GREEN BUILDINGS

UNIT-1

Syllabus:

Typical features of Green Buildings, benefits of green buildings – Sustainable Site Selection, maximizing comfort, integration of daylight, optimizing ventilation; Rain water harvesting, recharge, reuse strategies

Learning Outcomes:

Students will be able to

- understand various features of green buildings
- explain the benefits of green buildings
- plan and select a proper site for green building
- describe the measures of integrating daylight, optimizing ventilation and maximizing comfort
- explain the rainwater harvesting strategies

Learning Material

FEATURES OF GREEN BUILDINGS:

Energy Efficiency

- Most buildings can reach energy efficiency levels far beyond California Title 24 standards, yet most only strive to meet the standard. It is reasonable to strive for 40 percent less energy than Title 24 standards. The following strategies contribute to this goal.
- Passive design strategies can dramatically affect building energy performance. These measures include building shape and orientation, passive solar design, and the use of natural lighting.
- Develop strategies to provide natural lighting. Studies have shown that it has a positive impact on productivity and well-being.
- Install high-efficiency lighting systems with advanced lighting controls. Include motion sensors tied to dimmable lighting controls. Task lighting reduces general overhead light levels.
- Use a properly sized and energy-efficient heat/cooling system in conjunction with a thermally efficient building shell. Maximize light colors for roofing and wall finish materials; install high R-value wall and ceiling insulation; and use minimal glass on east and west exposures.
- Minimize the electric loads from lighting, equipment, and appliances.
- Consider alternative energy sources such as photo voltaic and fuel cells that are now available in new products and applications. Renewable energy sources provide a great symbol of emerging technologies for the future.
- Computer modeling is an extremely useful tool in optimizing design of electrical and mechanical systems and the building shell.

Materials Efficiency

- Select sustainable construction materials and products by evaluating several characteristics such as reused and recycled content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainably harvested materials, high recyclability, durability, longevity, and local production. Such products promote resource conservation and efficiency. Using recycled-content products also helps develop markets for recycled materials that are being diverted from California's landfills, as mandated by the Integrated Waste Management Act.
- Use dimensional planning and other material efficiency strategies. These strategies reduce the amount of building materials needed and cut construction costs. For example, design rooms on 4-foot multiples to conform to standard-sized wallboard and plywood sheets.
- Reuse and recycle construction and demolition materials. For example, using inert demolition materials as a base course for a parking lot keeps materials out of landfills and costs less.
- Require plans for managing materials through deconstruction, demolition, and construction.
- Design with adequate space to facilitate recycling collection and to incorporate a solid waste management program that prevents waste generation.

Water Efficiency

- Design for dual plumbing to use recycled water for toilet flushing or a gray water system that recovers rainwater or other nonpotable water for site irrigation.
- Minimize wastewater by using ultra low-flush toilets, low-flow shower heads, and other water conserving fixtures.
- Use recirculating systems for centralized hot water distribution.
- Install point-of-use hot water heating systems for more distant locations.
- Use a water budget approach that schedules irrigation using the California Irrigation Management Information System data for landscaping.
- Meter the landscape separately from buildings. Use micro-irrigation (which excludes sprinklers and high-pressure sprayers) to supply water in nonturf areas.
- Use state-of-the-art irrigation controllers and self-closing nozzles on hoses.

Occupant Health and Safety

Recent studies reveal that buildings with good overall environmental quality can reduce the rate of respiratory disease, allergy, asthma, sick building symptoms, and enhance worker performance. The potential financial benefits of improving indoor environments exceed costs by a factor of 8 and 14.

Choose construction materials and interior finish products with zero or low emissions to improve indoor air quality. Many building materials and cleaning/maintenance products emit toxic gases, such as volatile organic compounds (VOC) and formaldehyde. These gases can have a detrimental impact on occupants' health and productivity.

Provide adequate ventilation and a high-efficiency, in-duct filtration system. Heating and cooling

systems that ensure adequate ventilation and proper filtration can have a dramatic and positive impact on indoor air quality.

Prevent indoor microbial contamination through selection of materials resistant to microbial growth, provide effective drainage from the roof and surrounding landscape, install adequate ventilation in bathrooms, allow proper drainage of air-conditioning coils, and design other building systems to control humidity.

Building Operation and Maintenance

Green building measures cannot achieve their goals unless they work as intended. Building commissioning includes testing and adjusting the mechanical, electrical, and plumbing systems to ensure that all equipment meets design criteria. It also includes instructing the staff on the operation and maintenance of equipment.

Over time, building performance can be assured through measurement, adjustment, and upgrading. Proper maintenance ensures that a building continues to perform as designed and commissioned.

BENEFITS OF GREEN BUILDINGS:

Conventional building often fail to consider the inter relationship among building sitting, design elements, energy and resource constraints, building systems, and building function. Green buildings, through an integrated approach, take into consideration the effect of these factors have on one another. Climate and building orientation, design factors such as daylighting opportunities, and building envelope and system choices, as well as economic guide lines and occupant activities, are all factors that need to be considered in an integral approach. Such a green building location, design and commissioning provides various benefits. These include:

Environmental Benefits

- Reduces impact of natural resource consumption
- Develops long-term resource/energy strategies that are practical in use

Economic and Social Benefits

- Reduces reliance on public utilities
- Increases the value of a home and increases resale interest
- Improves the bottom line for homeowners over the long-term while offering significant immediate social benefits
- Increases home durability
- Encourages sustainable building practices
- Reduce the impact on natural resource consumption and leave for future generations

Health and Safety Benefits

- Reduces exposure to allergens, carcinogens, pollutants

- Enhances occupant comfort and health
- Improve productivity of occupants

Community Benefits

- Reduces strain on local infrastructures and improves quality of life
- Provides homeowner pride and drives values for community members

Competitive Costs

- Integrated Green Design allows higher benefits at lower cost by achieving synergies between disciplines and between technologies.

Reduces Operating and Tax Costs

- Utility costs significantly lower
- Life-cycle economic performance optimized
- Owner access to tax credits

Increases Building Valuation and ROI

- Using the income-capitalization method: asset value=net operating income(NOI)divided by capitalization rate/return. If cap rate is 7% divide the reduction in annual operating costs by 7% to calculate increase in building's asset value
- Quantifying financial benefit in terms of return on investment (ROI) instead of payback time demonstrates true financial advantage.

Faster environmental clearances for projects

In a major impetus to the Green Buildings movement in India, Government of Maharashtra has in-principle approved Priority Status for "Faster environmental Clearance for IGBC registered projects" from the Environment Department and other Municipalities.

SUSTAINABLE SITE SELECTION:

The selection and development of a building site are fundamental components of a green building practices .Environmental damage cauged by construction may take year of work to remedy.
Do not develop buildings on portions of sites that meet any of the following on a site
i) Prime farmland
ii) Previously under developed land whose elevation is lower than 1.5m above the elevation of the 100yrs flood frequency.
iii)Land specifically identified as habitat for any species on theranced or endangered list.
iv)Land within 30m of any wetland and isolated wetlands or areas of srecial concern identified state or central rule
v)Previously under developed land that is within 20m of any water-body such as lakes, rivers and reservoirs.
vi)Site shall not be located near to solid waste disposal sites, oxidation ponds and odour

producing industries.
vii)The site location shall be close to suburban transportation route, and is within walking, biking, or bus distance to medical clinics, schools, parks, temples, shopping, parks and other recreational spots.
viii)The site location are should demonstrate cultural diversity consistent with that statewide.
ix)The site shall not be located on brownfield which is a place of contamination. With hazardous substance or pollutants
x)The site location should not spoil the existing land scape and protect it from degradation during the process of construction.
xi)The site soil should be good in terms of soil bearing capacity, compactbility and soil permeability
Selecting a building site begins the process of calculating the degree of resource use and the degree of disturbance of existing natural systems that will be required to support a building's development. The most environmentally sound development is one that disturbs as little of the existing site as possible. Therefore, sites suitable for commercial building should ideally be located within or adjacent to existing commercial environments. Building projects also require connections to mass transit, vehicular infrastructure, and utility and telecommunication networks. Sound site planning and building design should consider locating building-support services in common corridors, or siting a building to take advantage of existing service networks.
This consolidation can minimize site disruption and facilitate building repair and inspection.

INTEGRATION OF DAYLIGHT:

Day lighting is the practice of placing windows or other openings and reflective surfaces so that during the day natural light provides effective internal lighting. Particular attention is given to day lighting while designing a building when the aim is to maximize visual comfort or to reduce energy use. Energy savings can be achieved either from the reduced use of artificial (electric) lighting or from passive solar heating or cooling. Artificial lighting energy use can be reduced by simply installing fewer electric lights because daylight is present, or by dimming/switching electric lights automatically in response to the presence of daylight, a process known as daylight harvesting.

Windows

Windows are the most common way to admit daylight into a space. Their vertical orientation means that they selectively admit sunlight and diffuse daylight at different times of the day and year. Therefore windows on multiple orientations must usually be combined to produce the right mix of light for the building, depending on the climate and latitude. There are three ways to improve the amount of light available from a window.

- Place window close to a light colored wall.
- Slant the sides of window openings so the inner opening is larger than the outer opening.
- Use a large light colored window sill to project light into the room.

Different types and grades of glass and different window treatments can also affect the amount of light transmission through the windows.

Clerestory windows

Another important element in creating daylighting is the use of **clerestory windows**. These are

high, vertically placed windows. They can be used to increase direct solar gain when oriented towards the equator. When facing toward the sun, clerestories and other windows may admit unacceptable glare. In the case of a passive solar house, clerestories may provide a direct light path to polar-side (north in the northern hemisphere; south in the southern hemisphere) rooms that otherwise would not be illuminated. Alternatively, clerestories can be used to admit diffuse daylight (from the north in the northern hemisphere) that evenly illuminates a space such as a classroom or office.

Often, clerestory windows also shine onto interior wall surfaces painted white or another light color. These walls are placed so as to reflect indirect light to interior areas where it is needed. This method has the advantage of reducing the directionality of light to make it softer and more diffuse, reducing shadows.

Skylights

Skylights are light transmitting fenestration (products filling openings in a building envelope which also includes windows, doors, etc.) forming all, or a portion of, the roof of a building space. Skylights (*roof windows, unit skylights, tubular daylighting devices (TDDs), sloped glazing*) are used to convey abundant daylight or toplighting, provide a connection to the outdoor environment to occupants, and often to help fresh outside air enter the space.

Light reflectors

Once used extensively in office buildings, the manually adjustable **light reflector** is seldom in use today having been supplanted by a combination of other methods in concert with artificial illumination. The reflector had found favor where the choices of artificial light provided poor illumination compared to modern electric lighting.

Light shelves

Light shelves are an effective way to enhance the lighting from windows on the equator-facing side of a structure, this effect being obtained by placing a white or reflective metal light shelf outside the window. Usually the window will be protected from direct summer season sun by a projecting eave. The light shelf projects beyond the shadow created by the eave and reflects sunlight upward to illuminate the ceiling. This reflected light can contain little heat content and the reflective illumination from the ceiling will typically reduce deep shadows, reducing the need for general illumination.

In the cold winter, a natural light shelf is created when there is snow on the ground which makes it reflective. Low winter sun (see Sun path) reflects off the snow and increases solar gain through equator-facing glass by one-to-two thirds which brightly lights the ceiling of these rooms. Glare control (drapes) may be required.

Light tubes

Another type of device used is the light tube, also called a tubular daylighting device, which is placed into a roof and admits light to a focused area of the interior. These somewhat resemble recessed ceiling light fixtures. They do not allow as much heat transfer as skylights because they have less surface area.

Sawtooth roof

Another roof-angled glass alternative is a "sawtooth roof" (found on older factories). Sawtooth roofs have vertical roof glass facing away from the equator side of the building to capture

diffused light (not harsh direct equator-side solar gain). The angled portion of the glass-support structure is opaque and well insulated with a cool roof and radiant barrier. The sawtooth roof's lighting concept partially reduces the summer "solar furnace" skylight problem, but still allows warm interior air to rise and touch the exterior roof glass in the cold winter, with significant undesirable heat transfer.

Heliostats

The use of heliostats, mirrors which are moved automatically to reflect sunlight in a constant direction as the sun moves across the sky, is gaining popularity as an energy-efficient method of lighting. A heliostat can be used to shine sunlight directly through a window or skylight, or into any arrangement of optical elements, for example light tubes, that distribute the light where it is needed.

OPTIMIZING VENTILATION:

Natural ventilation is the process of supplying and removing air through an indoor space without using mechanical systems. It refers to the flow of external air to an indoor space as a result of pressure or temperature differences. There are two types of natural ventilation occurring in buildings: wind driven ventilation and buoyancy-driven ventilation. While wind is the main mechanism of wind driven ventilation, buoyancy-driven ventilation occurs as a result of the directional buoyancy force that results from temperature differences between the interior and exterior.

