CII Sohrabji Godrej:

- Solar PV panels
- A wind tower is a prominent element used to cool the inside building and to improve indoor air quality.
- More than 600 floras are replaced during excavation, and all those are native trees and the ones which are capable of adapting themselves with that local climatic conditions.
- Roof gardens
- The traditional technique of rainwater harvesting
- 60% of the materials used in this building are recycled.

Enforcing sustainable and passive design:

Site preservation:



Preserved Topography on site

This building is constructed by maintaining the natural elements and conditions of the site like topography, rocks, landscape, etc. 70% of the existing site landscape is retained and the trees which are lopped during excavation are replanted inside the site itself. Also, preventing site's natural condition and designing in accordance with the surrounding environment is one the important quality in architecture which is achieved brilliantly here. Soil erosion inside the site is refrained by using honey comb trays in areas where the soil is loose and has high possibilities for soil erosion. These trays are further covered by turf. They used the soil which is discarded during excavation for landscape.



Retained natural rocks



Honeycomb trays

Passive architecture:



Wind tower

Wind towers are generally a traditional technique to maintain the circulation of natural air inside the building. This is basically, a tall tower with an opening at the top to catch prevailing winds and bring it down to cool the interior of the building. As a result, this is one of the best strategies for heat management. In this building wind tower's role is to pass the pre-cooled air directly to the Air Handling Unit, so that the mechanism burden of AHU can be controlled.

Another traditional element used is the jaali wall. Jaali walls act as a screen wall also provides sufficient amount of natural ventilation and daylight inside the building. This also performs aesthetically in the building's exterior. Huge trees are planted near the jaali wall to block and prevent the heat from direct sunlight. 90% of daylight is used efficiently inside the building which results in the reduction of electricity usage during day times. The North light concept is used to block heat gain inside the building. IBMS (Integrated Building Management System) is used to control the whole building. This is for automation of lights which again controls the wastage of electricity.



Jaali wall

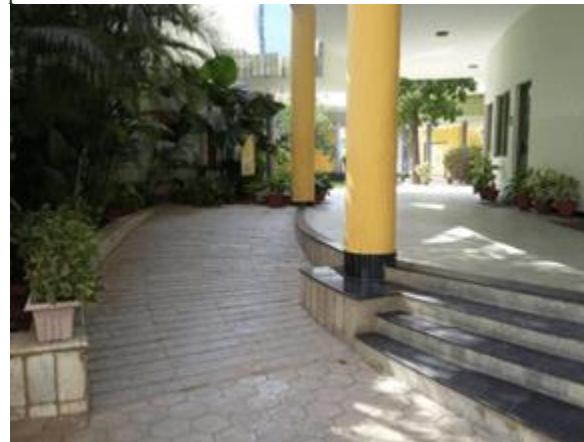


- Urban heat island – The heat island effect is controlled by using a greater number of floras, and SRI tiles on roofs and roof gardens.



Green pavers

- Universal design concept – This building can easily accessible to physically challenged and senior citizens. There is a separate car parking space for them which is nearer to the main entrance.



Ramp provided for easy access

Water conservation and wastewater treatment in CII Sohrabji Godrej



Rainwater harvesting pond

As turfs consume more water, the site has less than 10% of the turf area to conserve water. Drip systems and sprinkler systems are used for the irrigation of turf and plants. Therefore soil moisture sensors are installed which automatically sense the moisture content in soil and shut down the water supply to plants. 100% of wastewater is recycled by the phytoremediation technique. It is a natural remediation technique that living plants are using to uptake the contaminants in water through their roots.

Other case studies like

- 1. ITC Maurya Hotel in New Delhi**
- 2. Jawaharlal Nehru Bhawan, New Delhi**
- 3. ITC Green Center , Gurgaon**
- 4. Infinity Benchmark, Kolkata**
- 5. CRISIL House, Bangalore**

UNIT-5 Green Building Rating system

What is the LEED rating system?

LEED, which stands for ‘Leadership in Energy and Environmental Design’, is a rating system developed by the U.S. Green Building Council (USGBC) to evaluate the environmental performance of buildings and measure their sustainability. The LEED system provides a framework for healthy, efficient, carbon and cost-saving green buildings. It is widely recognized as the industry standard for green building in the United States, and used in over 160 countries worldwide.

How does the LEED rating system work?

