

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELGAUM**



GREEN BUILDINGS

(Subject Code: BETCK105B)

LECTURE NOTES

(MODULE-5)

I-SEMESTER

Mrs. Babitha B

Assistant Professor, Dept. of Civil Engineering



AJIET

A J INSTITUTE OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

(A unit of Laxmi Memorial Education Trust. (R))

NH - 66, KottaraChowki, Kodical Cross - 575 006

Module -5

Utility of Solar Energy in Buildings

Solar energy as a ‘green energy’ has been gaining amazing popularity in the last few decades. The use is amplified in recent times as more numbers of homes, offices, and industrial units are opting for this ‘clean energy’.

The popularity of this “photovoltaic energy” is increasing considerably in recent years. In total, 93% of the global population lives in countries that have an average daily solar photovoltaic potential between 3.0 and 5.0 kWh/kWp. In the UK, solar contributed 28% of the country’s total renewable energy generation in 2021. The related technology along with attention concerning the traditional sources (coal and oil) is also growing. Since 2012, this energy sub-sector is receiving double the amount of investment, which is quite gratifying. “Till now we looked down for energy...but from now on, we have to look at the sky”.

Types of Solar Energy Technologies

Currently, solar energy is harnessed using three primary technologies. Which are:

1. **Photovoltaic (PV)** – directly convert light to electricity;
2. **Concentrating solar power (CSP)** – heat is being used from the sun (thermal energy) to drive electric turbines, utility-scale, and
3. **Solar heating and cooling (SHC) systems** – accumulate thermal energy to supply hot water and air heating and/ or conditioning.

Reasons to use Solar Energy Technologies for Buildings

Solar energy is used in a wide variety of devices from a calculator to cooking and from agri-tech to space-tech. But over a few years, it is being used in buildings in a bigger way. There are *several reasons* behind buildings opting for solar sources in a greater way which are given below.

- **Increasing** energy consumption
- Environmental **consciousness**
- Global **climate change**
- CSR implication/ advantage for **Corporate** buildings
- Attraction towards cleanest, **renewable** energy
- High social value and an increase in the **value of the property**

Why are Buildings going Solar

Solar energy is a freely available, clean, renewable energy source. The per capita energy consumption is going at an alarmingly high rate. The price of energy is also seeing new high figures.

Buildings are now constructed keeping energy efficiency in mind. The aim is to minimize energy consumption and use alternative solar energy, which has multiple benefits.

There are four aspects of energy efficiency in a building, where technology can play a key role. Which are:

1. **Before the actual construction** – zero energy passive building design.
2. **During the Construction** – the usage of low-energy building materials.
3. **Energy-efficient equipment** – To make operational energy requirement low.
4. **Integration with other applications** – lastly integration of renewable energy technologies for various applications.

Advantages of Using Solar Power in Buildings

- **Limitless Resource:** Solar energy is renewable energy that never ends its supply.
- **Low environmental impact:** Depending on the scale of the system installed – from distributed rooftop PV arrays to large utilities – solar technologies can produce lower environmental pollution.
- **Energy Independence:** It makes Buildings energy independent and puts less pressure on natural sources of energy.
- **Multipurpose:** It can be used in various ways and for multiple applications.
- **The ability for Additions:** You can expand your PV systems effortlessly as they are modular.
- **Portable:** Can be transported easily.
- **Post-Installation is Zero:** Once the infrastructure has been installed no cost will be there after that (except for changing inverters and batteries).

3 Ways Solar Powered Buildings are efficient

1. Solar Powered Buildings improve the Heating & Cooling System's efficiency by 30 per cent by proper installation of a new HVAC system. The operating cost of a highly-efficient solar water heater can be reduced by 90% in ***Solar Powered Energy Efficient Buildings***.

2. When you use Low-Emissivity (Low-e) Window Glazing, it helps in reduces the space cooling need by approximately 40 per cent. A light-colour roof reduces a roof's temperature as it absorbs less than 50 per cent of the solar energy.
3. When Energy Efficient Lights and Energy Efficient Appliances are used, a Solar Building can reduce energy use by 20-30%. With the continued emergence of construction technology innovations, it is becoming easier to achieve greater energy efficiency in buildings.

In conclusion, solar Powered Buildings are quite efficient in preserving energy in various ways. By using the latest Solar Energy Technologies buildings can save around 30-40% on their energy use. You can also become a net-zero Energy Building owner when you create more energy than you utilize. Undoubtedly, Solar Powered Buildings with proper use of technology are more efficient in energy consumption.