Natural ventilation occurs when the air in a space is changed with outdoor air without the use of mechanical systems, such as a fan. Most often natural ventilation is assured through operable windows but it can also be achieved through temperature and pressure differences between spaces. Open windows or vents are not a good choice for ventilating a basement or other below ground structure. Allowing outside air into a cooler below ground space will cause problems with humidity and condensation.

Ventilation rate

•The ventilation rate, for CII buildings, is normally expressed by the volumetric flowrate of outside air being introduced to the building. The typical units used are cubic feet per minute (CFM) or liters per second (L/s). The ventilation rate can also be expressed on a per person or per unit floor area basis, such as CFM/p or CFM/ft², or as air changes per hour.

•For residential buildings, which mostly rely on infiltration for meeting their ventilation needs, the common ventilation rate measure is the number of times the whole interior volume of air is replaced per hour, and is called air changes per hour (I or ACH; units of 1/h). During the winter, ACH may range from 0.50 to 0.41 in a tightly insulated house to 1.11 to 1.47 in a loosely insulated house.

•ASHRAE now recommends ventilation rates dependent upon floor area, as a revision to the 62-2001 standard whereas the minimum ACH was 0.35, but no less than 15 CFM/person (7.1 L/s/person). As of 2003, the standards have changed to an addition of 3 CFM/100 sq. ft. (15 l/s/100 sq. m.) to the 7.5 CFM/person (3.5 L/s/person) standard.

MAXIMISING COMFORT:

- Preferably, position workstations away from the windows, or alternatively, position desk with window to the side of the worker.
- Position the desk to minimize glare. If you can see the image of the light fixture reflecting from your desktop, you have a glare problem.

- Adjust window blinds or drapes to control light and glare.
- Use non-glare finishes and neutral (not too bright) colours on walls and furniture. The colour and finish of a surface determines how much light it reflects.
- Use appropriate lighting fixture for the task and space.
- Use adjustable task lights to increase light levels when needed.
- Check fluorescent lights for flicker. Replace fluorescent tubes regularly and maintain fixtures properly. Update older fixtures as new electronic ballasts have less flicker.
- Ensure that storerooms, corridors and stairways are properly lit.
- Avoid placing a computer monitor so it faces a window.

RAINWATERHARVESTING:

(i) Roof top rain water harvesting through recharge pit

- In alluvial areas where permeable rocks are exposed on the land surface or at very shallow depth, roof top rain water harvesting can be done through recharge pits.
- The technique is suitable for buildings having a roof area of 100 sq.m. and are constructed for recharging the shallow aquifers.
- Recharge Pits may be of any shape and size and are generally constructed 1 to 2 m. wide and 2 to 3 deep which are back filled with boulders (5-20 cm), gravels (5-10mm) and coarse sand (1.5- 2mm) in graded form. Boulders at the bottom, gravels in between and coarse sand at the top so that the silt content that will come with runoff will be deposited on the top of the coarse sand layer and can easily be removed. For smaller roof area, pit may be filled with broken bricks/ cobbles.
- A mesh should be provided at the roof so that leaves or any other solid waste / debris is prevented from entering the pit and a desilting /collection chamber may also be provided at the ground to arrest the flow of finer particles to the recharge pit.
- The top layer of sand should be cleaned periodically to maintain the recharge rate.
- By-pass arrangement be provided before the collection chamber to reject the first showers.

ii)Roof top rain water harvesting through recharge trench

- Recharge trenches are suitable for buildings having roof area of 200-300 sq. m. and where permeable strata is available at shallow depths.
- Trench may be 0.5 to 1 m wide, 1 to 1.5m. deep and 10 to 20 m. long depending upon availability of water to be recharge.
- These are back filled with boulders (5-20cm), gravel (5-10 mm) and coarse sand (1.5-2 mm) in graded form – boulders at the bottom, gravel in between and coarse sand at the top so that the silt content that will come with runoff will be coarse sand at the top of the sand layer and can easily be removed.
- A mesh should be provided at the roof so that leaves or any other solid waste/debris is prevented from entering the trenches and a desilting/collection chamber may also be provided on ground to arrest the flow of finer particles to the trench.
- By-pass arrangement be provided before the collection chamber to reject the first showers.
- The top layer of sand should be cleaned periodically to maintain the recharge rate.

GREEN BUILDINGS

UNIT-2

Syllabus:

Renewable Materials, FSC (Forest Stewardship Council) certification – Rapid Renewal, bamboo, eucalyptus, poplar, rubber wood, linoleum – Low energy walling; rammed earth, stabilized mud, Adobe–Post Consumer, Post Industrial Waste recycling – Hollow blocks, lime, pozzolona cements, agri residues – Ferro cement, Ferro concrete – Alternative roofing systems; Vaults, Domes High albedo paints

Learning Outcomes:

Students will be able to

- understand the importance of renewable materials
- explain the benefits of rapid renewable materials
- outline the advantages of low energy walling
- describe the applications and advantages of hollow blocks, lime, pozzolans, ferro cement
- explain the features of vaults, domes and high albedo paints

Learning Material

RENEWABLE MATERIALS

A renewable resource is a natural resource which will replenish to replace the portion depleted by usage and consumption, either through natural reproduction or other recurring processes in a finite amount of time in a human time scale.

Renewable materials used in green buildings are Bamboo, Bamboo Based Particle Board & Ply Board, Bamboo Matting, Clay roofing tiles, sun dried bricks, Gypsum Board, Tiles, Plaster, Blocks, gypsum plaster, jute fiber etc

FSC CERTIFICATION:

FSC certification is designed to guarantee customers that the FSC-labelled product they buy has come from a forest and supply chain that is managed responsibly.

Types of certification

The two types of FSC certification are:

- For forest owners and managers, forest management certification is a guarantee your processes and operations meet FSC standards;

- For businesses manufacturing or trading forest products, chain of custody certification verifies that products are handled correctly at every stage of production – from forest to shelf.

RAPID RENEWABLE MATERIALS

Rapid renewable materials are plant-based materials that can be replenished within a period of 10 years or less. Bamboo and cork are rapidly renewable materials used to create flooring materials for homes and office buildings. Bamboo is commonly used instead of woods such as oak, which is a relatively slow-growing tree. Although oak is technically a renewable resource, it takes many years for an oak tree to mature compared to bamboo.

Bamboo:

Bamboo as a building material is used for the construction of scaffolding, bridges and structures, houses.

Due to a distinctive rhizome-dependent system, bamboos are one of the fastest-growing plants in the world and their growth is three times faster than most other species of plants. They are renewable and extremely versatile resource with multi-purpose usage. Among many uses of bamboo, Housing is one of the major areas applications especially in the wake of residential shortages around the globe.

Bamboo can be shaped in the following ways

Squared cross-section can be obtained by compressing the growing stalk of bamboo within a square section.

Arch shapes of bamboo can also be created by compressing the bamboo's growth into the desired shape. This would cost lesser than it would to get the same form with normal timber.

Curved and Flat shapes of bamboo are achieved through traditional techniques like applying heat and pressure.

The various advantages of bamboo are as mentioned below:

- Tensile strength: Bamboo has higher tensile strength than steel because its fibers run axially.
- Fire Resistance: Capability of bamboo to resist fire is very high and it can withstand temperature up to 4000 C. This is due to the presence of high value of silicate acid and water.
- Elasticity: Bamboo is widely preferred in earthquake prone regions due to its elastic features.
- Weight of bamboo: Bamboos due to their low weight are easily displaced

or installed making it very easier for transportation and construction.
- Unlike other building materials like cement and asbestos, bamboo poses no danger to health.
- They are cost effective and easy to use.
- They are especially in great demand in earthquake prone areas.

Eucalyptus:

Eucalyptus wood, a fast-growing hardwood, is sustainable because new growth only takes a few years to mature.

Building with eucalyptus wood is desirable because, unlike other timbers, it has very little taper over long lengths. This quality makes it more consistent and efficient. There are more timber and less waste. And generally speaking (each Eucalyptus species is slightly different) it is harder that most North American woods.

Because eucalyptus wood is sustainable, it is now being used as an alternative to mahogany and Brazilian cherry. Both of these species are endangered, slow-growing and comparatively expensive. Building with eucalyptus wood is quickly becoming a natural choice.

Pressure treated eucalyptus poles have at least a 20-year ground burial rate.

Poplar Wood

Wood from the yellow poplar tree is often used in light construction, such as in single-family homes or storage sheds. Wood from the yellow poplar tree is also used in kitchen cabinets and doors. Since wood from the yellow poplar tree can be easily machine-worked, painted and stained, this wood is an excellent choice for furniture making as well.

Rubberwood:

- Both eco-friendly and cost effective, rubber wood is ideal for furniture, flooring, ceiling, paneling and interiors
- Treated rubber wood possess advantages like
- Excellent stability
- Excellent machining properties
- Good strength properties
- Light color; easy to finish in any color
- Good glaring properties
- Attractive grain structure
- Eco-friendly
- Up to 40% cheaper than other hardwoods

Linoleum:

Linoleum, also called Lino, is a floor covering made from materials such as solidified linseed oil (linoxyn), pine rosin, ground cork dust, wood flour, and mineral fillers such as calcium carbonate, most commonly on a burlap or canvas backing. Pigments are often added to the materials to create the desired colour finish.

LOW ENERGY WALLING:

Rammed Earth:

Rammed earth walls are constructed by ramming a mixture of selected aggregates, including gravel, sand, silt and a small amount of clay, into place between flat panels called formwork.

Traditional technology repeatedly rammed the end of a wooden pole into the earth mixture to compress it. Modern technology replaces the pole with a mechanical ram.

The many advantages of building with rammed earth include superior thermal mass, temperature and noise control, strength and durability, low maintenance, fire proofing, load bearing and pest deterrence, as well as its beauty and the pleasure of building with a natural and environmentally sound material.

Stabilized Mud:

The input of soil stabilization allowed people to build higher with thinner walls, which have a much better compressive strength and water resistance. With cement stabilization, the blocks must be cured for four weeks after manufacturing. After this, they can dry freely and be used like common bricks with a soil cement stabilized mortar.

Ideally, the production is made on the site itself or in the nearby area. Thus, it will save the transportation, fuel, time and money.

Well-designed Compressed Stabilized Earth Blocks (CSEB) houses can withstand, with a minimum of maintenance, heavy rains, snowfall or frost without being damaged. The strength and durability has been proven since half a century.

Adobe:

Adobe bricks (mud bricks) are made of earth with a fairly high clay content and straw. The produced earth mix is cast in open moulds onto the ground and then left to dry out. Adobe bricks are only sun-dried, not kiln-fired. When used

for construction they are laid up into a wall using an earth mortar. Before drying out, the finished walls are smoothed down. Often a clay render is applied as a surface coating.

As with other forms of earth construction, adobe bricks are a fireproof, durable yet biodegradable, non-toxic building material which provides sufficient thermal mass to buildings to ensure excellent thermal performance. Other benefits include low sound transmission levels through walls and a general feeling of solidity and security.

POST CONSUMER WASTE RECYCLING:

Post-consumer waste is a waste type produced by the end consumer of a material stream; that is, where the waste-producing use did not involve the production of another product.

Examples are Construction and Demolition Debris, materials collected through recycling programs, Discarded products (e.g., furniture, cabinetry, decking), and Landscaping waste (e.g., leaves, grass clippings, tree trimmings).

POST INDUSTRIAL WASTE RECYCLING:

It is a material that was discarded before it was ready for consumer use. Pre-consumer waste is the reintroduction of manufacturing scrap (such as trimmings from paper production, defective aluminum cans, etc.) back into the manufacturing process. Pre-consumer waste is commonly used in manufacturing industries and is often not considered recycling in the traditional sense.

Examples: Shavings, sawdust, walnut shells, fly ash, over-issue publications, textile clippings, obsolete inventories.

HOLLOW BLOCKS:

Hollow concrete blocks have one or more hollow cores. These cores reduce the total cross-sectional area of the block by at least 25 percent. In general, a hollow-core concrete block is more than 50 percent solid. Standard hollow concrete blocks come in full and half sizes. Full-size blocks are rectangular and have two cores. Half size blocks are cubical and have one core.

Hollow blocks are often used to build large structures like boundary fences. The reduced volume of concrete used to make each block adds up to a significant savings in cost for the materials for the whole wall. Their lighter weight also makes them easier to lift. The hollow cores also give adequate room to place reinforcing materials like steel bars if the design calls for reinforcing. Sometimes water pipes or electrical conduits are run through them.

LIME:

- Provides building breathing property– the lime was regarded as a material by the society for protection against the depletion of ancient buildings. This material let the building to be vapor permeable, thus allowing to breathe. This reduces the chances of trapped moisture and the damage of the building.
- Renders Comfortable Environment– Absorbing moisture by the lime, stabilize internal humidity
- Ecological Benefits– energy conservation than cement, small scale production of lime is possible
- Protection of adjacent materials– Porous texture of lime handle the moisture movement, without affecting the adjacent materials
- Provides good workability
- Durability is high
- Beautiful finish for the building
- Self-healing properties– Any movement of the building made of lime, creates micro-cracks. Presence of moisture make the free lime active to precipitate and heal these micro cracks

POZZOLANS:

Pozzolans are a broad class of siliceous or siliceous and aluminous materials which, in themselves, possess little or no cementitious value but which will, in finely divided form and in the presence of water, react chemically with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.