The LEED rating system is based on a point system, with buildings earning points for meeting certain criteria in categories such as energy efficiency, water conservation, and indoor environmental quality. The more points a building earns, the higher its LEED rating will be. There are four levels of LEED certification: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80+ points).

To achieve LEED certification, a building must go through a rigorous review process conducted by Green Business Certification Inc. that includes a pre-certification review, a construction review, and a post-construction review. The building must also meet certain minimum requirements in each category and earn a certain number of points.

What are the different LEED rating systems?

There are several different LEED rating systems, each designed for a specific type of property type or project. These rating systems include:

- **Building Design and Construction (BD+C)** – designed for new construction projects or major renovations.
- **Interior Design and Construction (ID+C)** – covers complete interior fit-out projects including commercial interiors, retail and hospitality.
- **Building Operations and Maintenance (O+M)** – certification for existing buildings undergoing improvement work or minor renovations.
- **Neighborhood Development (ND)** – covers the sustainability and connectivity of communities as a whole.
- **LEED for Homes** – focuses on single residential properties, including single-family homes and low-rise to mid-rise buildings.
- **Cities and Communities** – evaluates entire cities and sub-sections based on energy use, waste, transportation, water consumption, and human experience.
- **LEED Zero** – for projects with net-zero goals in energy, waste, water, or carbon resources.
- **LEED Recertification** – for buildings that have previously achieved LEED certification, this system helps owners maintain and improve their properties over time.

What are the levels of certification in the LEEDS rating system?

LEED certification has four levels: Certified (40-49 pts), Silver (50-59 pts), Gold (60-79 pts), and Platinum (80+ pts).

- **Certified** - signifies that the project has obtained over 40% of the essential LEED points.
- **Silver** - reflects that the project has earned more than half of the basic LEED points.
- **Gold** - shows that the structure has achieved a score of over 60% on the fundamental LEED points.
- **Platinum** - the highest level, signifies that the project has earned more than 80% of the fundamental LEED points.

How does a building earn a LEED rating?

Earning a LEED rating for a building is a process that involves meeting specific requirements in various categories, such as energy efficiency, water conservation, and indoor environmental quality. The LEED rating system is divided into different categories, and buildings can earn points by meeting the requirements in each category.

The first step in earning a LEED rating is to choose the appropriate rating system for the building. The LEED rating system includes several different categories, see above. Each rating system has different requirements, so it's important to choose the one that best fits the building.

Once the appropriate rating system has been chosen, the building's design and construction team must register the project with the USGBC. This process involves providing information about the project's location, size, and proposed green building strategies.

The next step is for the building to be designed and constructed in accordance with the LEED requirements. This includes incorporating sustainable materials and technologies, such as energy-efficient lighting and HVAC systems, and promoting water conservation. The building must also be designed to promote indoor environmental quality and the well-being of the building's occupants.

After the building is completed, it must be independently verified by a LEED-accredited professional. This process involves a thorough review of the building's design and construction, as well as on-site inspections to ensure that the building meets the LEED requirements.

Once the building has been verified, it can be submitted for certification. The building will be awarded points based on how well it meets the LEED requirements, and it will be assigned a certification level of Certified, Silver, Gold, or Platinum.

How can I improve my building's LEED rating?

Improving a building's LEED rating can be achieved through a variety of strategies and approaches. Some of the most effective ways to improve a building's LEED rating include:

- Energy Efficiency: Building owners can improve their building's energy efficiency by implementing energy-efficient lighting systems, upgrading HVAC systems, and installing energy-efficient appliances.
- Water Efficiency: Building owners can reduce water consumption by installing low-flow fixtures, rainwater harvesting systems, and xeriscaping.
- Indoor Environment Quality: Building owners can improve indoor environment quality by providing natural daylight, improving ventilation, and implementing effective temperature and humidity control.
- Materials and Resources: Building owners can also improve their building's LEED rating by using sustainable and environmentally friendly building materials. This includes using materials that have been harvested, extracted, and manufactured responsibly, and choosing materials that have a low environmental impact throughout their lifecycle.
- Innovative Design: Building owners can demonstrate their commitment to sustainability by incorporating innovative design elements into their building. This can include green roofs, solar panels, and other design features that promote sustainability and improve the building's LEED rating.
- Use of Building Analytics: Building analytics can provide real-time data on building performance and can help building owners identify areas for improvement, this can help in identifying the areas where the building is not performing per the LEED framework and take corrective actions.

