UNIT 5

ENERGY EFFICIENT BUILDINGS AND TECHNOLOGIES

Introduction and need for energy efficiency in existing buildings. Renewable energy systems - solar passive cooling and heating of buildings, solar active thermal and photovoltaic systems, building management system. Introduction to Green Buildings Concepts and green buildings ratings for certification, Case studies.

Energy efficient buildings (new constructions or renovated existing buildings) can be defined as buildings that are designed to provide a significant reduction of the energy need for Space conditioning ie .heating and cooling, independently of the energy and of the equipments that will be chosen to heat or cool the building.

Needs for Energy Efficiency in Existing Buildings:

i. Environmental needs :

- Enhance and protect biodiversity and ecosystems
- Improve air and water quality
- Reduce waste streams
- Conserve and restore natural resources

ii. Economic needs :

- Reduce operating costs
- Create, expand, and shape markets for green product and services
- Improve occupant productivity
- Optimize life-cycle economic performance

iii. Social needs :

- Enhance occupant comfort and health
- Increase aesthetic qualities
- Minimize strain on local infrastructure
- Improve overall quality of life

Renewable Energy systems:

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished).

About 16% of global final energy consumption comes from renewables, with 10% coming from traditional biomass, which is mainly used for heating, and 3.4% from hydroelectricity.

New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 3% and are growing very rapidly. The share of renewables in electricity generation is around 19%, with 16% of global electricity coming from hydroelectricity and 3% from new renewables.

Renewable energy replaces conventional fuels in four distinct areas: electricity generation, hot water/ space heating, motor fuels, and rural (off-grid) energy services.

The conversion of solar radiation in to heat for technological, comfort heating and cooking purposes. Solar thermal heating is applied to water, air or structural materials. Conversion of light to heat can be achieved through passive systems or active systems (mechanically transferring heat by means of a working fluid such as oil, water or air).

The following renewable energy systems are adopted in buildings:

A) Passive solar heating
B) Passive solar cooling
C) Active solar heating
D) Active solar cooling
E) Photovoltaic system

Passive Solar Design:

Passive solar design refers to the use of the sun's energy for the heating and cooling of living spaces. In this approach, the building itself or some element of it takes advantage of natural energy characteristics in materials and air created by exposure to the sun. Passive systems are simple, have few moving parts, and require minimal maintenance and require no mechanical systems.

Design considerations for Passive solar systems:

- The building should be elongated on an east-west axis.
- The building's south face should receive sunlight between the hours of 9:00 A.M. and 3:00 P.M. (sun time) during the heating season.
- Interior spaces requiring the most light and heating and cooling should be along the south face of the building.
- Less used spaces should be located on the north.
- An open floor plan optimizes passive system operation.
- Use shading to prevent summer sun entering the interior.

Passive Solar Heating System:

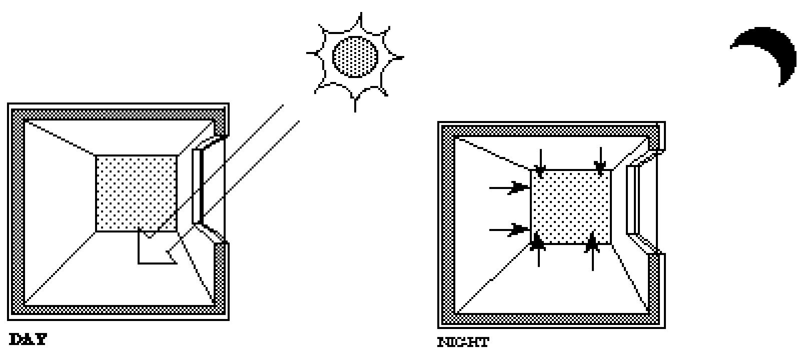
Two primary elements of passive solar heating are required:

i. South facing glass
ii. Thermal mass to absorb, store, and distribute heat

There are three approaches to passive systems – **direct gain, indirect gain, and isolated gain.** The goal of all passive solar heating systems is to capture the sun's heat within the building's elements and release that heat during periods when the sun is not shining (night time). At the same time that the building's elements (or materials) are absorbing heat for later use, solar heat is available for keeping the space warmth and comfortable (not overheated).

Direct Gain

In this system, the actual living space is a solar collector, heat absorber and distribution system. South facing glass admits solar energy into the house where it strikes directly and indirectly thermal mass materials in the house such as masonry floors and walls. The direct gain system will utilize 60 – 75% of the sun's energy striking the windows.



Thermal mass in the interior absorbs the sunlight and radiates the heat at night.

In a direct gain system, the thermal mass floors and walls are functional parts of the house. It is also possible to use water containers inside the house to store heat. However, it is more difficult to integrate water storage containers in the design of the house.

The thermal mass will temper the intensity of the heat during the day by absorbing the heat. At night, the thermal mass radiates heat into the living space.

Design considerations Direct gain system:

- A heat load analysis of the house should be conducted.
- Do not exceed 150 mm of thickness in thermal mass materials.