The benefits of pozzolan use in cement and concrete are threefold. First is the economic gain obtained by replacing a substantial part of the Portland cement by cheaper natural pozzolans or industrial by-products. Second is the lowering of the blended cement environmental cost associated with the greenhouse gases emitted during Portland cement production. A third advantage is the increased durability of the end product.

AGRI RESIDUES:

Wastes from agricultural activities are in very high quantities, especially in some places of the world and they are another source of environment pollution and social problems because their accumulation in landfills and uncontrolled burning.

Rice husk is generated by the rice milling process, from which 78% of weight is rice, broken rice and bran and the rest of 22% is husk. Some quantities of rice husk is burnt, which is polluting the environment. In the composition of rice husk there is nearly 20% silica, which after thermal treatment converts to a crystalline form that is with high reactivity, ultrafine size and large surface

area. Because it's high pozzolanic activity the rice husk silica is used in obtaining high strength concrete instead silica fume. The cementing properties of rice husk offer the possibility of its use in ordinary concrete as cementitious material, for replacing cement or in production of supplementary cementing material. Other uses are referred to its use as filler in polymer concrete, green concrete or in production of green building materials.

Banana leaves ashes had been studied because it's pozzolanic activity which arises from the content of amorphous silica. The banana leaf ash is obtained by burning at a controlled temperature. The use as addition in mortar and concrete for civil structures had some advantages such as a reduction of costs of building materials and the consumption of huge quantities of banana produced every year.

Bamboo leaf waste was experimentally analyzed because it's pozzolanic property which can be used for introducing this waste in cement composition. The test results shown that in composition of bamboo leaf waste the SiO2 are 78.7%., being a very reactive pozzolan, comparable to silica fume. The blended cements obtained with bamboo leaf waste in a percentage of 10 and 20% showed the same compressive strength as the witness cement.

Bagasse ash is a waste sugar factory and it is used in obtaining blended Portland cements or as replacement of cement in concrete in dosages of 10 to 30% of binder.

FERRO CEMENT:

Ferrocement is a construction material consisting of wire meshes and cement mortar. Applications of ferro cement in construction are vast due to the low self-weight, lack of skilled workers, no need of framework etc.

Advantages

- Basic raw materials are readily available in most countries.
- Fabricated into any desired shape.
- Low labour skill required.
- Ease of construction, low weight and long lifetime.
- Low construction material cost.
- Better resistance against earthquake

VAULTS:

A vault is a self-supporting arched form, usually of stone or brick, serving to cover a space with a ceiling or roof. The simplest kind of vault is the barrel vault (also called a wagon or tunnel vault), which is generally semicircular in shape. The barrel vault is a continuous arch, the length being greater than its

diameter.

DOMES:

A dome is a hollow semi-spherical structural element. However, there are many variations on this basic shape, and The 'Building Construction Handbook' describes domes as: 'Double curvature shells which can be rotationally formed by any curved geometrical plane figure rotating about a central vertical axis.'

Domes evolved from arches, originally being adapted only to small buildings such as huts and tombs; however, as construction and design techniques developed, they became more popular as a means of showcasing grand structures such as cathedrals, legislative buildings and, more recently, leisure buildings such as sports stadia.

HIGH ALBEDO PAINTS:

Heat Reflective Paint has been designed to give relief from roof heat as it is a high albedo paint having high (Solar Reflective Index)SRI value which makes it most suitable for roof insulation. This high SRI paint acts as heat reducing paint which can be applied as cool roof coating having single objective of roof insulation. Being a roof cooling and insulation paint, it will act as a protective coating and best summer cool paint. Its solar reflective properties make it one of the most suitable solar reflective paint. In the case of air-conditioned spaces, the power consumption is reduced due to the lowered temperature gradient across the slab. Roof temperatures are reduced up to 20oC depending on the material of the roof.

GREEN BUILDINGS

UNIT-3

Syllabus:

Need for energy conservation in buildings, various forms of energy used in buildings, embodied energy of materials, energy used in transportation and construction processes – Water Conservation systems in Buildings, water harvesting in buildings, waste to energy in residential complexes, Modular wastewater treatment systems

Learning Outcomes:

Students will be able to

- understand the need for energy conservation in buildings
- explain the various forms of energy used in buildings
- outline the concept of embodied energy in buildings
- illustrate the water conservation systems in buildings
- explain the features of modular wastewater treatment systems

Learning Material

NEED FOR ENERGY CONSERVATION IN BUILDINGS:

Buildings consume approximately 39% of the energy and 74% of the electricity produced annually according to the Department of Energy. Generating electricity from fossil fuels such as oil, natural gas and coal negatively affects the environment at each step of production and use beginning with extraction and transportation followed by refining and distribution and ending with consumption. For example coal mining disrupts natural habitats and can devastate landscapes. Coal is rinsed with water producing billions of gallons of sludge that must be stored in ponds. Mining itself is a dangerous occupation in which accidents and the long-term effects of breathing coal shorten the lifespans of coal miners.

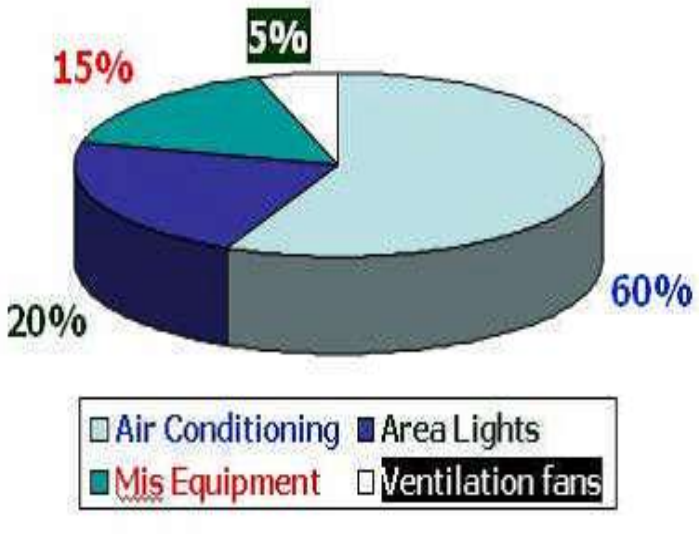
Electricity is most often generated by burning fossil fuels whose combustion releases carbon dioxide and other greenhouse gases that contribute to eliminate change. Coal-fired plants accounted for more than half of generation in 2006. Burning coal releases harmful pollutants such as carbon dioxide, sulfur dioxide and nitrogen oxides, small particulates and mercury. Each megawatt of coal-generated electricity releases into the atmosphere an average of 2,249 pounds of carbon dioxide,13 pounds of sulphar dioxide and 6 pounds of nitrogen oxides. More than 65% of the sulphar dioxide released into the air more than 13 million tons per year comes from electricity generation. Primarily coal-burning generators, mining, processing and transporting coal to power

plants create additional emissions including methane vented from the coal during transport.

Natural gas, nuclear fission and hydroelectric generators all have adverse environmental consequences as well. Natural gas is a major source of nitrogen oxide and greenhouse gas emissions. Nuclear power increases the potential for catastrophic accidents and raises significant waste transportation and disposal issues. Hydroelectric generating plants disrupt natural water flows and disturb aquatic habitats.

Green buildings address those issues in two ways. First, they reduce the amount of energy required for building operations and second, they use more benign forms of energy. The better the energy performance of a building the fewer greenhouse gases are emitted from energy production. Electricity generation using sources other than fossil fuels also reduces the environmental impacts from a building's energy use. Additionally, improved energy performance results in lower operating costs. As global competition for fuel accelerates the rate of return on energy efficiency measures improves.

VARIOUS FORMS OF ENERGY USED IN BUILDINGS:



EMBODIED ENERGY OF MATERIALS:

Embodied energy is the energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery. Embodied energy does not include the operation and disposal of the building material, which

would be considered in a life cycle approach. Embodied energy is the 'upstream' or 'front-end' component of the life cycle impact of a home.

A complex combination of many processed materials determines a building's total embodied energy.

The single most important factor in reducing the impact of embodied energy is to design long life, durable and adaptable buildings.

Every building is a complex combination of many processed materials, each of which contributes to the building's total embodied energy. Renovation and maintenance also add to the embodied energy over a building's life.

Choices of materials and construction methods can significantly change the amount of energy embodied in the structure of a building, as embodied energy content varies enormously between products and materials. Assessing the embodied energy of a material, component or whole building is often a complex task.

ENERGY USED IN TRANSPORTATION PROCESS:

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e transportation component of embodied energy is often small compared to the total embodied energy of a material, but investigations have shown that in general, oversimplifications are made when estimating this component.

It is common practice to estimate transportation energy embodied in building materials through the use of a standard consumption in MJ/tonne/km.

Material	MJ/tonne/km	Material	MJ/tonne/km
RMC Concrete	0.10	Chipboard Flooring	0.29
RMC Mortars	0.05	Plasterboard	0.24
Dense Concrete Blocks	0.02	External Plaster	0.62
High Density Blocks			0.48
Thermal Blocks			0.33
Concrete lintels			2.55
Structural Steel Beams			7.92
Steel Shuttering			49.24
Concrete Reinforc			1.34
Roofing timber	0.15		

Country	MJ/tonne/km
Canada	1.18
Denmark	1.44
UK	4.50
USA	2.13

ENERGY USED IN CONSTRUCT	Main activities	Sub-activities	Total power	Unit
	Builders moving to site	Diesel for transportation	12	Litre
		Crane operation	206,000	kWh
		Computers (200 watt)	1500	kWh
		Printer (350 watt)	175	kWh
		Air conditioner (1000 watt)	5000	kWh
		Telephone (10 watt)	25	kWh
		Lighting (100 watt)	2,500	kWh
	Fencing around the site	Fences	24	Litre
		Tree chipper	240	Litre
	Site clearing	Transfer/removal of green waste	250	Litre
		Levelling	500	Litre
	Excavation and filling	Diesel for transportation	12	Litre
		Operation of excavator	1000	Litre
	Installing tower crane	Installation by crane	1030	kWh
		Operation	38,250	kWh
	Concrete pouring	Diesel for Ready mix truck	1456	Litres
		Concrete pump	59	Litres
		Operation	7175	kWh
	Precast concrete	Diesel for transporting materials	102	Litre
			6180	kWh
	Mortar preparation	Diesel for transport	12	Litres
		Operation	8250	kWh
	Waste removal		48	Litre

ION PROCESS:

WATER CONSERVATION SYSTEMS IN BUILDINGS:

1. Efficient water use during construction

The objective is to minimize use of potable water during construction activity.

Controlling wastes of curing water

To avoid wastage of curing water, follow the following guidelines.

- Curing water should be sprayed on concrete structures; free flow of water should not be allowed for curing.
- After liberal curing on the first day, all concrete structures should be painted with curing chemical to save water.This will stop daily water curing hence save water.
- Concrete structures should be covered with thick cloth/gunny bags and then water should be sprayed on them. This would avoid water rebound and will ensure sustained and complete curing.
- Ponds should be made using cement and sand mortar to avoid water flowing away from the flat surface while curing.
- Water ponding should be done on all sunken slabs, this would also highlight the importance of having an impervious formwork.

2.Reduce the water use by the building plumbing system

The objective is To reduce the water consumption in the building by using efficient fixtures

Best practices

1) Use of efficient plumbing fixtures, sensors, auto valves, pressure reducing device wherever possible can result in significant reduction in water consumption

2) Water efficient fixtures

- Conventional toilets use 13.5 litres of water per flush. Low flush toilets are available with flow rate of 6.0 litres and 3.0 litres of water per flush.
- Dual flush adapters can be used for standard flushing for solid waste and a modified smaller flush for liquid waste.
- Flush valves with 20–25 mm inlets can be used for restricting the water flow

- Composting toilets
- Water-efficient urinals

The conventional urinals use water at a rate of 7.5–11 litres per flush. Use of electronic flushing system or magic eye sensor can further reduce the flow of water to 0.4 litres per flush. Waterless urinals use no water.

3) Auto control valves

Installation of magic eye solenoid valve (self-operating valves) can result in water savings. The sensor taps has automatic on and off flow control. It is not only convenient and hygienic but also an excellent water saving device that can work under normal water pressure. It functions with parameters such as distance and timing.

4) Pressure reducing device

Aerators and pressure inhibitors for constant flow. Use of aerators can result in flow rates as low as 2 litres per minute, which is adequate for hand wetting purpose. Installation of flow regulators is done where the aerators cannot be installed.

5) Other means of reducing water for flushing toilets is to use composting toilets. Composting toilets is based on the biological process of conversion of the solids present in the human waste into enriched manure. This consists of two underground pits. Over one to two years, the first pit will be filled with waste. During this time, bacteria digest the sludge. After two years of digestion, the contents are odourless and safe to handle, and perfect to be used as soil fertilizer. The second pit is used when the first is full.