GRIHA - Green Rating for Integrated Habitat Assessment

GRIHA (Green Rating for Integrated Habitat Assessment), the national green building rating system of India, is the product of the collaboration of The Energy and Resources Institute (TERI) with the Ministry of New and Renewable Energy (MNRE).

Being the country's own green building grading system, GRIHA analyzes a building's resource consumption, waste generation, and overall environmental impact.

Requirements of a Green Habitat

A green habitat strives to:

- Keep the demand for electricity, water, and other natural resources as minimal as possible in all phases of construction, operation, and demolition.
- Use renewable energy to generate on-site electricity.

- Meet all of its water requirements using environmentally friendly ways such as rainwater harvesting.
- Recycle and reuse all of its waste on-site, resulting in a minimal environmental effect.

GRIHA Assessment Criteria

Green Rating for Integrated Habitat Assessment (GRIHA) assesses a building on 30 parameters divided into 11 sections. They are:

1. Sustainable site planning

- Green infrastructure
- Low-impact design
- UHIE-mitigation designs

2. Construction management

- Pollution control- air and soil
- Preserving topsoil
- Adopting best practices for construction management

3. Energy efficiency

- Optimizing energy consumption
- Using renewable energy
- Using materials with low GWP (Global Warming Potential) and ODP (Ozone Depleting Potential)

4. The comfort of the occupant

- Visual comfort
- Thermal comfort
- Internal air quality

5. Water management

- Reducing water demand
- Treating wastewater
- Managing/ storing rainwater
- Self-sufficiency and water quality analysis

6. Solid waste management

- Waste management methods after the occupation
- The on-site organic waste treatment facility

7. Use of environmentally-friendly building materials

- Using green alternatives for construction
- Life Cycle Assessment and reducing global warming potential
- Using alternate materials for developing the external site

8. Analysis of life cycle costing

9. Socio-economic parameters

- Sanitation and workplace safety of workers involved in construction activities
- Accessibility
- Facilities for service staff
- Favourable social impact

10. Performance Monitoring

- Commissioning for final rating
- Smart metering
- Protocol for operation and maintenance

11. Innovation

GRIHA Ratings

Green Rating for Integrated Habitat Assessment (GRIHA) allocates points to buildings on a scale of 100, based on the 30 parameters discussed above. However, to be certified by GRIHA, a project must receive at least 50 points.

Rating	Points
5-star	86 above
4-star	71-85
3-star	56-70
2-star	41-55
1-star	25-40

Significance of GRIHA

- Environmental protection and climate change mitigation are fundamental problems for our country and the rest of the world.
- Urban infrastructure must provide critical services to the residents while also dealing with massive demographic transitions sustainably amidst rising urbanization.
- Cities bear a large amount of responsibility for balancing current requirements with the needs of future generations to maintain a sustainable balance and reduce the negative environmental repercussions of urbanization.
- India lacks adequate infrastructure for water recycling, reuse, and treatment despite its enormous coastline and rivers.
- Green Buildings are crucial in ensuring that people don't misuse, abuse, and overuse resources to the point of scarcity in the coming years.
- Green buildings can aid in the achievement of nine of the seventeen SDGs (Sustainable Development Goals).

12th GRIHA Summit

The 12th Virtual Green Rating for Integrated Habitat Assessment (GRIHA) Summit was held in New Delhi on 15th December 2020.

- Theme- Rejuvenating Resilient Habitats.
- India's Vice President released SHASHWAT Magazine and a book titled 30 Stories Beyond Buildings.
- Sessions of the summit promoted knowledge sharing and the development of green and sustainable ecosystems across the country.

To sum up, the GRIHA rating system determines the position of your building, in comparison to nationally recognized green norms.

GRIHA proposes a wide definition of what makes a green building by measuring a building's environmental performance over its entire life cycle.

The grading system, based on recognized energy and environmental principles, will strive to strike a balance between present practices and emerging green developments.

Modular Waste Treatment Systems:

What is modular wastewater treatment plant?