Concepts of Solar Passive Cooling and Heating of Buildings

Passive solar heating and cooling, sometimes referred to simply as passive solar design, is the process of using specific building systems to help regulate internal temperature by using the Sun's energy selectively and beneficially in an attempt to improve the energy efficiency. In these systems, the building itself or some element of it takes advantage of the natural energy characteristics of materials when exposed to the Sun. Generally these passive systems are simplistic with few moving parts, thus requiring minimal maintenance.^[2]

The engineering required to create these systems includes carefully selecting materials for the building envelope - including the building's walls, floors, roofs, windows and their glazing materials - and determining their proper orientation. Passive heating and cooling strategically captures or shades against solar radiation.

Solar passive cooling and heating are techniques used to maintain a comfortable temperature inside a building by using natural sources of energy, such as sunlight and wind, without relying on mechanical systems. Here are some of the key concepts of solar passive cooling and heating:

1. Orientation: The orientation of a building can play a significant role in passive solar cooling and heating. A building should be oriented to maximize exposure to the sun during the winter months and minimize exposure during the summer months. This can be achieved by designing the building with larger windows on the south-facing side and smaller windows on the north-facing side.

2. **Insulation:** Insulation is important for both passive solar cooling and heating. Proper insulation can help to prevent heat loss during the winter months and prevent heat gain during the summer months.
3. **Shading:** Shading is an important concept in passive solar cooling. Shading devices such as awnings, overhangs, and trees can be used to block direct sunlight from entering the building during the summer months, reducing heat gain.
4. **Thermal Mass:** Thermal mass refers to the ability of a material to absorb and store heat. Materials with high thermal mass, such as concrete and brick, can be used to absorb excess heat during the day and release it at night, helping to maintain a more constant temperature inside the building.
5. **Natural Ventilation:** Natural ventilation is an important concept in passive solar cooling. Operable windows, skylights, and vents can be strategically placed to allow for cross-ventilation and to draw cool air into the building and exhaust hot air out.
6. **Solar Collectors:** Solar collectors are used to collect and store solar energy, which can be used to heat the building during the winter months. Solar collectors can be integrated into the building's design, such as in the form of south-facing glass walls or roof-mounted solar panels.

By incorporating these concepts into the design of a building, it is possible to create a comfortable and energy-efficient living or working environment that relies on natural sources of energy. This not only reduces energy costs but also helps to mitigate the environmental impact of traditional heating and cooling methods.

Low Energy Cooling

Low energy cooling refers to techniques that reduce energy consumption associated with traditional air conditioning systems, while still providing a comfortable indoor environment. Here are some of the key strategies used in low energy cooling:

1. **Natural Ventilation:** Natural ventilation is a low-energy way to cool a building. By opening windows, doors, and vents, cool outside air can be drawn into the building and hot air can be exhausted. This technique can be especially effective during cooler times of the day and night.
2. **Evaporative Cooling:** Evaporative cooling is a process that uses water to cool the air. In this process, water is evaporated into the air, which absorbs heat and cools the surrounding area. This technique can be effective in dry climates, but less so in humid climates.

3. **Radiant Cooling:** Radiant cooling uses the thermal properties of surfaces to cool a space. This can be done by cooling the floors, walls, and ceilings of a building, which will then radiate coolness into the space.
4. **Earth Tubes:** Earth tubes are underground tubes that bring cool air into a building. As air flows through the tubes, it is cooled by the surrounding earth, and then brought into the building.
5. **Cool Roofs:** Cool roofs are roofs that are designed to reflect more sunlight and absorb less heat than traditional roofs. This helps to reduce heat gain in the building and keep it cooler.
6. **Building Design:** Building design can play a major role in low energy cooling. By orienting the building to take advantage of shading, natural ventilation, and other cooling techniques, it is possible to reduce the need for air conditioning and other mechanical systems.

By combining these strategies, low energy cooling can provide a comfortable and energy-efficient way to cool buildings without relying on energy-intensive air conditioning systems. This not only reduces energy costs but also helps to mitigate the environmental impact of traditional cooling methods.

