21MEO110T: Energy Systems for Sustainable Buildings

Unit I: Energy Transfer in Buildings

(Concepts of energy efficient buildings, Conventional versus Energy Efficient buildings, Types of Energy buildings)

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Unit-1: Topics

Energy Transfer in Buildings

- Concepts of thermal comfort and energy efficient buildings
- Conventional versus Energy Efficient Buildings
- Climate and its influence in building design for energy requirement
- Thermal properties of building materials
- Heat transmission in building structures
- Energy balance for cooling and heating of buildings
- Estimation of heating and cooling loads
- Low and zero energy buildings- Global and Indian energy scenario-Future building design aspects.

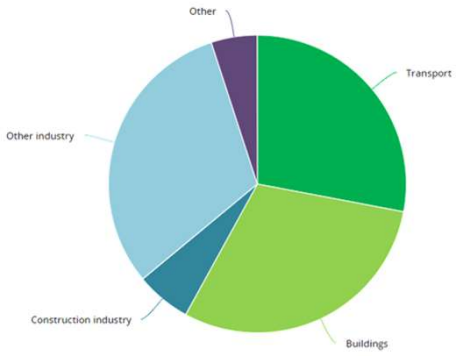
Syllabus..Unit 2 to 5

Unit-2 - Solar Heating and Cooling	**9 Hour**
General principles of active and passive solar heating- Key design elements of passive heating- Direct solar heat gain by Trombe mass walls- Passive cooling and its key design elements, - Water walls, evaporative cooling- Convective air loops and solar chimney effects, Thermal Bridge and barrier, Thermal insulation, load control, air infiltration- Odor removal and heat recovery in large buildings.	
Unit-3 - Heat Control and Ventilation	**9 Hour**
Air currents around the building, Air movement through the buildings, air changes, quality of air- Psychometrics, Design parameters influencing thermal design of buildings- Impact of micro and macro climatic changes- Heat transmission through building sections-Effect of orientation of buildings. Ventilation, requirements for heat control in buildings- Standards for ventilation-Ventilation designs.	
Unit-4 - Lighting Systems of Buildings	**9 Hour**
Introduction to lighting systems of building-Functional and aesthetic aspects of lighting - Offices, Residences, Hospitals, Malls, Museum Lighting-Glazing materials: Sources and concepts of optical materials-Concepts of day lighting- Components of daylight factors and Recommended daylight factors- Day lighting analysis- Electrical lighting and Illumination requirement-Selection of luminaries and performance parameters-Electric lighting control for day lighted buildings- Comparison of day and electrical lighting	
Unit-5 - Green Buildings and Standards	**9 Hour**
Sustainability - need and challenges, Environment benefits of green buildings, Integrated ecological design, Effluent management systems-environmental acts and protocols-ISO 14000-Green building features and green construction materials-Green building standards, ratings and certifications - Green Globe, LEED, GRIHA, IGBC, Socioeconomic aspects of green buildings, Sustainable urbanization, Governmental proposal on green buildings.	

Basic requirements of Buildings

- To provide shelter and safety
- To provide comfortable indoor environment (thermal, visual, air quality and noise)
- To meet social expectations (social standards, representation, work task etc.)

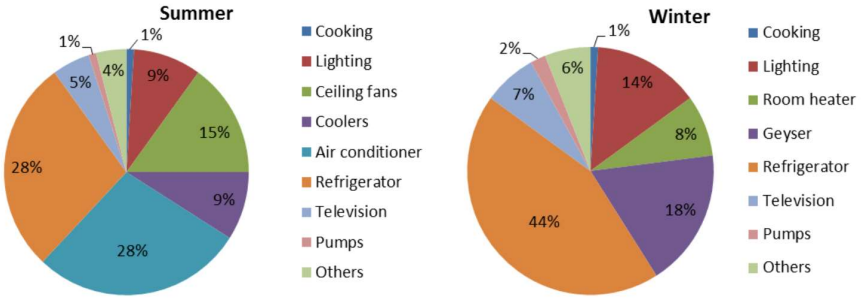
Energy requirements for Buildings



Sector wise energy utilization in the world

- Buildings, as they are designed and used, contribute to serious environmental problems because of excessive consumption of energy & other natural resources.
- The global energy scenario has undergone a drastic change in the last two decades. It is estimated that almost **2/3rd of the global energy demand is due to buildings**, as their construction, operation and maintenance are concerned
- It is expected to grow by an additional 45 percent by 2025.