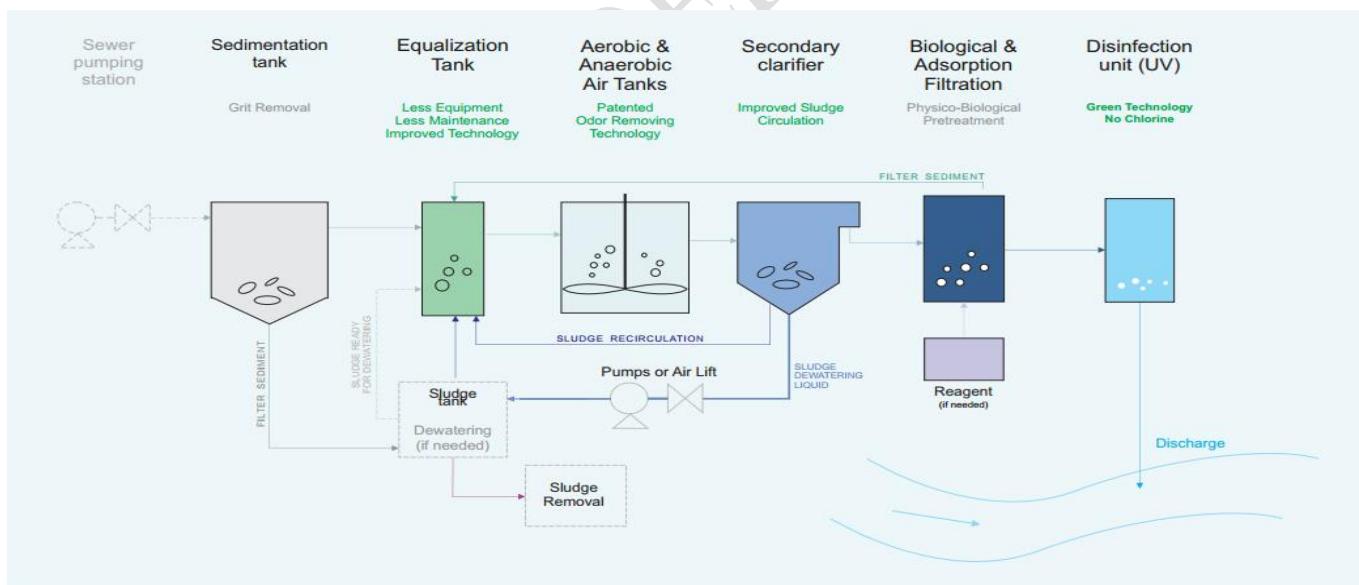
Containerized MBR systems are designed with simplicity, flexibility and durability in mind. These containerized wastewater treatments plants provide high quality, portable treatment solutions ideal for remote and tight locations

modular wastewater treatment plants are economical, require minimal maintenance and staff, and modular construction is decreases environmental impact and budget friendly.