Case studies of Solar Passive Cooled and Heated Buildings

There are many examples of solar passive cooled and heated buildings around the world. Here are a few case studies:

1. **The Edge:** The Edge is a 430,000 square foot office building in Amsterdam, which has been designed to be one of the most sustainable buildings in the world. The building features a south-facing glass facade that helps to maximize natural light and passive solar heating, while also using shading devices to prevent heat gain during the summer months. Natural ventilation is also used to cool the building, and excess heat is stored in the building's thermal mass to be released at night.
2. **Manitoba Hydro Place:** Manitoba Hydro Place is a 22-story office building in Winnipeg, Canada, which has been designed to be one of the most energy-efficient high-rise buildings in the world. The building features a south-facing glass facade that helps to maximize natural light and passive solar heating, while also using shading devices to prevent heat gain during the summer months. The building also incorporates natural ventilation and radiant cooling, as well as a geothermal heating and cooling system.

3. **The New York Times Building:** The New York Times Building is a 52-story office building in New York City, which has been designed to be one of the most energy-efficient skyscrapers in the world. The building features a double-skin facade that helps to maximize natural light and passive solar heating, while also using shading devices to prevent heat gain during the summer months. The building also incorporates natural ventilation and radiant cooling, as well as a cogeneration system that generates electricity and hot water.
4. **Villa Bio:** Villa Bio is a private residence in Denmark, which has been designed to be a zero-energy home. The building features a passive solar design, which maximizes natural light and passive solar heating, as well as a green roof that helps to insulate the building and absorb excess rainwater. The building also incorporates natural ventilation and radiant heating and cooling, as well as a ground-source heat pump.

These examples demonstrate how passive solar design can be used to create energy-efficient buildings that are comfortable, sustainable, and visually striking. By taking advantage of natural sources of energy, these buildings reduce their reliance on mechanical systems and help to mitigate the environmental impact of traditional building designs.

Green Composites for Buildings

Concepts of Green Composites

Green composites are composite materials that are made from renewable and sustainable resources, such as natural fibers and biodegradable polymers. Here are some of the key concepts of green composites:

1. **Natural Fibers:** Green composites are made from natural fibers, such as flax, hemp, jute, sisal, bamboo, and kenaf. These fibers are renewable and sustainable resources, and they offer several advantages over traditional synthetic fibers, such as lower weight, lower cost, and biodegradability.
2. **Biodegradable Polymers:** Green composites are also made from biodegradable polymers, such as polylactic acid (PLA), polyhydroxyalkanoates (PHAs), and starch-based polymers. These polymers are derived from renewable resources, such as corn, sugarcane, and potatoes, and they are biodegradable, which means they can be broken down by natural processes and do not contribute to environmental pollution.
3. **Manufacturing Techniques:** Green composites are produced using a variety of manufacturing techniques, including compression molding, injection molding, and extrusion. These techniques can be adapted to suit the specific properties of the natural

fibers and biodegradable polymers, and they can be used to produce composites with a range of mechanical and physical properties.

4. Applications: Green composites are used in a range of applications, including automotive, aerospace, construction, and packaging. They offer several advantages over traditional composite materials, such as improved sustainability, lower environmental impact, and lower weight.
5. Advantages: Green composites offer several advantages over traditional composite materials. They are sustainable and renewable, which reduces their impact on the environment. They are also biodegradable, which means they do not contribute to environmental pollution. In addition, green composites can offer improved mechanical and physical properties, such as higher strength-to-weight ratio and improved thermal insulation.

By taking advantage of renewable and sustainable resources, green composites offer a more environmentally friendly alternative to traditional composite materials. They offer several advantages over traditional composites, such as improved sustainability, lower environmental impact, and improved mechanical and physical properties. As a result, green composites are gaining increasing attention and use in a range of applications.

Water Utilisation in Buildings

Water utilization in buildings is an important aspect of sustainable building design and operation. Here are some key concepts related to water utilization in buildings:

1. Water Efficiency: Water efficiency is a key concept in sustainable building design, and it involves reducing water usage in buildings by using water-efficient fixtures, appliances, and systems. Water-efficient fixtures, such as low-flow toilets, showerheads, and faucets, can reduce water consumption by up to 50%. Water-efficient appliances, such as dishwashers and washing machines, can also help to reduce water usage in buildings.
2. Water Reuse: Water reuse is another important concept in sustainable building design, and it involves using treated wastewater for non-potable applications, such as flushing toilets, irrigating landscapes, and cooling buildings. Water reuse can reduce the demand for freshwater and help to conserve water resources.
3. Rainwater Harvesting: Rainwater harvesting is the process of collecting and storing rainwater for later use, such as irrigation, toilet flushing, and cooling. Rainwater harvesting can help to reduce the demand for freshwater and can also help to mitigate stormwater runoff and erosion.