Energy requirements for Buildings



Electricity consumption in buildings: Delhi Scenario

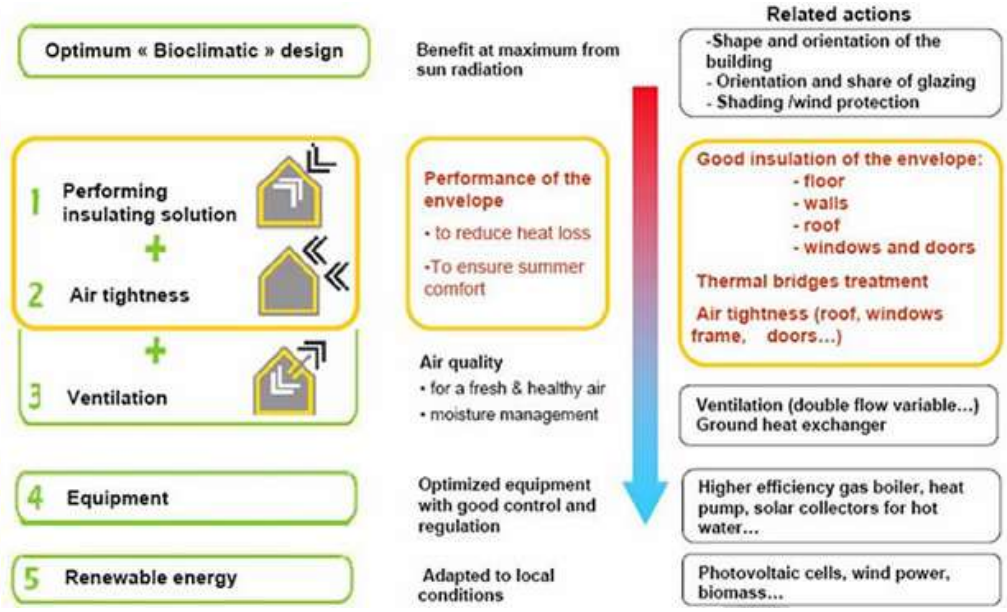
- **Commercial and residential buildings account for more than 30 percent of the electricity consumption in India. We add more than 40 million sq. m of commercial and residential space annually and this results in the additional burden of 5.6 billion units of electricity.**
- **Based on this scenario energy efficient building design concept has to be implemented**

Concepts of energy efficient buildings

Energy efficient buildings

- **Energy efficient building design** involves constructing or upgrading buildings that are to reduce energy loss such as decreasing the loss of heat through the building envelope. (**through building envelope**)
- Energy efficient buildings can be defined as buildings that are designed to provide a significant reduction of the energy need for heating and cooling. (**reduce the energy for heating and cooling**)
- Energy efficient buildings are **less expensive to operate, more comfortable to live in, and more environmentally friendly**.

Energy efficient buildings



Effective energy efficiency in new constructions can be achieved by adopting an integrated approach to building design.

The primary steps in this approach would be to:

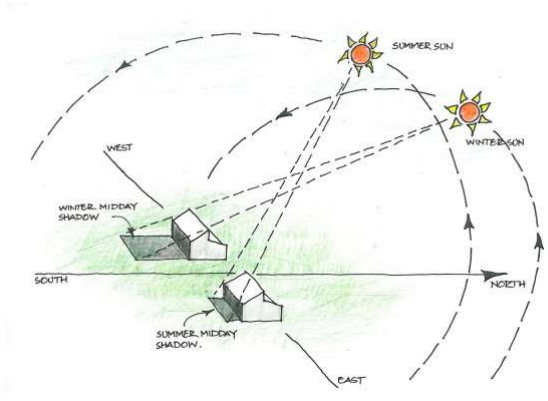
- Incorporate **passive solar techniques** in building design to minimize load on conventional systems (heating, cooling, ventilation and lighting).
- Design the **energy efficient lighting** and HVAC systems.
- Use of **renewable energy sources** to meet part of building load.
- Use of **low energy materials & methods of construction** & reduce transportation energy.