- Do not cover thermal mass floors with wall to wall carpeting; keep as bare as functionally and aesthetically possible.
- Use a medium dark color for masonry floors; use light colors for other lightweight walls; thermal mass walls can be any color.
- For every square foot of south glass, use 150 pounds of masonry or 4 gallons of water for thermal mass.
- Fill the cavities of any concrete block used as thermal storage with concrete or other high mass substance.
- Use thermal mass at less thickness throughout the living space rather than a concentrated area of thicker mass.
- The surface area of mass exposed to direct sunlight should be 9 times the area of the glazing.
- Sun tempering is the use of direct gain without added thermal mass. For most homes, multiply the house square footage by 0.08 to determine the amount of south facing glass for sun tempering.

Indirect Gain

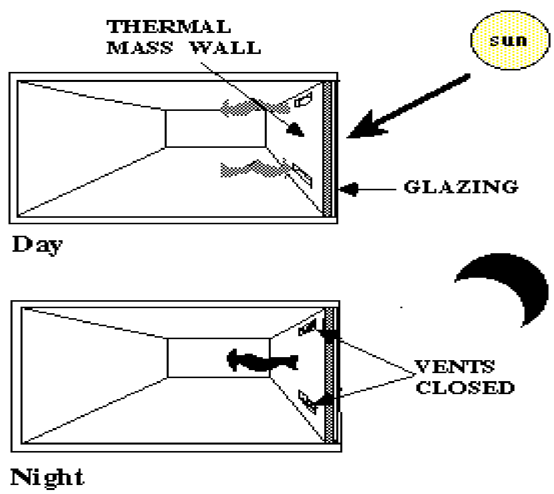
In an indirect gain system, thermal mass is located between the sun and the living space. The thermal mass absorbs the sunlight that strikes it and transfers it to the living space by conduction. The indirect gain system will utilize 30 – 45% of the sun's energy striking the glass adjoining the thermal mass.

There are two types of indirect gain systems:

- Thermal storage wall systems (Trombe Walls)
- Roof pond systems

Thermal storage wall systems:

The thermal mass is located immediately behind south facing glass in this system.



Thermal Mass Wall or Trombe Wall Day and Night Operation

Operable vents at the top and bottom of a thermal storage wall permit heat to convect from between the wall and the glass into the living space. When the vents are closed at night radiant heat from the wall heats the living space.

Roof pond systems

- Six to twelve inches of water are contained on a flat roof.
- This system is best for cooling in low humidity climates but can be modified to work in high humidity climates. (Effectively provides heat in southern latitudes during the heating season for one story or upper stories of buildings.)
- Water is usually stored in large plastic or fiberglass containers covered by glazing and the space below is warmed by radiant heat from the warm water above.
- These require somewhat elaborate drainage systems, movable insulation to cover and uncover the water at appropriate times, and a structural system to support up to 65 lbs/sq ft dead load.

Design considerations of Indirect gain system for thermal storage walls

- The exterior of the mass wall (toward the sun) should be a dark color.
- Use a minimum space of 4 inches between the thermal mass wall and the glass.
- Vents used in a thermal mass wall must be closed at night.

- A well insulated home (7-9 BTU/day-sq. ft.-degree F) will require approximately 0.20 square feet of thermal mass wall per square foot of floor area or 0.15 square foot of water wall.

- If movable night insulation will be used in the thermal wall system, reduce the thermal mass wall area by 15%.

- Thermal wall thickness should be approximately 10-14 inches for brick, 12-18 inches for concrete, 8-12 inches for adobe or other earth material and at least 6 inches for water.