4. **Greywater Recycling:** Greywater recycling is the process of treating and reusing wastewater from non-toilet fixtures, such as sinks, showers, and washing machines. Greywater can be treated and reused for non-potable applications, such as landscape irrigation and toilet flushing.
5. **Water Monitoring:** Water monitoring involves measuring and analyzing water usage in buildings to identify inefficiencies and opportunities for improvement. Water meters and monitoring systems can help to track water usage and identify leaks and other issues.

By implementing these concepts, buildings can reduce their demand for freshwater and minimize their impact on the environment. Water utilization in buildings is a critical aspect of sustainable building design, and it plays an important role in conserving water resources and promoting sustainable development.

Low Energy Approaches to Water Management

Low energy approaches to water management involve using innovative technologies and design strategies to reduce energy consumption in water treatment, distribution, and use. Here are some key concepts related to low energy approaches to water management:

1. **Efficient Water Fixtures:** Using low-flow toilets, faucets, showerheads, and other water-efficient fixtures can significantly reduce the amount of water used in buildings, which in turn can reduce energy consumption for water treatment and distribution.
2. **Water Reuse:** Reusing treated wastewater for non-potable applications, such as toilet flushing and landscape irrigation, can reduce the demand for freshwater and minimize energy consumption for water treatment and distribution.
3. **Greywater Recycling:** Greywater recycling involves treating and reusing wastewater from non-toilet fixtures, such as sinks, showers, and washing machines. Greywater can be treated and reused for non-potable applications, such as landscape irrigation and toilet flushing. This approach can significantly reduce energy consumption for water treatment and distribution.
4. **Rainwater Harvesting:** Collecting and storing rainwater for later use can reduce the demand for freshwater and minimize energy consumption for water treatment and distribution.
5. **Smart Irrigation Systems:** Smart irrigation systems use sensors and weather data to optimize the timing and amount of water applied to landscapes, which can reduce water usage and minimize energy consumption for water distribution.

6. **Water Monitoring:** Monitoring water usage can identify inefficiencies and opportunities for improvement. Water meters and monitoring systems can help track water usage and identify leaks and other issues, which can reduce the energy required for water treatment and distribution.

By implementing these low energy approaches to water management, buildings can reduce their energy consumption and minimize their impact on the environment. These approaches can also help conserve water resources and promote sustainable development.

Management of Solid Wastes

Solid waste management involves the collection, transportation, processing, and disposal of solid waste in a way that minimizes its impact on the environment and human health. Here are some key concepts related to the management of solid wastes:

1. **Waste Reduction:** Waste reduction involves minimizing the amount of waste produced in the first place. This can be achieved through strategies such as recycling, composting, and product design that reduces waste generation.
2. **Source Separation:** Source separation involves separating different types of waste at the point of generation, such as separating recyclable materials from non-recyclable materials. This approach makes it easier to recycle and compost waste.
3. **Recycling:** Recycling involves processing and reusing materials that would otherwise be discarded as waste. Recycling can help reduce the amount of waste that goes to landfills and can conserve natural resources.
4. **Composting:** Composting involves the breakdown of organic waste materials, such as food waste and yard waste, into nutrient-rich soil amendments. Composting can reduce the amount of organic waste that goes to landfills and can provide a sustainable source of soil amendments for landscaping and agriculture.
5. **Waste-to-Energy:** Waste-to-energy involves using solid waste as a fuel to generate electricity or heat. This approach can reduce the amount of waste that goes to landfills and can provide a source of renewable energy.
6. **Landfill Management:** Landfills are sites where waste is disposed of in the ground. Proper landfill management involves using techniques such as liner systems and leachate collection to prevent contamination of the surrounding environment. Landfills should also be designed to capture methane gas, which can be used as a renewable energy source.

By implementing these solid waste management strategies, buildings can reduce the amount of waste they generate, minimize their impact on the environment, and promote sustainable

development. Effective solid waste management can also reduce the cost of waste disposal and support the circular economy.

Management of Sullage Water and Sewage

Management of sullage water and sewage is crucial for maintaining public health and environmental sustainability. Sullage water refers to wastewater from kitchens, laundry, and bathing activities, while sewage refers to human excreta and wastewater from toilets. Here are some general steps that can be taken to manage these types of wastewater:

1. **Collection:** Both sullage water and sewage must be collected through appropriate plumbing systems. In some cases, separate plumbing systems may be required to collect and manage sullage water and sewage.
2. **Treatment:** Once collected, sullage water and sewage must be treated to remove contaminants and reduce the risk of disease transmission. Treatment methods can vary depending on the scale of the system, but may include physical, biological, or chemical treatment.
3. **Disposal:** Treated sullage water and sewage can be safely disposed of through various means, including discharging to surface water bodies, using for irrigation, or reusing for non-potable uses such as toilet flushing or washing.
4. **Monitoring:** To ensure that the wastewater is being effectively managed and that the treatment systems are working correctly, regular monitoring of the wastewater and the surrounding environment is necessary.
5. **Education and awareness:** It is essential to educate the public on proper wastewater management practices to prevent contamination and maintain public health.