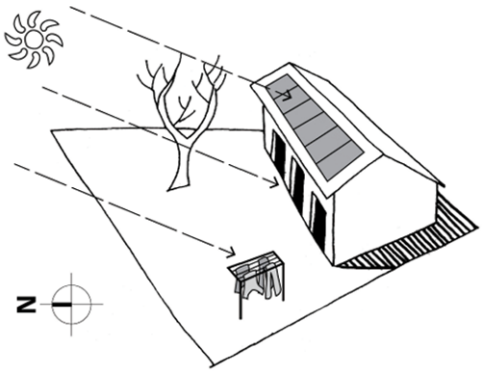
The task for an Architect

Architects can achieve energy efficiency in the buildings they design by studying the macro-and micro-climate of the site, applying bioclimatic architectural principles. Some common design elements that affect the thermal conditions are:

1. ***Orientation:*** The placement of the building in north-south direction, reduces the heat energy input in the building, increases overall ventilation and provide thermal comfort to the building.

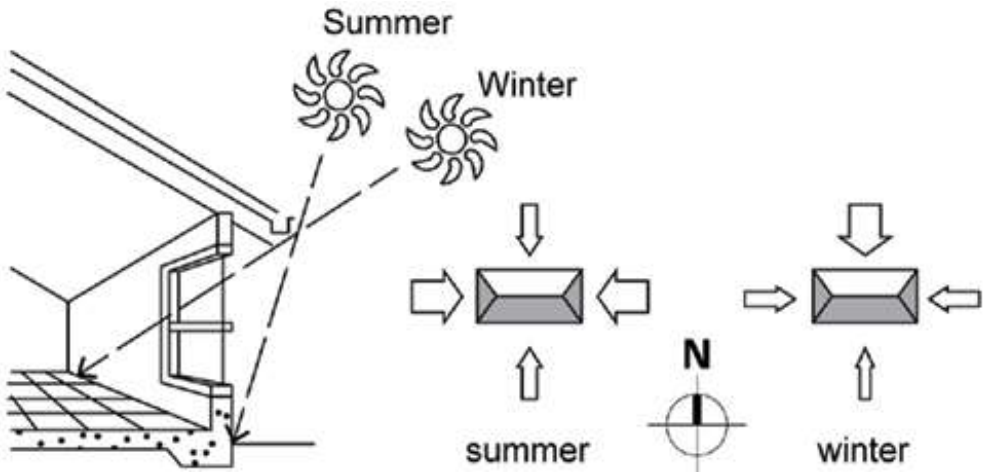
Sun path





Gross errors in structure orientation, solar system sizing, collector placement, component specification, and scientific studies can result when designers/engineers fail to accurately assess shading patterns at proposed building/ecological sites.

Building orientation (Case: Australia)