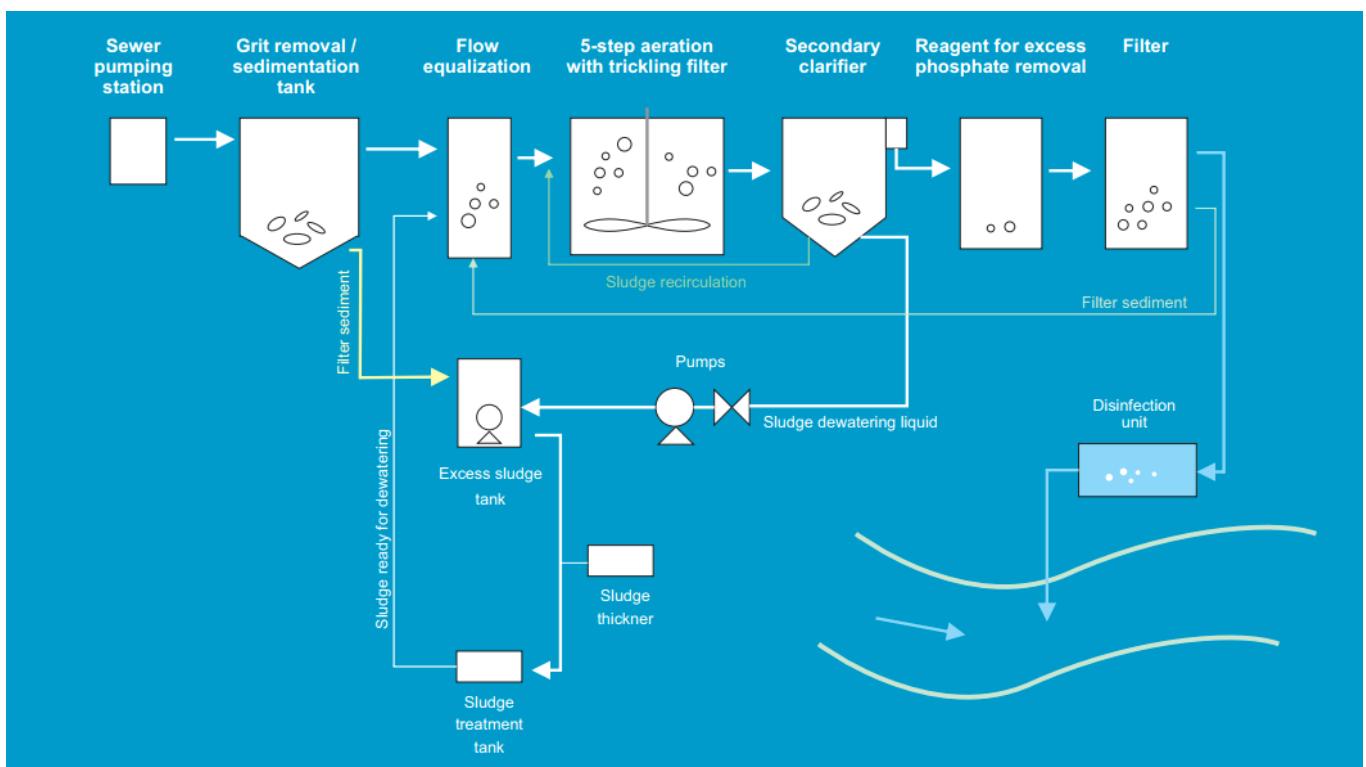
Modular waste treatment plants are quite, leak and smell proof with the capacity to expand seamlessly with the growing construction. The fairly compact nature of our wastewater treatment system gives you the ability to save on valuable real estate and comparatively low cost of maintenance and installation allows you to have room in your budget to concentrate on things you really want to spend money

- Packaged wastewater Treatment system
- Residential wastewater Treatment System
- Compact wastewater Treatment System

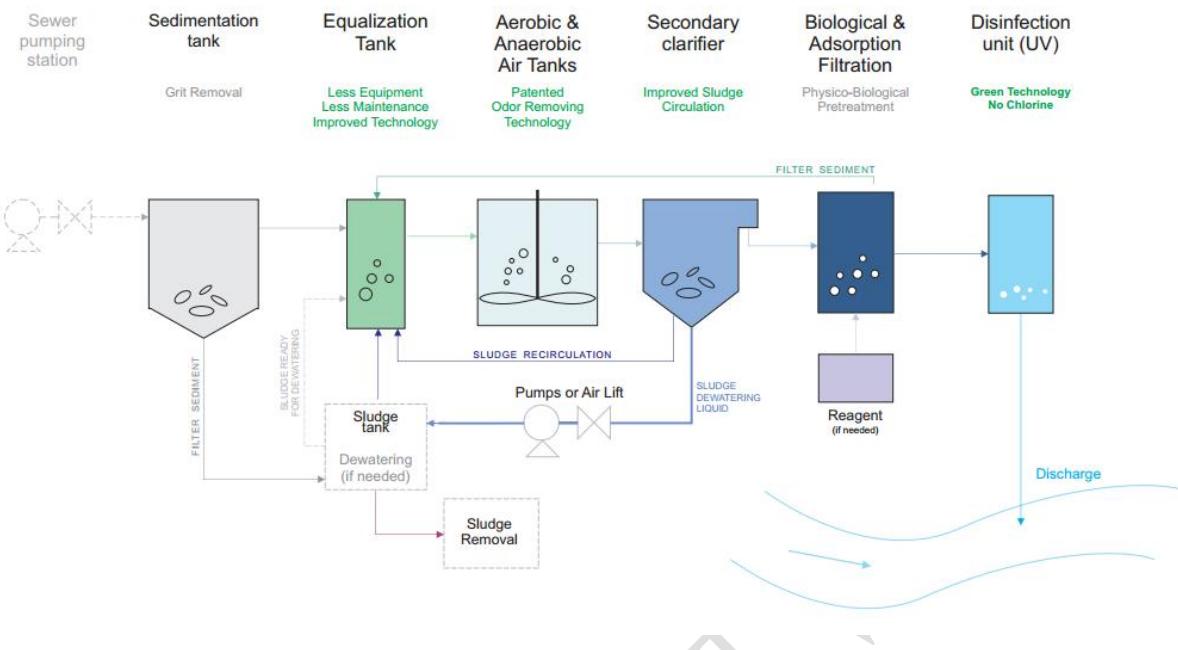
- Packaged wastewater Treatment system



- Residential wastewater Treatment System



Compact wastewater Treatment System



Building Automation and Building Management Systems :