3. Reduce landscape water requirement

The objective is To reduce the landscape water requirement for so as to minimize the load on the municipal water supply and depletion of groundwater resources.

Best practices to reduce water usage for landscaping

Xeriscaping

Xeriscape means the conservation of water and energy through creative landscaping. This word is derived from the Greek word *Xeros* meaning dry and these plants can live, once established, with little or no supplemental watering.

- Some are drought tolerant**.** It is recommended that:
- The landscape should be a mix of native shrubs and xeriscape plants.
- Reduce the lawn area, and plant more of trees that require no water after establishment.
- Plant palm trees which are xerophytic such as *Phoenix dactylifera, Yucca starlite*.
- Use ground covers such as *Asparagus sprengeri*, which is succulent, *Pandanus* dwarf which is xerophytic, and Bougainvillea which is a climber.

Drip irrigation

Drip irrigation system or sub-surface drip irrigation system results in saving of water as it avoids loss of water due to run-off, deep percolation, or evaporation.

Sprinkler irrigation

Sprinkler irrigation is a method similar to natural rainfall in which water is distributed through a system of pipes. For
maintaining uniform distribution of water, the pump supply system, sprinklers and operating conditions must be designed appropriately. Sprinklers are most suited to sandy soils with high infiltration rates. The average application
rate should be less than the basic infiltration rate of the soil so as to avoid surface ponding and run-off. It is better to use sprinklers that produce fine sprays and not those that produce larger water droplets.

WATER HARVESTING IN BUILDINGS:

Rain water naturally soft,contains almost no dissolved minerals of salts and therefore,reduces water conditioning costs involved in softening, de-mineralising, reverse osmosis treatment etc.

Rain water harvesting and localized utilization results in energy savings,since the energy input required to operate a central water system designed to treat and pump water over a vast service area,is bypassed.

Water accessibility is easier,since it is harvested at the concerned site itself. Increased independence and water security.

Ground water recharging can be instrumental in reducing the concentration of the salts in the ground water by dilution.This recharging acts as potential resource for future withdrawals.

Reducing the demand for waste water supply from external sources.

It can be used in individual processes like cooling towers and steam generation,with reduced blow down quantities.

Design systems of Rain water Harvesting

1. Filtration followed by ground water re-charge bore wells
2. Direct infiltration through re-charge through trenches
   Filtration followed by ground water re-charge through bore wells are common methods for areas of Raw material yards, Roads and pavement,Unpaved area and Paved area.
   Direct infiltration through is good for landscape gardens and green belt.

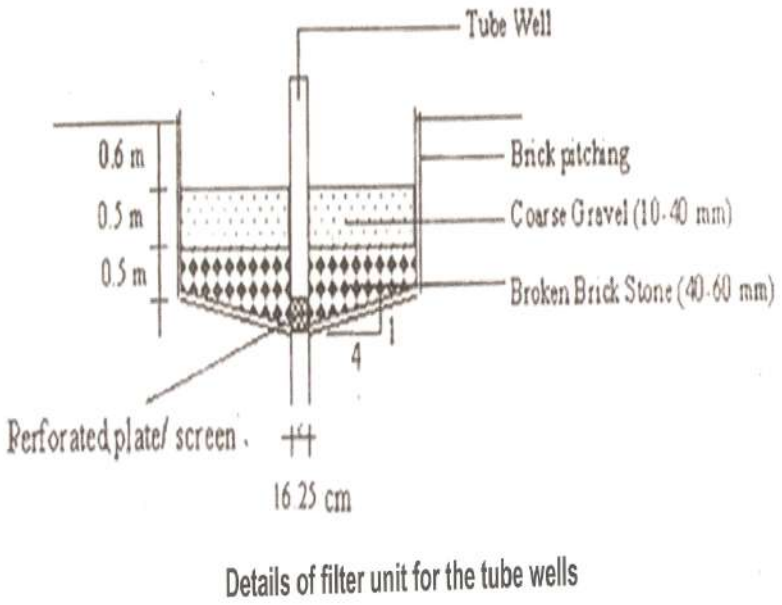
Design of filters

The filter unit is provided for removal of Suspended solids of rainwater

normally picked up during its run-off.The design criteria is

1. Total quantity of rainwater available from root tops=36.0 m^3/hour
2. Rate of filtration 15.00 m^3/m^2/hour and coarse gravel of 10 to 40 mm (0.5 mm depth)and broken brick stone of 40 to 60 mm(0.5m depth).A water depth above the filter media is normally kept 0.6m.
3. Area of filter(s)required=7.62m^2
4. Size of the filter=2.8 m x 2.8 m

A general view of the filter unit attached to tube wells is shown below



Details of filter unit for the tube wells

Building court-yard water

It is a simple technique of caching rainwater and storing it in underground aquifers.

Rain water collected from the court-yard of a building is diverted by drain pipes to a re-charge structure an efficient rainwater harvesting structure should be able to direct clean rainwater runoff to the groundwater in the active aquifer of the area and should have the capacity to hold at least the runoff generated in one hour of high intensity rainfall.

The depth of the borewell may be decided based on the depth and thickness of the wealthered formation/granular zone(receptive to water)and should always be kept above the post monsoon water level.Abandoned/dried borewells can also be used for recharge.

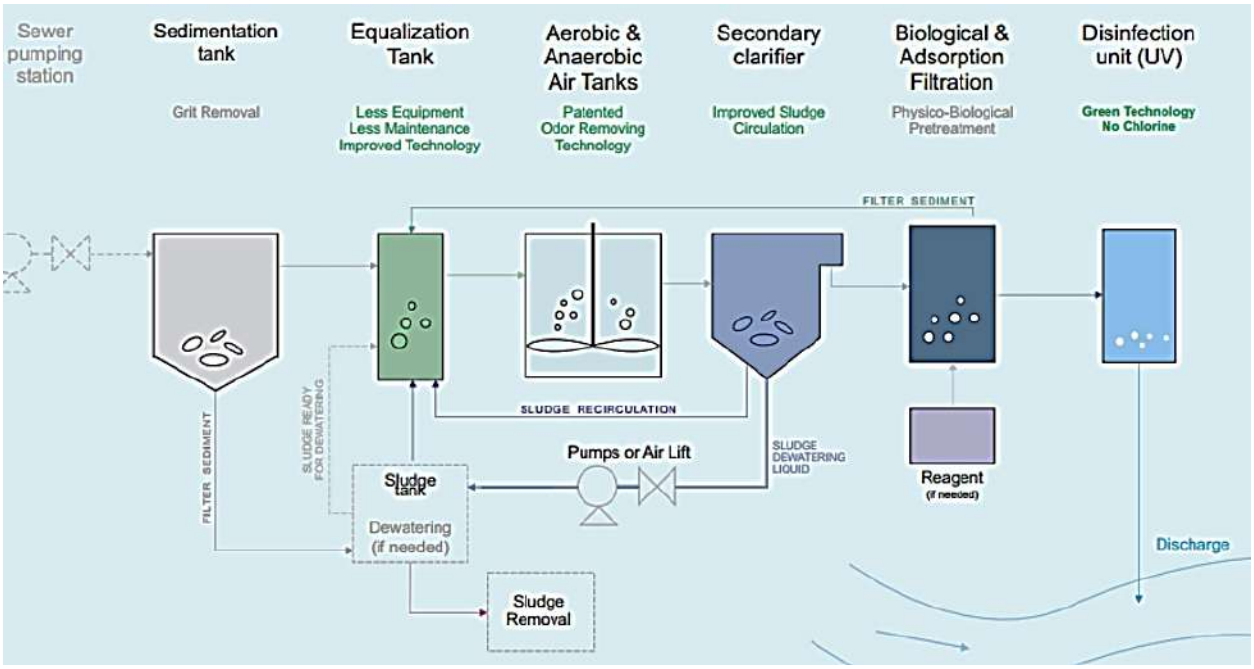
WASTE TO ENERGY IN RESIDENTIAL COMPLEXES:

The major Objective is to maximize the recovery of resources from the recyclable and biodegradable waste and to reduce the burden on landfills.
The municipal solid wastes contain useful resources that can be recovered after recycling or after biological processing. Recycling and further processing would reduce the waste going to landfills and is beneficial due to the resource generation.
Most non-biodegradable wastes such as plastics, old papers, newspapers, glass, cardboard, metal scraps etc. can be recycled. Biodegradable waste such as food waste, horticulture, and other organic wastes can be processed through techniques such as composting or anaerobic digestion. In case of processing of paper, waste paper is converted into sheets of recycled paper, which can be sold to newspaper agencies. Glass and plastics can be converted into various household goods.
Horticulture wastes such as grass trimmings, leaves, and vegetable wastes can be composted in pits or heaps.
Sufficient care should be taken to prevent pollution due to leachate generation, odour, flies, and bird menace by providing cover to the area. The compost generated should meet the standards prescribed in Management and Handling Rules, 2000 of MoEF.
Food wastes and other organic wastes including the garden wastes can also be processed through anaerobic digestion to generate biogas that can be used for cooking applications in place of liquefied petroleum gas. In addition,the digested sludge from the biodigester has a good manure value.

MODULAR WASTE TREATMENT PLANT:
Advantages:

- Idea for sites where water reuse is premium.
- Advanced environmental protection equipment to achieve quality discharge.
- High removal efficiency for nitrogen, BOD & COD,
- Fewer process to achieve comparable effluent quality.
- Eliminate Sludge ability Issues.
- Small Foot Prints.
- Reduce sludge yield

Layout:


Sewer pumping station
Sedimentation tank
Grit Removal
Equalization Tank
Less Equipment
Less Maintenance
Improved Technology
Aerobic & Anaerobic Air Tanks
Patented Odor Removing Technology
Secondary clarifier
Improved Sludge Circulation
Biological & Adsorption Filtration
Physico-Biological Pretreatment
Disinfection unit (UV)
Green Technology
No Chlorine
FILTER SEDIMENT
SLUDGE RECIRCULATION
SLUDGE READY FOR DEWATERING
FILTER SEDIMENT
Pumps or Air Lift
SLUDGE DEWATERING LIQUID
Sludge tank
Dewatering (if needed)
Reagent (if needed)
Discharge
Sludge Removal

UNIT -4
NET-ZERO ENERGY BUILDINGS

Introduction:

Amid growing concerns about rising energy prices, energy independence, and the impact of climate change, statistics show buildings to be the primary energy consumer. This fact underscores the importance of targeting building energy use as a key to decreasing the nation's energy consumption. The building sector can significantly reduce energy use by incorporating energy-efficient strategies into the design, construction, and operation of new buildings and undertaking retrofits to improve the efficiency of existing buildings. It can further reduce dependence on fossil fuel derived energy by increasing use of on-site and off-site renewable energy sources.

The concept of a Net Zero Energy Building (NZEB), one which produces as much energy as it uses over the course of a year, recently has been evolving from research to reality. Currently, there are only a small number of highly efficient buildings that meet the criteria to be called "Net Zero". As a result of advances in construction technologies, renewable energy systems, and academic research, creating Net Zero Energy buildings is becoming more and more feasible.

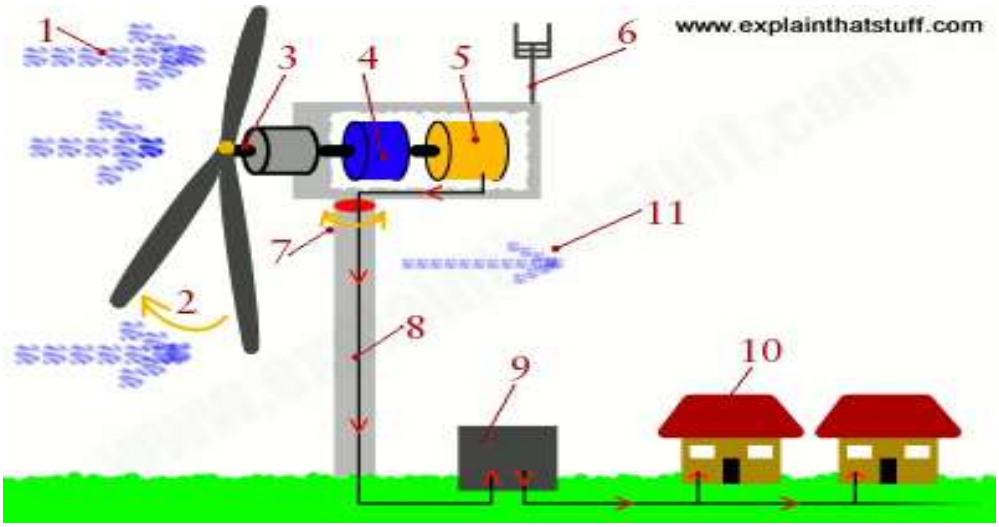
Generally speaking, a zero energy building produces enough renewable energy to meet its own annual energy consumption requirements, thereby reducing the use of non-renewable energy in the building sector.

wind energy or wind power:

Wind energy refers to capturing the energy from moving air, i.e., wind, and converting it into electricity

How does a wind turbine work?