<u>The task for an Architect</u>

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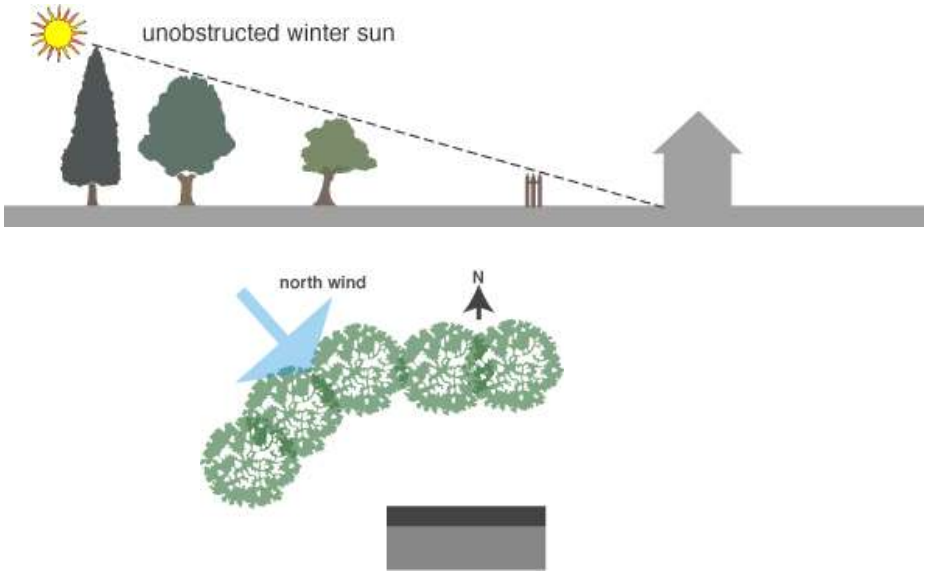
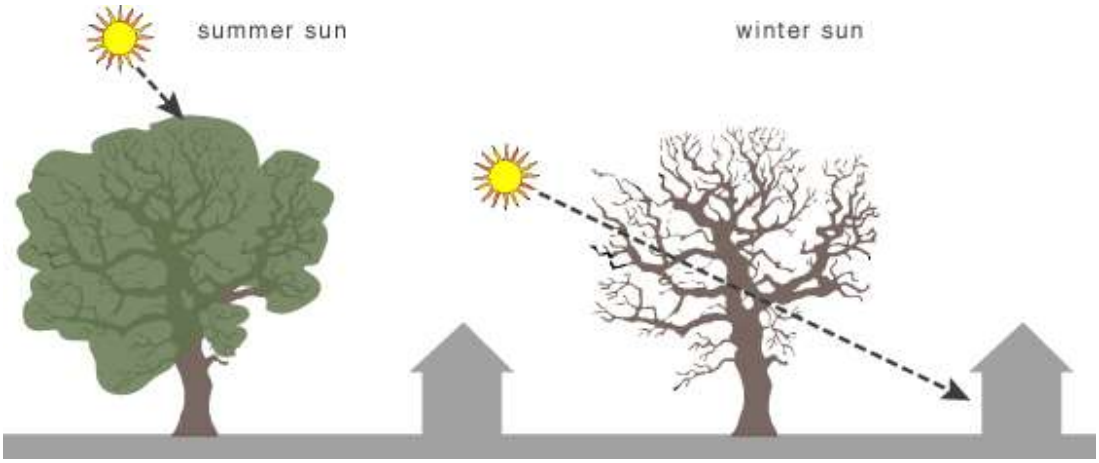
<u>2. Landscaping:</u> Landscaping alters the microclimate of the site. **It reduces direct sun radiation on the buildings & heating up the building surfaces.**

Use of trees in passive design



Use of deciduous trees

Use of deciduous trees in passive design



The task for an Architect

Architects can achieve energy efficiency in the buildings they design by studying the macro-and micro-climate of the site, applying bioclimatic architectural principles. Some common design elements that affect the thermal conditions are:

3. Materials of construction: Choice of building materials is very important in reducing the energy contents of buildings.