In addition to these general steps, it is crucial to consider local regulations and cultural practices when designing and implementing a sullage water and sewage management system. Consulting with experts in the field and engaging with the local community can help ensure that the system is effective, sustainable, and culturally appropriate.

Urban Environment and Green Buildings

Urban environments are characterized by a high concentration of people, buildings, and infrastructure. The impact of urbanization on the environment is significant, including increased energy consumption, pollution, and waste production. In response, green buildings

have emerged as a solution to mitigate the negative impact of urbanization on the environment. Green buildings are designed to be energy-efficient, sustainable, and environmentally friendly. Here are some ways green buildings can help improve the urban environment:

1. **Energy efficiency:** Green buildings use advanced technologies and design strategies to reduce energy consumption, which in turn reduces greenhouse gas emissions and helps mitigate the effects of climate change.
2. **Water conservation:** Green buildings incorporate water-efficient technologies such as low-flow toilets, faucets, and showers. These technologies can significantly reduce the amount of water consumed in buildings, leading to water conservation and cost savings.
3. **Improved indoor air quality:** Green buildings use materials and ventilation systems that improve indoor air quality, promoting the health and well-being of occupants.
4. **Reduced waste:** Green buildings are designed to minimize waste and promote recycling. Construction waste is reduced by using sustainable building materials and reducing packaging, and building occupants are encouraged to recycle and reduce waste.
5. **Urban green spaces:** Green buildings can incorporate green roofs, living walls, and other features that promote the integration of urban green spaces into the built environment. These features provide many benefits, including improving air quality, reducing heat island effects, and creating habitat for urban wildlife.
6. **Education and awareness:** Green buildings can serve as educational tools that raise awareness of environmental issues and inspire people to take action to reduce their impact on the environment.

In conclusion, green buildings offer a practical solution to improve the urban environment by reducing energy consumption, conserving water, improving indoor air quality, reducing waste, and promoting the integration of urban green spaces into the built environment. These benefits make green buildings a critical component of sustainable urban development.

Green Cover and Built Environment

Green cover refers to the percentage of land area covered by vegetation, including trees, shrubs, and grasses. The built environment refers to human-made structures such as buildings, roads, and other infrastructure. The relationship between green cover and the built environment is essential for promoting sustainable development and mitigating the impact of

urbanization on the environment. Here are some ways that green cover can be incorporated into the built environment:

1. **Green roofs:** Green roofs are a type of roof that is partially or completely covered with vegetation. They provide many benefits, including reducing the urban heat island effect, improving air quality, reducing energy consumption, and providing habitat for wildlife.
2. **Green walls:** Green walls, or living walls, are vertical structures that are covered with vegetation. They can be used as exterior cladding for buildings or as interior features, providing many of the same benefits as green roofs.
3. **Urban forests:** Urban forests are clusters of trees and other vegetation that are integrated into the built environment. They provide many benefits, including reducing heat island effects, improving air quality, providing habitat for wildlife, and reducing stormwater runoff.
4. **Parks and green spaces:** Parks and green spaces are essential components of the built environment that provide many benefits, including promoting physical activity, improving mental health, and providing opportunities for recreation.
5. **Stormwater management:** Vegetation can be used to manage stormwater runoff in the built environment. Green infrastructure, such as bioswales, rain gardens, and permeable pavements, can be used to capture and treat stormwater, reducing the impact of urbanization on water quality.

In conclusion, incorporating green cover into the built environment can help promote sustainable development and mitigate the negative impact of urbanization on the environment. Green roofs, green walls, urban forests, parks and green spaces, and stormwater management are all examples of ways that green cover can be incorporated into the built environment, providing many benefits to the environment and the community.

REVIEW QUESTIONS

1. What are the advantages of using solar power in buildings?
2. Explain the concepts of solar passive cooling and heating in buildings.
3. Explain low energy cooling.
4. Write the different case studies of solar passive cooled and heated buildings.
5. Explain the concepts of green composites.
6. Explain how water utilisation is done in buildings.
7. Illustrate the management of solid waste and sullage water and sewage.

AIJET