1. Wind (moving air that contains kinetic energy) blows toward the turbine's rotor blades.
2. The rotors spin around, capturing some of the kinetic energy from the wind, and turning the central drive shaft that supports them. Although the outer edges of the rotor blades move very fast, the central axle (drive shaft) they're connected to turns quite slowly.
3. In most large modern turbines, the rotor blades can swivel on the hub at the front so they meet the wind at the best angle (or "pitch") for harvesting energy. This is called the pitch control mechanism. On big turbines, small electric motors or hydraulic rams swivel the blades back and forth under precise electronic control. On smaller turbines, the pitch control is often completely mechanical. However, many turbines have fixed rotors and no pitch control at all.
4. Inside the nacelle (the main body of the turbine sitting on top of the tower and behind the blades), the gearbox converts the low-speed rotation of the drive shaft (perhaps, 16 revolutions per minute, rpm) into high-speed (perhaps, 1600 rpm) rotation fast enough to drive the generator efficiently.
5. The generator, immediately behind the gearbox, takes kinetic energy from the spinning drive shaft and turns it into electrical energy. Running at maximum capacity, a typical 2MW turbine generator will produce 2 million watts of power at about 700 volts.
6. Anemometers (automatic speed measuring devices) and wind vanes on the back of the nacelle provide measurements of the wind speed and direction.
7. Using these measurements, the entire top part of the turbine (the rotors and nacelle) can be rotated by a yaw motor, mounted between the nacelle and the tower, so it faces directly into the oncoming wind and captures the maximum amount of energy. If it's too windy or turbulent, brakes are applied to stop the rotors from turning (for safety reasons). The brakes are also applied during routine maintenance.
8. The electric current produced by the generator flows through a cable running down through the inside of the turbine tower.
9. A step-up transformer converts the electricity to about 50 times higher voltage so it can be transmitted efficiently to the power grid (or to nearby buildings or communities). If the electricity is flowing to the grid, it's converted to an even higher voltage (130,000 volts or more) by a substation nearby, which services many turbines.
10. Homes enjoy clean, green energy: the turbine has produced no greenhouse gas emissions or pollution as it operates.
11. Wind carries on blowing past the turbine, but with less speed and energy (for reasons explained below) and more turbulence (since the turbine has disrupted its flow).



Pros:

- Very low carbon dioxide emissions (effectively zero once constructed).
- No air or water pollution.
- No environmental impacts from mining or drilling.
- No fuel to pay forever
- Completely sustainable—unlike fossil fuels, wind will never run out.
- Turbines work almost anywhere in the world where it's reliably windy, unlike fossil-fuel deposits that are concentrated only in certain regions.
- Unlike fossil-fuel power, wind energy operating costs are predictable years in advance.
- Freedom from energy prices and political volatility of oil and gas supplies from other countries.
- Wind energy prices will become increasingly competitive as fossil fuel prices rise and wind technology matures.
- New jobs in construction, operation, and manufacture of turbines.

Cons:

- High up-front cost (just as for large nuclear or fossil-fuel plants).
- Economic subsidies needed to make wind energy viable (though other power forms are subsidised too, either economically or because they don't pay the economic and social cost of the pollution they make).
- Extra cost and complexity of balancing variable wind power with other forms of power.
- Extra cost of upgrading the power grid and transmission lines, though the whole system often benefits.
- Variable output though that problem is reduced by operating wind farms in different areas and (in the case of Europe) using interconnectors between neighbouring countries.
- Large overall land take though at least 95 percent of wind farm land can still be used for farming, and offshore turbines can be built at sea.
- Can't supply 100 percent of a country's power all year round, the way fossil fuels, nuclear, hydroelectric, and biomass power can.
- Loss of jobs for people working in mining and drilling.

Types of Wind Turbines:

On the basis of axis of rotation of the blades, it is divided into two parts.

1. Horizontal axis wind turbine (HAWT)
2. Vertical axis wind turbine (VAWT)

Horizontal Axis Wind Turbine (HAWT):

It is a turbine in which the axis of rotation of rotor is parallel to the ground and also parallel to wind direction.

They are further divided into two types
(i) Upwind turbine
(ii) Downwind turbine

Upwind Turbine:

- The turbine in which the rotor faces the wind first are called upwind turbine.
- Today most of the HAWT is manufactured with this design.
- This turbine must be inflexible and placed at some distance from the tower.
- The basic advantage of this turbine is that, it is capable of avoiding wind shade behind the tower.
- It requires yaw mechanism, so that its rotor always faces the wind.

Downwind Turbine:

- The turbine in which the rotor is present at the downside of the tower is called downwind turbine. In these types of wind turbines, the wind first faces the tower and after that it faces the rotor blades.
- Yaw mechanism is absent in this turbine. The rotors and nacelles are designed in such a way that the nacelle allows the wind to flow in a controlled manner.
- It receives some fluctuation in wind power because here the rotor passes through the wind shade of the tower. In other words the rotor is present after nacelle of the tower and this create fluctuation in the wind power.

Advantages and Disadvantages of HAWT:

The various advantages and disadvantages of the horizontal axis types of wind turbines are:

Advantages:

- It has self-starting ability. It does not require any external power source to start.
- It has high efficiency as compared with the HAWT.
- Capable of working in high wind speed condition.
- In the case of slow wind condition, its angle of attack can be varied to get maximum possible efficiency.
- Since all blades of this turbine work simultaneously, so it is capable of extracting maximum energy form the wind.

Disadvantages:

- Its initial installation cost is high.
- It requires large ground area for its installation.
- Because of its giant size of blades and towers, it becomes difficult to transport it to the sites.
- High maintenance cost.
- Creates noise problem.
- It cannot be installed near human population.
- It is not good for the bird's population. They are killed by its blades rotation.

Vertical Axis Wind Turbine (VAWT):

It is a turbine in which the axis of rotation of the rotor is perpendicular to the ground and also perpendicular to the wind direction.

- It can operates in low wind situation.
- It is easier to build and transport.
- These types of Wind turbines are mounted close to the ground and are capable of handling turbulence in far better way as compared with the HAWT.
- Because of its less efficiency, it is used only for the private purpose.

VAWTsare further classified as
(i) Darrieus turbine
(ii).Giromill turbine
(iii) Savonius turbine

(i) Darrieus Turbine
Darrieus turbine is type of HAWT. It was first discovered and patented in 1931 by French aeronautical engineer, Georges Jean Marie Darrieus. It is also known as egg beater turbine because of its egg beater shaped rotor blades.

- It consists of vertically oriented blades which are mounted on a vertical rotor. It is not a self-starting turbine and hence a small powered motor is required to start its rotation.
- First the Darrieus turbine is rotated by using a small powered motor. Once it attains sufficient speed, the wind flowing across its blades generates lift forces and this lift forces provides the necessary torque for the rotation. As the rotor rotates, it also rotates the generator and electricity is produced.

(ii) Giromill Turbine:

- It is similar to the Darrieus turbine but the difference is that, it has H-shaped rotor. It works on the same principle of Darrieus turbine.
- This turbine has H- shaped rotor. Here Darrieus design which has egg beater shaped rotor blades are replaced by straight vertical blades attached with central tower with horizontal supports. It may consists of 2-3 rotor blades.
- Giromill turbine is cheap and easy to build as compared with Darrieus turbine. It is less efficient turbine and requires strong wind to start. Same as darrieus types of wind turbines, it is also not self-starting and requires small powered motor to start. It is capable of working in turbulent wind conditions.

(iii) Savonius Turbine

- Savonius turbine is HAWT. It was first discovered in 1922 by a Finnish Engineer Sigurd Johannes Savonius. It is one of the simplest turbine among all known turbines.
- It is a drag-type device and consists of two or three scoops. If we look it from above than it looks 'S' shape in cross section. The scoops of these turbines have curvature shape and because of that, it experiences less drag when it moves against the wind instead of moving with the wind.
- Since it is a drag-type machine, it is capable of extracting very less amount of wind power as compared with other similar sized lift-type turbines.

Difference between Horizontal Axis Wind Turbine and Vertical Axis Wind Turbine

The various difference between horizontal axis and vertical axis types of wind turbines in tabular form are given below:

S.no	Horizontal Axis Wind Turbine	Vertical Axis Wind Turbine
1.	In HAWTs, the axis of rotation of the rotor is Horizontal to the ground.	In VAWTsthe axis of rotation of the rotor is perpendicular to the ground.
2.	Yaw mechanism is present.	Absence of Yaw mechanism.
3.	It has high initial installation cost.	It has low initial installation cost.
4.	They are big in size.	They are small in size.
5.	Its efficiency is high.	It has low efficiency.
6.	It requires large ground area for installation.	It requires less ground area for installation.
7.	High maintenance cost.	Low maintenance cost as compared with HAWT.
8.	They are self-starting.	They are not self-starting.
9.	They are unable to work in low wind speed	They are capable of working in low wind speed

	condition.	condition.
10.	Difficult in transportation.	Easy in transportation.
11.	They are mostly used commercially.	They are mostly used for private purpose only.
12.	It cannot be installed near human population.	It can be installed near human population.
13.	It is not good for the bird's population.	It is good for the bird's population.

Micro wind turbine:

The installation of a micro-wind turbine usually consists of the turbine and an inverter. Wind causes the blades of the wind turbine to rotate, generating mechanical energy. The mechanical energy from the rotation is converted to direct current (DC) in the turbine and using the inverter, is converted to alternating current (AC). The inverter output is connected to a breaker panel where the electricity can be shared among the electrical equipment in the home. Excess electricity can be exported from the home to the electrical grid using a bidirectional meter and credits will be provided accordingly by the retailer based on the electric current tariff for electricity.

Wind energy potential and status in Andhra Pradesh and in India:

The production of power from wind energy has considerably increased in the recent years. Very recently in June this year, India became the fourth largest country with 34.293 gigawatt of installed wind power capacity in the world.

Tamil Nadu produces almost 29 percent of wind power in India, which is the highest among the states engaged in the generation of wind power. With the highest installed wind capacity, the state is home to Muppandal wind farm, the biggest wind power plant located in India. This wind farm situated in the Kanyakumari district of Tamil Nadu has a capacity of generating 1500 megawatt of power. The state's wind turbines have a total installed capacity of 7.9 gigawatt which makes it a world leader in renewable energy. India has largest windmills facilities and the location are Tamil Nadu windfarm at Tuticorin, Coimbatore, Kanyakumari, Thirunelveli and Tiruppur.

Currently, the maximum renewable power in Tamil Nadu is generated from wind turbines which constitutes more than two-thirds of the total renewable power. The Institute for Energy Economics and Financial Analysis (IEEFA) has predicted that Tamil Nadu will double its wind-power capacity to 15 gigawatt by 2027.

In 2017, India introduced 5.5GW of wind-power capacity,1.5 gigawatt more than the estimated target. As per the predictions of the World Resources Institute, if the country continues to function at the current installation rates, it will definitely be successful in doubling its wind-power capacity to about 60 gigawatt by 2022. With this, India will stand among the elite producers of wind energy in the world.

Other well known windfarms or windmills in India are located at Sangli and Satara District of Maharashtra, Kayathar, Tirupur, Kanyakumari, Kethanur in Tamil Nadu and Dewas Wind Farm in Madhya Pradesh

The other five Indian states which contribute to wind-power capacity after Tamil Nadu are-

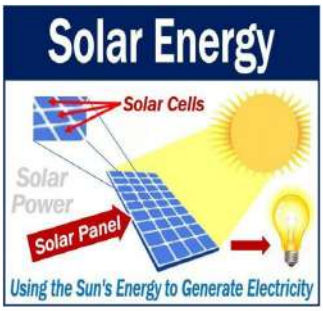
1. Andhra Pradesh- 2.2 gigawatt
2. Gujarat- 1.3 gigawatt
3. Karnataka- 882 megawatt
4. Madhya Pradesh- 357 megawatt
5. Rajasthan- 888 megawatt

Anantapur: The government of Andhra Pradesh has identified 32 locations in the State which are suitable for setting up wind energy plants. While 25 locations are in Anantapur, the remaining seven places are located in the districts of Kurnool, Nellore, Kadapa and Visakhapatnam. Anantapur has acquired the tag of non-conventional energy hub with promoters making a beeline to invest in the district.

Andhra Pradesh is already the largest producer of wind energy state of India and working towards the installation of wind farm. Penukonda and Nallakonda wind farm in Andhra Pradesh are two large windmill farms in Andhra Pradesh.

.Solar energy:

Solar energy refers to capturing the energy from the Sun and subsequently converting it into electricity. We can then use that electricity to light up our homes, streets, and businesses, and power our machines as well. We can also use the term solar power with the same meaning.



How does solar energy work?