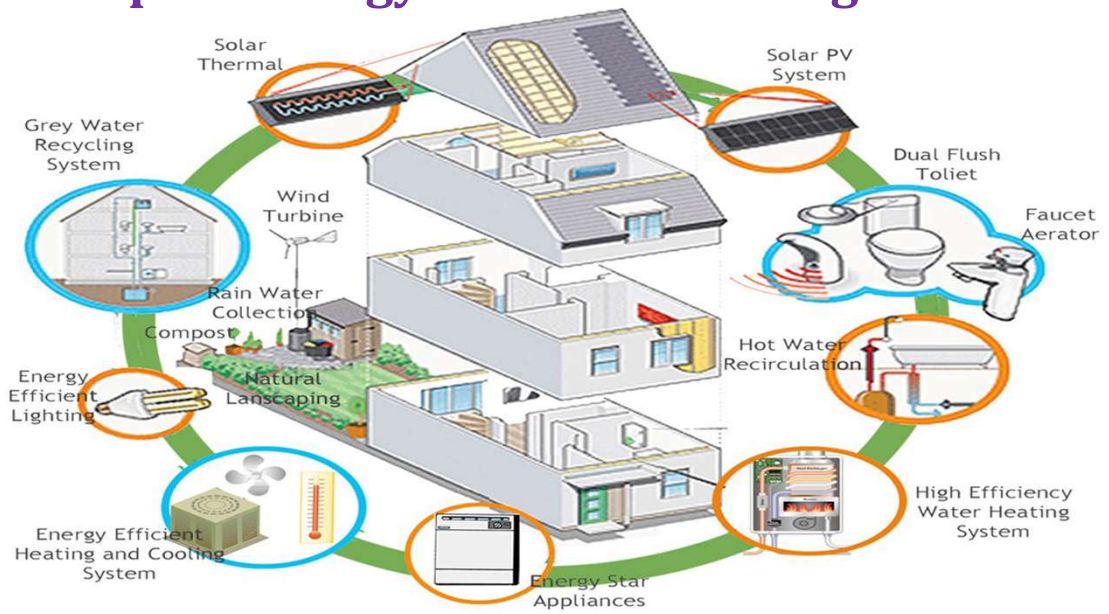
Clay and wooden houses

The task for an Architect

4. ***Location of water bodies:*** Water is a very good modifier of microclimate. **It takes up large amount of heat in evaporation and causes significant cooling in hot and dry climate**. On the other hand, in humid climates, water should be avoided as it adds to humidity.

5. ***Building form/surface to volume ratio:*** The **volume of space inside a building that needs to be heated or cooled** and its relationship with the area of the envelope enclosing the volume affects the thermal performance of the building. For any given building volume, the more compact in the shape, the less wasteful it is in gaining/ losing heat.