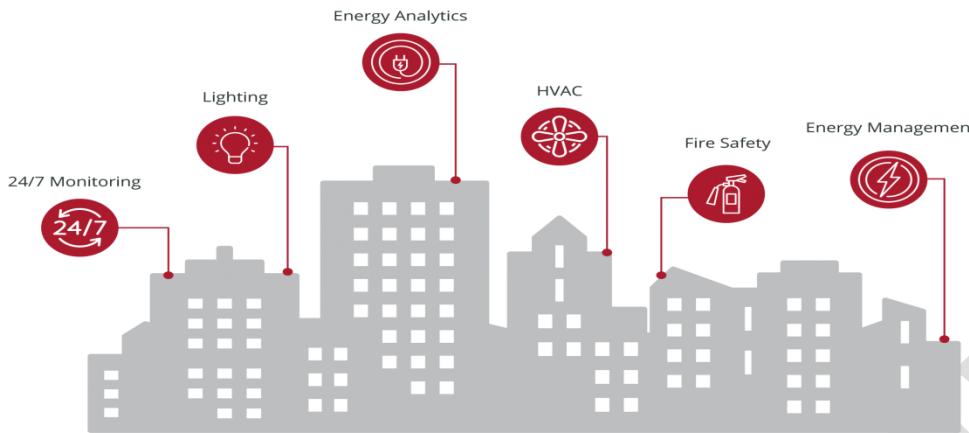
The two terms are frequently used interchangeably in the industry. For some time, vendors were trying to differentiate Building Automation Systems as an advanced version of Building Management Systems. But then everybody started to call their BMS a BAS.

The software vendors looked at BAS as an evolution to BMS systems by adding smarter analytics and advanced automated controls. However, the building owners and operators view BAS as a subset to BMS with a focus on automating HVAC and Lighting controls.

Two other terms that are synonymous with BMS are Building Control Systems (BCS) and Energy Management Systems (EMS/EMCS).

- **BMS** – Building Management Systems
- **BAS** – Building Automation Systems

What is a Building Management System?



The BMS's core function is to manage the internal environmental conditions within a building, i.e., temperature, in a way that is as energy-efficient as possible.

A Building Management System (BMS) is a computer-based system installed in buildings to control and monitor mechanical and electrical plants, including; HVAC (heating, ventilation, air conditioning), lighting, power systems, fire systems, and security systems.

Effective well-utilized Building Management Systems (BMS) provides the core management tool required by building managers to ensure monitoring and efficient management of energy and occupant comfort. It enables Building Managers to provide the optimal working environment while minimizing the landlords' and tenants' costs. Effective BMS utilization allows for optimal building performance by extending equipment and systems' operational life by reducing loads and operating hours. Therefore, maintenance and capital costs are reduced, and less embedded energy is consumed through equipment replacement and upgrades.

When a building has been completed, its structure's impact on its energy consumption performance is usually fixed until refurbishment occurs. However, base Building and Tenant Light and Power energy consumption can be increased or decreased by the performance of both building systems and tenants. A BMS will show increases in energy use due to equipment failure or adjustments to operating parameters. For example, heating valves open when the building requires cooling or whole floors of lights for extended periods due to cleaning activity.

A BMS may also indicate that air-conditioning is starting up hours before the building is fully occupied due to security staff activities. With this information in hand, the building manager may rectify such issues through consultation or engineering solutions.

Additionally, a BMS may not react quickly enough to changes in data center computing demands as application workloads spin up or down. The introduction of new equipment will also change power draw and thermal dynamics.

In the absence of a BMS, the impact of such events can be disguised by seasonal variations, changes in occupancy levels, or technology upgrades. A correctly configured BMS with an adequate number of precisely located monitoring points is the only way a building manager can quickly alert problems that could otherwise remain undetected until annual inspections or external audits are undertaken.