A photon is a basic unit that makes up all light; it is a bundle of electromagnetic energy. When photons strike a solar cell, they loosen electrons from their atoms. If we attach a conductor to a cell's negative and positive sides, we have an electrical circuit. When the electrons flow through the circuit, they generate electricity.

Solar panel – solar cell – solar array

Solar panels (solar modules) consists of many **solar cells**. When there are many panels wired up together, we have a **solar array**.

The amount of electricity a solar panel produces depends on three factors:

- Its size.
- The efficiency of the solar cells within that panel.
- How much sunlight hits the solar panel.

Solar energy – renewable energy

Solar energy is renewable energy. Renewable energy is energy whose source never runs out. We can never use up the energy source completely.

Solar energy, wind energy, and geothermal energy, for example, have renewable sources of energy in a human timescale. The energy from the Sun, in our personal timescale, never runs out. Wind is always there, and heat from below Earth's surface (geothermal energy) is continuous.

Generating electricity when it's cloudy

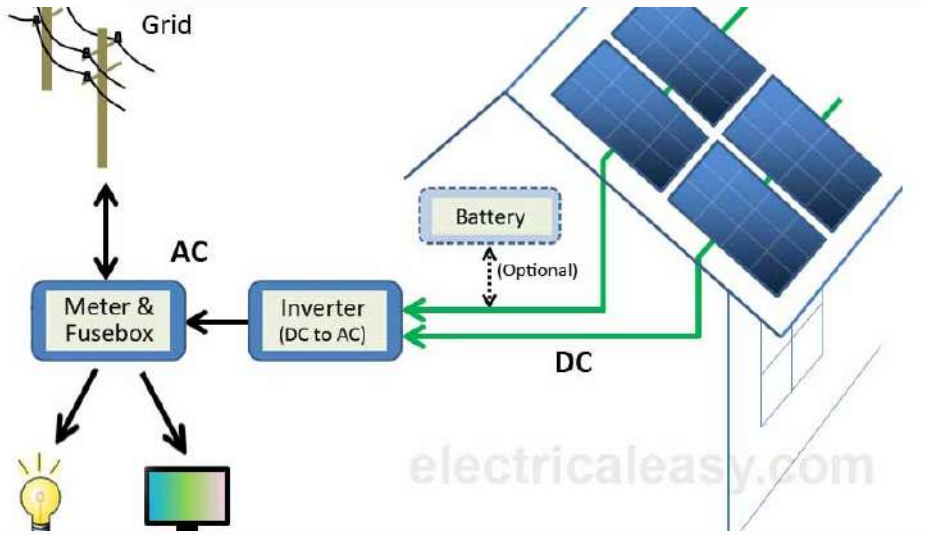
Solar power electricity systems or **photovoltaics** (PV) do not need direct sunlight to work. Even on a cloudy day, they can still generate electricity.

Solar energy – benefits

- **Sunlight is free**. Therefore, as soon as you have paid for the initial installation, your electricity costs are virtually free.
- The UK government has a Feed-in Tariff scheme. The scheme pays people for the electricity they generate, even if they use it. Many countries across the world have similar schemes.
- **Sell electricity** to the grid. The electricity grid will pay households for the electricity that they export through the UK's Feed-in Tariff scheme. Similar schemes also exist in other countries.
- **Lower carbon footprint**. Solar energy is a green renewable energy. It does not release carbon dioxide and other gases that contribute to climate change.

Solar Photovoltaic energy:

The process of solar energy conversion, the sun releases photons. When this sunlight hits the semi-conductor metal of the photovoltaic panels, electrons are released, which is what creates direct current electricity. Solar panels are made up of hundreds of photovoltaic cells, which are most often composed of silicon as the semi-conductor. When sunlight hits the cells, electrons are released from the movement of the atoms. The interaction between the photons released from the sun and the electrons released from the solar cell are what creates the direct current of electricity. the PV cells convert sunlight into direct current (DC) and an inverter connected to the system is what converts direct current into alternating current (AC) – which is the type of current needed to power your household appliances. Metal conductor plates located within the solar panel are the mechanisms used to allow the electric current to travel through wires. Once moving freely through the wires, the current will power your house, like other sources of electricity. This power runs through your electrical panel box, just like electricity you get from the grid, and you can potentially run your entire house on solar power than power taken from the grid.

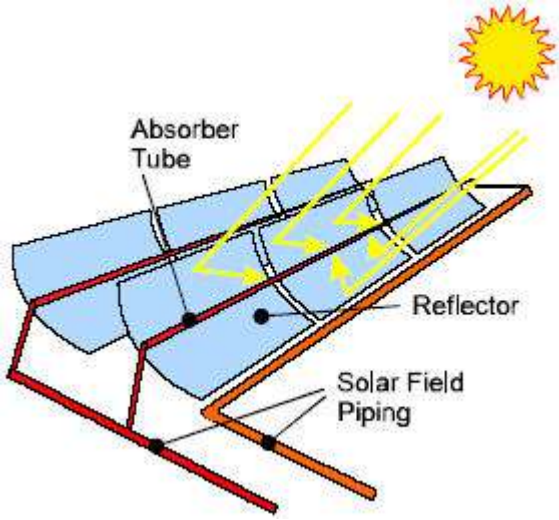


Concentrating solar power energy:

Concentrating solar power technologies use different mirror configurations to concentrate the sun's light energy onto a receiver and convert it into heat. The heat can then be used to create steam to drive a turbine to produce electrical power or used as industrial process heat. They can integrate thermal energy storage systems to use to generate electricity during cloudy periods or for hours after sunset or before sunrise. These attributes, make concentrating solar power the most attractive renewable energy option in the world's sunbelt regions. There are four types of CSP technologies used, with the earliest in use being trough, For each

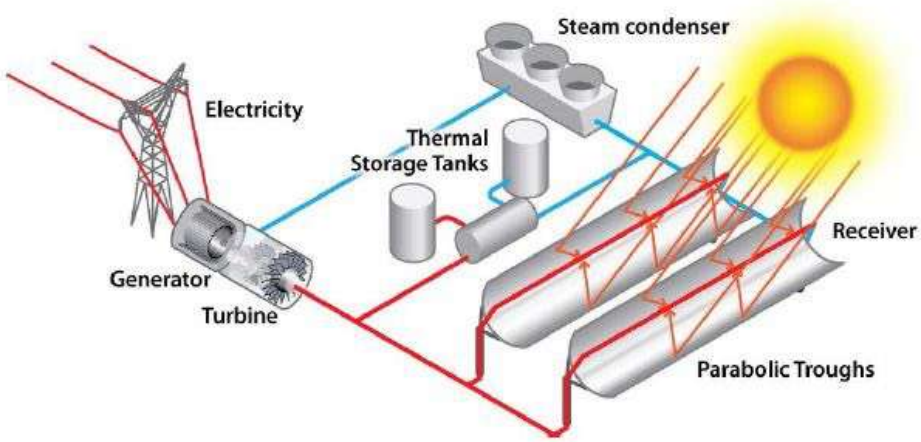
of these, there are various design variations or different configurations, depending on whether thermal energy storage is included. Most popular parabolic troughs.

Parabolic Trough Systems:



The sun's energy is concentrated by parabolically curved, trough-shaped reflectors onto a receiver pipe running along the inside of the curved surface. The temperature of the heat transfer fluid flowing through the pipe, usually thermal oil, is increased from 293ºC to 393ºC, and the heat energy further drive in to exchanger, exchanger produces steam and then steam passed through generator which converts it in to electricity.

A collector field comprises many troughs in parallel rows aligned on a north-south axis. This configuration enables the single-axis troughs to track the sun from east to west during the day to ensure that the sun is continuously focused on the receiver pipes.



Solar thermal energy:

Solar thermal power plants are electricity generation plants that utilize energy from the Sun to heat a fluid to a high temperature. This fluid then transfers its heat to water, which then becomes superheated steam. This steam is then used to turn turbines in a power plant, and this mechanical energy is converted into electricity by a generator. These systems use solar collectors to concentrate the Sun's rays on one point to achieve appropriately high temperatures.
Example: CSP

Types of solar power:

There are two main categories of solar power technologies: active solar and passive solar.

Active solar technologies are used to directly convert solar energy into another form of useful energy, such as electricity or heat conversion

- Concentrating solar power (CSP)
- Solar Photovoltaic (PV) energy
- Solar heating and cooling

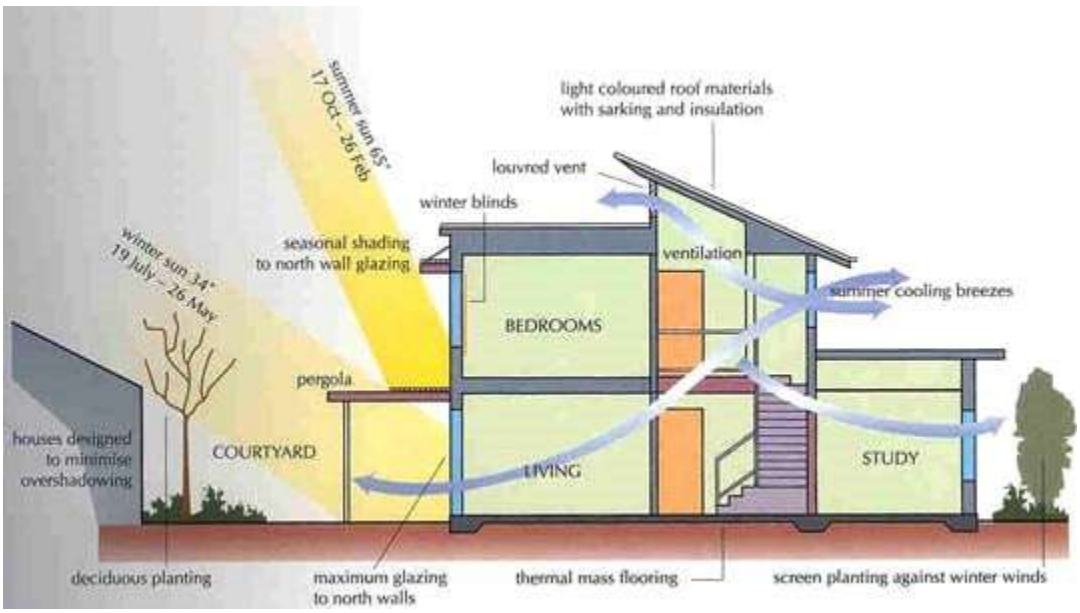
Solar heating and cooling : Solar heating and cooling technologies collect the thermal energy from the sun and use this heat to provide hot water, space heating, cooling and pool heating for residential, commercial and industrial applications. These technologies displace the need to use electricity or natural gas.

Solar Water Heating: The solar collector gathers the heat from solar radiation and transfers the heat to potable water. This heated water flows out of the collector to a hot water tank, and is used as necessary. Auxiliary heating can remain connected to the hot water tank for back-up if necessary.

Solar space heating: Solar space heating systems are similar to solar water heating systems, but generally involve more solar collectors, larger storage units, and a more sophisticated design. These heating systems can use a non-toxic liquid, water, or air as the heat-transfer medium from the solar collector. The heated liquid or air is then circulated throughout the building or home to provide space heating.

Solar cooling: it can be done by desiccant system. In a desiccant system, air passes over a common desiccant or "drying material" such as silica gel to draw moisture from the air and make the air more comfortable. The desiccant is regenerated by using solar heat to dry it out.

Passive solar : The main concept of passive solar buildings is that its building elements i.e. the windows, walls and the floors are made able to collect solar energy and store them. This energy is then used in the winter for warmth and used to reject the heat during the summer seasons.



The buildings convert the solar energy into useful energy without the help of any other mechanical system.

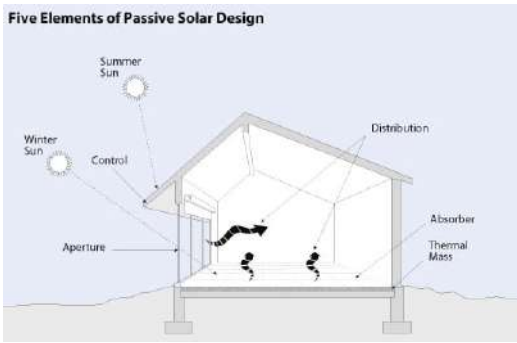
The passive solar buildings work based on the following principles:

- The first principle is based on the route of the sun in different seasons. The sun in winter will be traveling in a lower route compared to summer.
- In winter, the south direction faced glass will help in energy absorption and storage in the building.
- The location of thermal mass in a position enabling easy absorption of solar energy later would help in the easy release of the same during evening time.
- The direct sun can be resisted by overhanging elements as shown in the figure below. These are also called control elements.