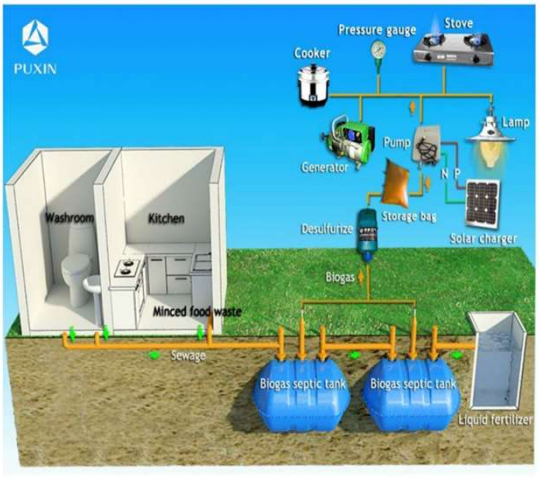
Concept of Energy Efficient Buildings



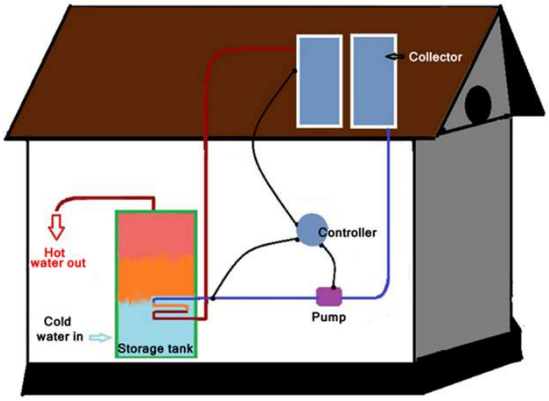
Building with solar heating and cooling

Building with wind energy

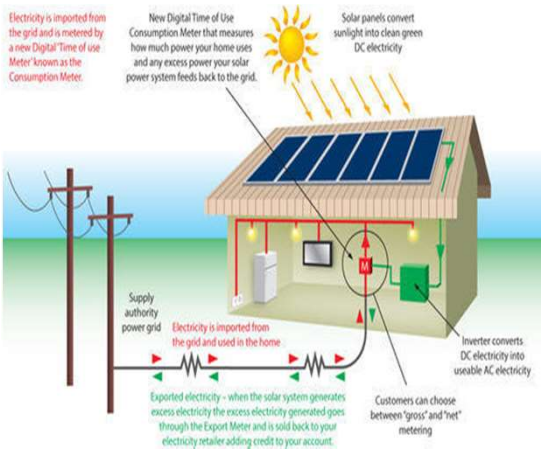
Building with Biogas plant



Building with solar water heating



Solar operated power system in buildings



An open-roofed entrance hall / central court in a house.

Conventional building vs Energy Efficient Building

• **Conventional buildings** were built using **non-energy saving techniques**; however, that does not mean they are unable to have energy saving improvements made to them.

• Cost of the building and energy spend is high.

• It depends on the external Energy sources

• **Energy Efficient buildings** both increase a **building's** energy efficiency by using energy star appliances and improve the design of the **building.**

• Cost of the building and energy spend is low.

• It may partially depend on the external energy sources

Conventional building vs Energy Efficient Building

Energy Efficient building is the one which **uses less water, optimizes energy efficiency, conserves natural resources generate less waste and provides healthier spaces for occupants as compared to conventional buildings.**

- Low Maintenance and Operation Cost. Green buildings incorporate unique construction features that ensure efficient use of resources such water and **energy**. ...
- **Energy** Efficiency. ...
- Enhances Indoor **Environment** Quality. ...
- Water Efficiency. ...
- Better Health. ...
- Material Efficiency. ...
- Better **Environment**. ...
- Reduces Strain on Local Resources.

According **to** builders, "**construction** costs of **green buildings are** about 5% higher **than conventional** homes but the difference in costs gets covered within the first 3-4 years, along with a great reduction in operational costs". Think of a **green building as** an investment that guarantees multiplied returns.

Conventional building vs Energy Efficient Building

A **Energy efficient building** is a **building** that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. '**Energy efficient buildings** preserve precious natural resources and improve our quality of life.

The **Energy efficient buildings** is designed with highly effective systems and techniques to increase the efficiency and lower the cost. This increase in the energy and water efficiency reduces the amounts of energy and water required for **building** operations.

One of the most common **disadvantages of Energy efficient buildings** is the additional cost incurred. This is due to the increase in the quality of construction methods and materials used. ... While projects close to larger cities may have no difficulty finding **Energy efficient buildings** materials, suppliers may be scarce in other areas.

Conventional building vs Energy Efficient Building

Compared to a conventional building, a green Building:

- Uses less energy, water and natural resources
- It is located and built with as little impact on the environment as possible,
- Creates less waste, and
- It is healthier for the occupants

Types of Energy buildings

- Energy-efficient buildings are designed to use as little energy as possible. Buildings can be made energy-efficient by using **quality building and insulation materials which help prevent heat loss and make the building airtight**.
- High-quality design and craftsmanship are prerequisites in energy-efficient building, thus minimizing thermal bridges.
- Energy-efficient buildings are classified into four categories
  - ❖ Low energy buildings :
  - ❖ Passive energy buildings
  - ❖ Zero energy buildings
  - ❖ Plus energy buildings

Type 0 - Standard Building

A standard building is constructed to meet only minimum building energy efficiency requirements.

Type I - Low Energy Building

A low energy building consumes **only half of the energy** as compared to a standard building. Energy efficiency is achieved by improved insulation, windows and a ventilation heat recovery system.

Type II – Passive Energy Building

A passive building consumes less than a quarter of the energy used by a standard building.

Type III – Zero Energy Building

A zero energy building is a building with **zero net energy consumption and zero carbon emissions annually.** These buildings can be independent of the energy grid supply.

Type IV - Plus Energy Building

The plus energy concept is based on buildings having an **energy efficiency level of a passive building** and additional integrated active energy supply systems such as solar or wind energy.

Thank you