A BMS is also a primary tool for identifying energy intensity improvement opportunities, for example, refining the size and number of lighting time blocks, providing meaningful reports to the Building Management Committee on issues and opportunities, and enabling identification of faults, maintenance planning, and energy-saving upgrades.

What are the benefits of using a BMS?

To begin with, the correct use of a BMS reduces **energy consumption by 30%**, according to the "[Building Management System Market Forecast to 2023](#)". In addition, building automation saves on preventive maintenance. So, while the average cost of a building management system is still high, **the investment is recouped in just 3-8 years**.

However, reducing energy consumption and expenditure are not the only benefits of using a building management system. Building management technology also allows for an increase in occupant comfort, lower carbon footprint, and increased technical efficiency.

- **Energy savings**

A building without a building management system uses 10-30% more energy than a similar building with a BMS.

- **Improved comfort**

Building management automation allows better control of room temperature and other air quality indicators in real time.

- **Facility management**

Centralising all information allows assets to be better managed and monitored, which reduces **reactive maintenance**.

- **Environmental impact**

Smart buildings are more sustainable and more efficient than conventional buildings. This reduces your company's environmental impact.

However, savings are not the only reason why a BMS, iBMS, or BAS is important for facility managers, owners, and users:

- A BMS allows facility managers to understand where and how they are wasting energy;
- A BMS helps extend the life of assets, which improves ROI for owners;
- For highly complex buildings, such as hospitals or refineries, a BMS promotes optimal working conditions and offers improved safety.

Types of Building Management Software

There are various types of building management software, each designed for specific tasks or operations. Some of the most common types are:

Computerised Maintenance Management System (CMMS)

A **CMMS** is designed to manage and schedule maintenance activities, track inventory, and monitor work orders. It's focused on centralizing maintenance data across physical equipment, machinery, communications, infrastructures, and other technical assets.

Building Automation System (BAS)

A **BAS** is a software and hardware system that monitors buildings' mechanical, electrical, and plumbing systems. It typically comprises energy metres, IoT sensors that measure environmental conditions, fire alarms, carbon monoxide detectors, etc. Sensors feed this data to a centralized dashboard for analysis and control.

Energy Management System (EMS)

An EMS manages and optimizes a building's energy usage by tracking consumption, identifying wastage, and automating energy-saving measures.

For example, the software could shut off lights, HVAC units and heaters when no one is present in a room or building to save energy.

What Is a Building Automation System?

A **Building Automation System (BAS)**, (also referred to as a *Building Management System* or a *Building Control System*), is a system that controls various electric, electronic and mechanical systems throughout a building.

It is a distributed control system that integrates different types of building systems together into one centralized location. Building automation systems are primarily utilized to control the heating, ventilation, and air conditioning (HVAC) in a building, but are also used to control lighting, security and other building systems.

BAS works as a computer networking system that monitors and controls a range of other electronic and mechanical systems. It provides a means for these disparate systems to communicate across platforms, software and languages.



Building Automation and Energy Management

As of 2014, more than half of the large-sized buildings in the U.S. (buildings that are larger than 100,000 square feet) are controlled by BAS. Studies have shown that in the past ten years, building automation systems have demonstrated a range of energy savings. This range runs from no energy savings to a savings of greater than 30%. It is estimated that the savings is even larger with older buildings or buildings that have not been maintained well.

How are building automation systems beneficial?

A well-running Building Automation System has many benefits. Some of these benefits are as follows:

- An extensive BAS can control many systems (such as fire and flood safety, ventilation and security) at one time, which diminishes the opportunity for human error.
- A BAS system can monitor the performance of various systems.
- A building automation system can provide fail-safe mechanisms to come online when electronic or mechanical failures occur. This is especially important in dangerous, high-risk work environments.
- It can improve the efficiency of the other systems within a building.
- An energy management system can reduce energy consumption and subsequently the operating expenses of the various systems involved.
- It can extend the life cycle of various utilities so that you get more bang for your buck and less frequent repairs.

- A BAS can provide a consistent level of comfort for occupants.
- A building automation system can run lockouts, which ensure that machinery doesn't turn on unless it's supposed to.
- It can run diagnostics to monitor temperature, pressures, flows, etc. over various systems.
- A well-integrated BAS eliminates the redundancy that can occur when too much of the automation in a building overlaps

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