- Proper insulation enables warmth in winter and coolness in summer

The main elements considered are:

- Room types, internal doors, walls and furniture in buildings and their placement.
- The Equator faced orientation for the building
- Building dimension extension in east-west direction
- Window size fixed to get adequate solar in winter and shade in summer.
- Windows in the west are avoided.
- Use of thermal mass like floors or walls



The five elements of passive solar design:

- Passive solar **aperture** (admitting sunlight/solar energy)
- Passive solar energy **control** (seasonal needs)
- Passive solar heat/energy **distribution** through the building
- Passive solar **absorber** to surface absorption of energy for later release
- Passive solar **thermal mass** providing heat storage

Aperture (Collector):

The large glass (window) area through which sunlight enters the building. Typically, the aperture(s) should face within 30 degrees of true south and should not be shaded by other buildings or trees from 9 a.m. to 3 p.m. each day during the heating season

Absorber

The hard, darkened surface of the storage element. This surface—which could be that of a masonry wall, floor, or partition (phase change material), or that of a water container—sits in the direct path of sunlight. Sunlight hits the surface and is absorbed as heat.

Thermal mass

The materials that retain or store the heat produced by sunlight. The difference between the absorber and thermal mass, although they often form the same wall or floor, is that the absorber is an exposed surface whereas thermal mass is the material below or behind that surface.

Distribution

The method by which solar heat circulates from the collection and storage points to different areas of the house. A strictly passive design will use the three natural heat transfer modes conduction, convection, and radiation exclusively. In some applications, however, fans, ducts, and blowers may help with the distribution of heat through the house

control

Roof overhangs can be used to shade the aperture area during summer months. Other elements that control under- and/or overheating include electronic sensing devices, such as a differential thermostat that signals a fan to turn on; operable vents and dampers that allow or restrict heat flow, low-emissivity blinds, and awnings.

solar energy potential and status in Andhra Pradesh and in India:

Solar power in India is the country's fastest developing industry going to be world's largest installed

solar-power capacity country. Solar thermal storage power, Hybrid solar plants and Solar heating technology generates the during the summer months in India.

Andhra Pradesh**:**

Andhra Pradesh state is home to world's largest solar power plant in Kurnool district. The state also has Ananthapur Ultra Mega Solar Park and produce 2,138.82 MW of solar power.

Rajasthan:

Rajasthan is known as most solar developed state of India and also home to the worlds largest Fresnel type plant in Dhirubhai Ambani Solar Park along with Bhadla Solar Park in Jodhpur district as well as solar park in Jaisalmer and Bikaner. Jaisalmer also has one of the largest wind farm in India.

Tamil Nadu:

Tamil Nadu has the highest installed solar power capacity in India. Kamuthi Solar Power Project near Madurai is the world's second largest solar park. The state of Tamil Nadu is also the largest producer of Wind Energy in India.

Gujarat:

Gujarat is India's most solar developed state and a leader in solar power generation in India. The state has one of the largest solar park in Patan district and first state to commissioned Canal Solar Power Project on the Narmada Canal.

Maharashtra:

Maharashtra has some of the best region in India in to install solar power plants, Sakri solar plant in Dhule district is the largest solar power plant in Maharashtra and Saibaba Trust has the largest solar steam system in the world.

Madhya Pradesh:

Madhya Pradesh is another fast renewable energy developed states in India, Welspun Solar MP project and Rewa Ultra Mega Solar are two largest solar power plant in Madhya Pradesh.

Karnataka

Pavagada Solar Park in Tumkur district of Karnataka will be one of the largest solar park in the world. Shakti Sthala solar park with full potential of 2,000 MW will become world's largest solar park.

Telangana:

Telangana currently has 1300 MW installed capacity of solar power and will become highest solar power generation in India by year 2019. ReNew Power announced the commissioning of biggest solar plant in Telangana in Dharmaraopet village.

Punjab**:**

Adani group is commissioning largest solar power plant in Punjab with 100 MW. Punjab also has World's largest single rooftop solar plant.

Uttar Pradesh**:**

Prime Minister Narendra Modi has inaugurated Uttar Pradesh's biggest solar power plant in Mirzapur. The state already has solar power plant in Allahabad and in Jalaun district.

Kerala is home to largest floating solar power plant in India that floats on the Banasura Sagar reservoir

in Wayanad.

UNIT-5

INDOOR ENVIRONMENT QUALITY

Introduction:

Indoor Environmental Quality (IEQ) refers to the quality of a building environment in relation to the health and wellbeing of those who occupy space within it. IEQ includes many factors indoor air quality, thermal comfort or indoor climate, visual or lighting quality, acoustical quality. Strategies for addressing IEQ include those that protect human health, improve quality of life, and reduce stress and potential injuries. Better indoor environmental quality can enhance the lives of building occupants, increase the resale value of the building, and reduce liability for building owners.

Weather is the state of the atmosphere, describing for example the degree to which it is hot or cold, wet or dry, calm or stormy, clear or cloudy.

Weather Station:

A weather station is a device that collects data related to the weather and environment using many different sensors. Weather stations are also called weather centers, personal weather stations, professional weather stations, home weather station, weather forecaster and forecasters.

Weather stations sensors may include a **thermometer** to take temperature readings, a **barometer** to measure the pressure in the atmosphere, as well as other sensors to measure rain, wind, humidity and more. Weather stations range from simple analog technology to digital technology [pictured below]. Some even connect to your computer or the internet, so the data collected can be analyzed using weather station software.

The following is a list of measurement devices that are included with AcuRite home weather stations:

Thermometer - A thermometer measures **temperature**. AcuRite weather stations measure both the temperature indoors and outdoors, record highs and lows, show trend arrows to indicate temperature rising or falling, and even predict short-term future temperature ranges.

Hygrometer - A hygrometer measures **relative humidity**. Relative humidity is the quantity or percentage of water vapor (water in gas form) in the air. Humidity influences environmental factors and calculations like precipitation, fog, dew point and heat index. In addition, maintaining proper humidity indoors has implications for your health and home.

Barometer - A barometer measures **atmospheric pressure**. A barometer can help to forecast upcoming weather based on the changes it measures in the atmospheric pressure. Some AcuRite weather stations feature a barometric pressure history chart or a pressure trend arrow so you can easily track changes, like a pressure drop.

Anemometer - An anemometer measures how fast the wind is blowing, or **wind speed**. AcuRite weather stations can display wind speed in MPH, KPH or knots, and record current, peak and average wind speed readings.

Wind Vane - A wind vane, or weather vane, is an instrument that determines which **direction the wind is blowing**. AcuRite weather stations display this information using a 16 point wind

rose [pictured right].

Rain Gauge - A rain gauge measures **rainfall** or liquid precipitation. Some AcuRite weather stations include rainfall alerts to notify you when a rain event has begun, or to alert you of potential flood conditions.

Transmissometer: an instrument for measuring the transmission of light through a fluid (such as the atmosphere)

Indoor air quality:

Indoor Air Quality (IAQ) refers to the air quality within and around buildings and structures, especially as it relates to the health and comfort of building occupants. IAQ refers the quality of air inside the building as represented by concentrations of pollutants and thermal conditions that effect the health and occupant performance.

Causes of air pollution:

1. Air tightness of buildings
2. Poorly designed air conditioning and ventilation systems
3. Indoor sources of pollution
4. Outdoor sources of pollution

1.Air tightness of buildings:

Inadequate supply of fresh air, as a result, negative pressure develops, which causes

- Ground level pollutants, e.g. CO, Radon etc. to be drawn inside the buildings.

Release of odor (Bioaerosols) and other pollutants.
Pull outside polluted air from vents, cracks and openings and increase dust, pollen etc.
Causes “Sick Building Syndrome”.

“Sick Building Syndrome” is the feeling of illness among majority of occupants of a conditioned space. A variety of illness symptoms reported by occupant are headache, fatigue, eye irritation, nose and throat, breathe shortness etc,

2. Poorly designed air conditioning and ventilation systems:

Enclosed space inhabited by humans produce following effects:
Reduction in oxygen level of spaces.
Increase in CO_2 level.
Increase in temperature.
Increase in humidity
Increase in Bioaerosols and odor

ventilation system: ventilation is a process whereby air is supplied and removed from an indoor space by natural or mechanical

objectives of ventilation:

1. Provide a continuous supply of fresh outside air.
2. Maintain temperature and humidity at comfortable levels.

3. Remove or dilute airborne contaminants.

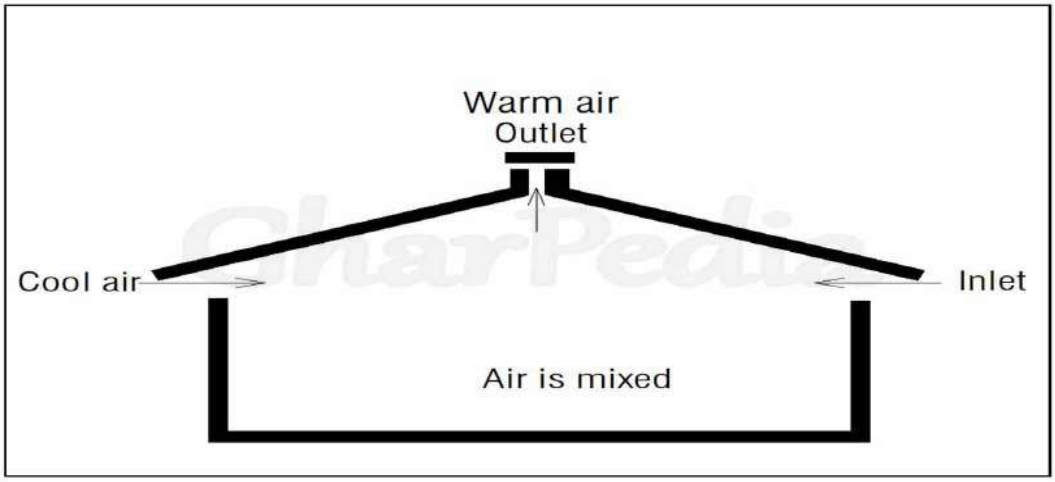
Types of ventilation:

- Natural
- Mechanical

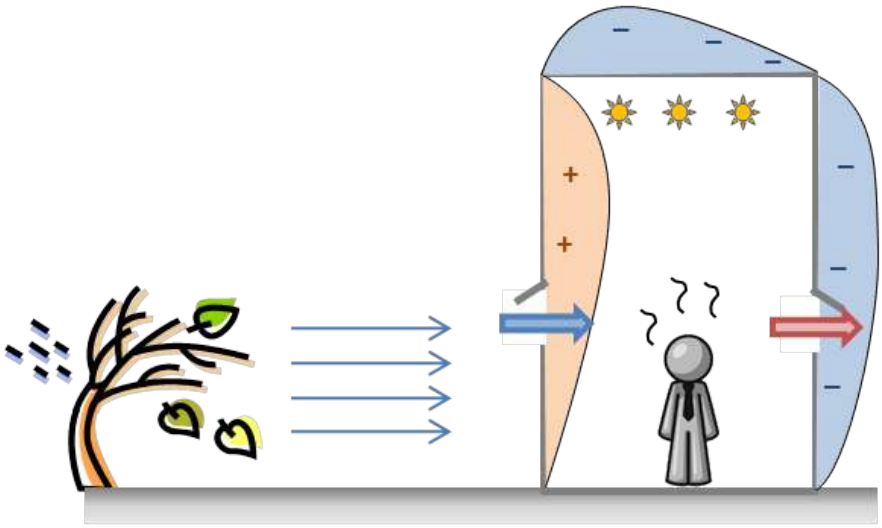
Natural ventilation involves infiltration ie., random flow of outdoor air through natural openings those are windows doors, cracks in wall and a variety openings in buildings.

Two types of natural ventilation:

1. Stack effect: The stack effect happens, when warm air moves or flow upwards in the building. the warm air rises because it is lighter than cold air. So when it rises, it escapes out of the upper levels of the building through ventilation openings, windows or leakages. The rising warm air reduces the pressure at the base of the building, forcing cold air to infiltrate through either open doors, windows, or other openings and leakage in lower levels of the building.



2. Cross ventilation: Cross ventilation (also called **Wind Effect Ventilation**) is a natural method of cooling. The system relies on wind to force cool exterior air into the building through an inlet (like a wall louver, a gable, or an open window) while outlet forces warm interior air outside (through a roof vent or higher window opening). Modern natural ventilation systems help increase the flow of cool air coming in and assist the hot air going out. This increases building air flow naturally.



Limitation of natural ventilation:

1. It brings pollens and other pollutants from outside
2. Fairly inefficient as it is not uniformly distributed.

Mechanical ventilation:

All of the fans, vents, and ventilation equipment in a home work together as a "ventilation system" to exchange indoor and outdoor air without wasting energy.
Mechanical Ventilation systems can be categorized as one of three types:
exhaust, supply, balanced. The right ventilation system for a particular house depends upon the climate and the needs of the structure.

Exhaust system:

Exhaust ventilation systems are relatively simple and inexpensive to install. Typically, an exhaust ventilation system is composed of a single fan connected to a centrally located, single exhaust point in the house.

Supply system:

supply ventilation systems are relatively simple and inexpensive to install. A typical system has a fan and duct system that introduces fresh air into usually one—but preferably several—rooms that residents occupy most (for example, bedrooms, living room, kitchen). This system may include adjustable window or wall vents in other rooms.

Balance system:

A typical balanced ventilation system is designed to supply fresh air to bedrooms and common rooms where people spend the most time. It also exhausts air from rooms where moisture and pollutants are most often generated, such as the kitchen, bathrooms, and the laundry room.

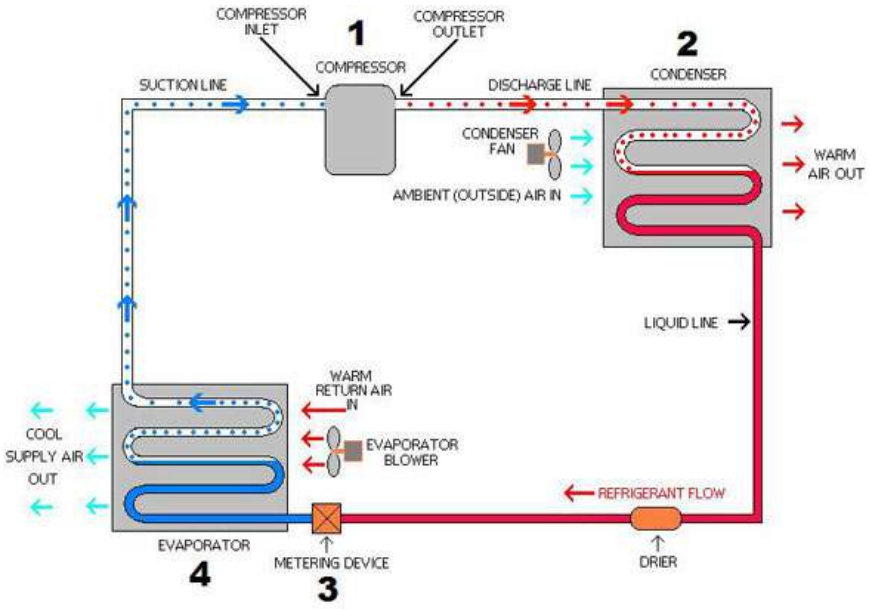
Supply and exhaust systems, balanced ventilation systems do not temper or remove moisture from the air before it enters the house. They do, however, use filters to remove dust and pollen from outside air before introducing it into the house.

Air conditioning system: A system for controlling the humidity, ventilation, and temperature in a building or vehicle, typically to maintain a cool atmosphere in warm conditions.

Working principle:

An air conditioner collects hot air from a given space, processes it within itself with the help of a refrigerant and a bunch of coils and then releases cool air into the same space where the hot air had originally been collected.

Mechanism



3. Indoor sources of pollution:

Asbestos: Asbestos is a mineral fiber that occurs in rock and soil. Because of its fiber strength and heat resistance it has been used in a variety of building construction materials for insulation and as a fire-retardant. Asbestos has been used in a wide range of manufactured goods, mostly in:

- Building materials:
  - Roofing shingles
  - Ceiling and floor tiles
  - Paper products
  - Asbestos cement products
- Friction products:
  - Automobile clutch
  - Automobile brake

- Transmission parts
- Heat-resistant fabrics
- Packaging
- Gaskets
- Coatings

Elevated concentrations of airborne asbestos can occur after asbestos-containing materials are disturbed by cutting, sanding or other remodeling activities. Improper attempts to remove these materials can release asbestos fibers into the air in homes, increasing asbestos levels and endangering people living in those homes.

Biological pollutants: Sources

- pollens, which originate from plants
- viruses, which are transmitted by people and animals
- mold
- bacteria, which are carried by people, animals, and soil and plant debris
- household pets, which are sources of saliva and animal dander (skin flakes)
- droppings and body parts from cockroaches, rodents and other pests or insects
- viruses and bacteria
- The protein in urine from rats and mice is a potent allergen. When it dries, it can become airborne.
- Contaminated central air handling systems can become breeding grounds for mold, mildew and other sources of biological contaminants and can then distribute these contaminants through the home

Allergic reactions and hay fever are health effects of biological pollutants.

Carbon monoxide:

Sources of CO include:

- unvented kerosene and gas space heaters
- leaking chimneys and furnaces
- back-drafting from furnaces, gas water heaters, wood stoves and fireplaces
- gas stoves
- generators and other gasoline powered equipment
- automobile exhaust from attached garages
- tobacco smoke
- auto, truck, or bus exhaust from attached garages, nearby roads, or parking areas
- incomplete oxidation during combustion in gas ranges, and unvented gas or kerosene heaters
- worn or poorly adjusted and maintained combustion devices (e.g., boilers, furnaces)
  - if the flue is improperly sized, blocked or disconnected
  - if the flue is leaking

Health Effects Associated with Carbon Monoxide
At low concentrations:

- fatigue in healthy people
- chest pain in people with heart disease

At moderate concentrations:

- angina
- impaired vision
- reduced brain function

At higher concentrations:

- impaired vision and coordination
- headaches
- dizziness
- confusion
- nausea
- flu-like symptoms that clear up after leaving home
- fatal at very high concentrations

Formaldehyde:

Formaldehyde is an important chemical used widely by industry to manufacture building materials and numerous household products. It is also a by-product of combustion and certain other natural processes. Thus, it may be present in substantial concentrations both indoors and outdoors.
Formaldehyde can cause irritation of the skin, eyes, nose and throat. High levels of exposure may cause some types of cancers.

Nitrogen dioxide:
sources of Nitrogen Dioxide

- unvented combustion appliances, e.g. gas stoves
- vented appliances with defective installations
- welding
- tobacco smoke
- kerosene heaters.

Health effects

- NO_2 acts mainly as an irritant affecting the mucosa of the eyes, nose, throat and respiratory tract.
- Extremely high-dose exposure (as in a building fire) to NO_2 may result in pulmonary edema and diffuse lung injury.

Voc's:

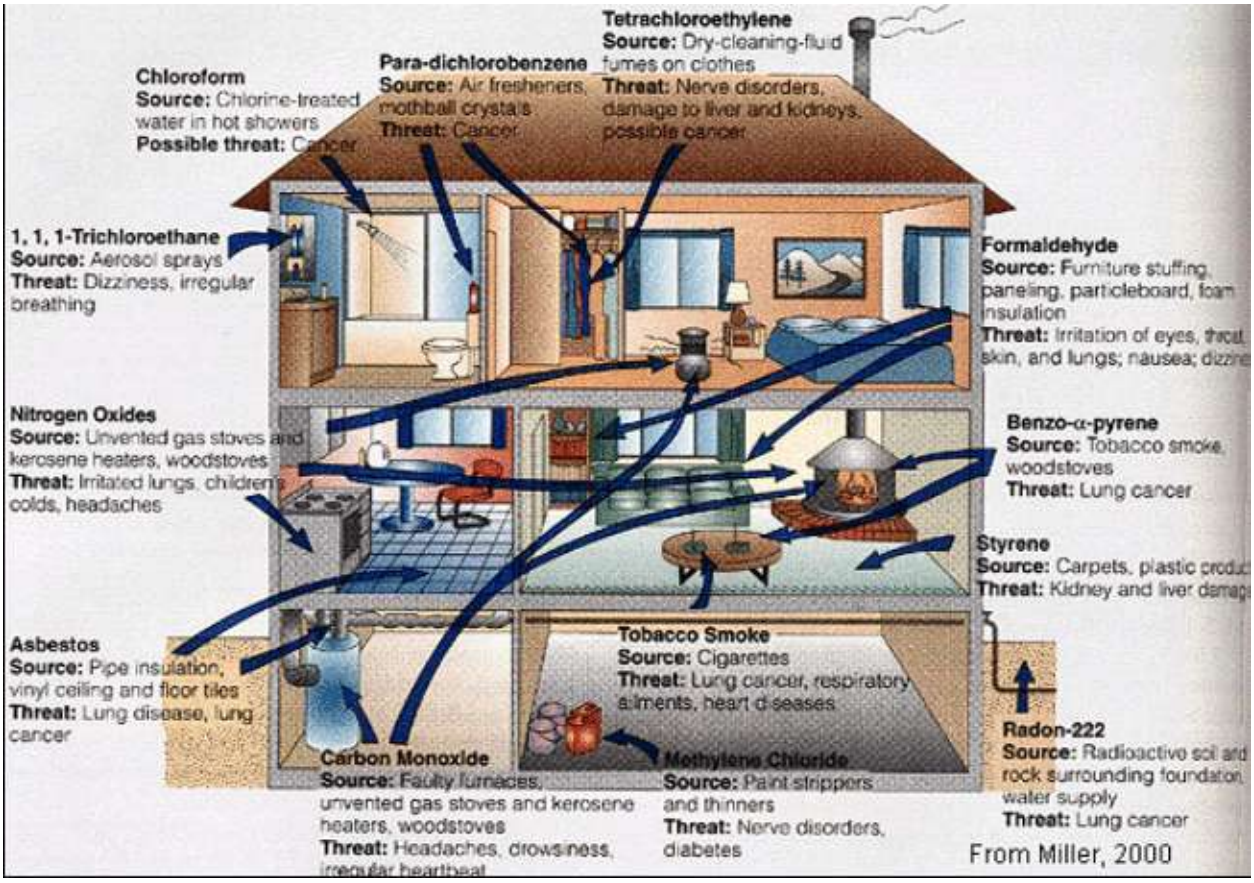
Sources of VOCs
Household products, including:

- paints, paint strippers and other solvents

- wood preservatives
- aerosol sprays
- cleansers and disinfectants
- moth repellents and air fresheners
- stored fuels and automotive products
- hobby supplies
- dry-cleaned clothing
- pesticide

Health effects may include:

- Eye, nose and throat irritation
- Headaches, loss of coordination and nausea
- Damage to liver, kidney and central nervous system
- Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans.



Indoor Air Pollutants and Their Health Effects

Pollutant	Effect	Limits
NOz	Type: Immediate Causes: irritation to the skin, eyes and throat, cough etc.	0.05 ppm (avg. over one year for 8 hours exposure daily)- **EPA**
CO	Type: Immediate Causes: headache, shortness of breath, higher	9.0 ppm (avg. over 8 hours period)- **EPA**

	conc. May cause sudden deaths. .	
RSPM	Type: Cumulative Causes: Lung cancer	150 µg/ m3 (24 hr. average)
SO2	Type: Immediate Causes: lung disorders and shortness of breath	0.05 ppm (avg. over one year for 8 hours exposure daily)- **EPA**
Radon	Type: Cumulative Causes: Lung cancer	>/ 4 pCi/ Litre of indoor air
Formaldehyde	Type: Immediate Causes: irritation to the eyes, nose and throat, fatigue, headache, skin allergies, vomiting etc.	120 ? g/ cu.m. (continuous exposure)- **ASHRAE**
Asbestos	Type: Cumulative Causes: Lung cancer	>/ 2 fibers/ cu.cm. Of the indoor air (8 hrs. exposure period)- **OSHA**
Pesticides	Type: Immediate Causes: Skin diseases	
VOCs	Type: Immediate Causes: Liver, kidney disorders, irritation to the eyes, nose and throat, skin rashes and respiratory problems.	Not for all VOCs. For chlordane: 5? g/cu.m.(continuous exposure))
CO2	Surrogate index of ventilation	1000 ppm
O3	Type: Immediate Causes: eyes itch, burn, respiratory disorders, lowers our resistance to colds and pneumonia.	100 ? g/cu.m (continuous exposure)- **OSHA**

WHO Standards

• **Pollutants**	**Concentration reported**	**Concentrations of limited or no concern**	**Concentration of concern**	**Remarks**
• Respirable particulates	0.05 – 0.7	<0.1	>0.015	Japanese standard 0.15 mg/cubic m
• CO	1-1.5	<2	>5	Indicator for eye irritation(only from passive smoking)
• NO2	0.05 – 1	<0.19	>0.32	------
• CO	---- 1-100	2% CO Hb < 11	3%COHb >30	99.9% Continuous exposure
• Formaldehyde	0.05 – 2	< 0.06	>0.12	Long- and Short- term
• SO2	0.02 – 1	< 0.5	>1.35	SO2 alone, short-term
• CO2	500 – 5000 ppm	< 1000 ppm	>1000 ppm	Occupancy

• O3	600-9000	< 1800	>12000	indicator Japanese standard 1800 mg/cubic m
•	<10 fibres/cubic m	~ 0	fibre/m	For long Exposure

* typical ranges of concentration is given in mg/cubic m, unless otherwise indicated

4.Outdoor sources of pollution:

Outdoor air is often referred to as ambient air. The common sources of outdoor air pollution are emissions caused by combustion processes from motor vehicles, solid fuel burning and industry. Other pollution sources include smoke from bushfires, windblown dust, and biogenic emissions from vegetation (pollen and mould spores).

The most common air pollutants of ambient air include:

- Particulate matter (PM10 and PM2.5)
- Ozone (O3)
- Nitrogen dioxide (NO2)
- Carbon monoxide (CO)
- Sulphur dioxide (SO2)