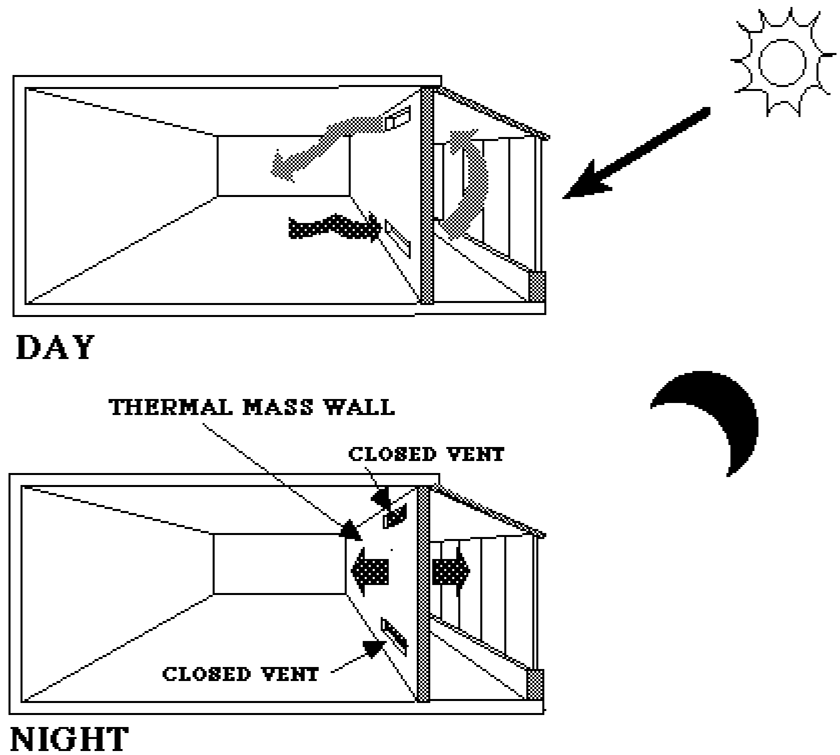
Isolated Gain

An isolated gain system has its integral parts separate from the main living area of a house. Examples are a sunroom and a convective loop through an air collector to a storage system in the house. The ability to isolate the system from the primary living areas is the point of distinction for this type of system.

The isolated gain system will utilize 15 – 30% of the sunlight striking the glazing toward heating the adjoining living areas. Solar energy is also retained in the sunroom itself.

Sunrooms (or solar greenhouses) employ a combination of direct gain and indirect gain system features. Sunlight entering the sunroom is retained in the thermal mass and air of the room. Sunlight is brought into the house by means of conduction through a shared mass wall in the rear of the sunroom, or by vents that permit the air between the sunroom and living space to be exchanged by convection.

The use of a south facing air collector to naturally convect air into a storage area is a variation on the active solar system air collector. These are passive collectors. Convective air collectors are located lower than the storage area so that the heated air generated in the collector naturally rises into the storage area and is replaced by return air from the lower cooler section of the storage area. Heat can be released from the storage area either by opening vents that access the storage by mechanical means (fans), or by conduction if the storage is built into the house.



Day and Night Operation of a Sunroom Isolated Gain System

The sunroom has some advantages as an isolated gain approach in that it can provide additional usable space to the house and plants can be grown in it quite effectively.

The convective air collector by comparison becomes more complex in trying to achieve additional functions from the system. This is a drawback in this area where space heating is less of a concern than in colder regions where the system would be used longer. It is best to use a system that provides more than one function if the system is not an integral part of the building. The sunroom approach will be emphasized in this information since it can provide multiple functions.

Sunrooms

Sunrooms can feature sloped and/or overhead glass, but is not recommended for the Austin area. A sunroom will function adequately without overhead or sloped glazing. Due to long hot summers in this area, it is important to use adequate ventilation to let the heat out. Sloped or overhead glazing is also a maintenance concern. Due to the intensity of weather conditions for glazing facing the full .i.ventilation: passive design and brunt of the sun and rain, seals between the gazing panels need to be of extremely high material and installation quality.

A thermal wall on the back of the sunroom against the living space will function like the indirect gain thermal mass wall. With a thermal wall in the sunroom, the extra heat during the day can be brought into the living space via high and low vents like in the indirect gain thermal wall.

More elaborate uses of the heated air generated in the sunspace can be designed into this system, such as transferring the hot air into thermal mass located in another part of the house.

Design considerations for Isolated Gain of sunrooms:

- Use a dark color for the thermal wall in a sunspace.
- The thickness of the thermal wall should be 8-12 inches for adobe or earth materials, 10-14 inches for brick, 12-18 inches for (dense) concrete.
- Withdraw excess heat in the sunroom (if not used for warm weather plants) until the room reaches 45 degrees and put the excess heat into thermal mass materials in other parts of the house.
- For a sunroom with a masonry thermal wall, use 0.30 square feet of south glazing for each square foot of living space floor area.
- If a water wall is used between the sunroom and living space instead of masonry, use 0.20 square feet of south facing glass for each square foot of living area.
- Have a ventilation system for summer months.
- If overhead glass is used in a sunroom, use heat reflecting glass and or shading systems in the overhead areas.

Passive Solar Cooling System

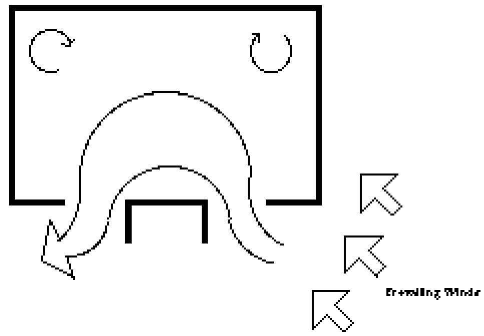
Ventilation & Operable Windows

A primary strategy for cooling buildings without mechanical assistance (passive cooling) in hot humid climates is to employ natural ventilation. (The Fan and Landscape sections also address ventilation strategies.) In the Austin area, prevailing summer breezes are from the south and southeast. This matches nicely with the increased glazing on the south side needed for passive heating, making it possible to achieve helpful solar gain and ventilation with the following strategies:

- Place operable windows on the south exposure.
- Casement windows offer the best airflow. Awning (or hopper) windows should be fully opened or air will be directed to ceiling. Awning windows offer the best rain protection and perform better than double hung windows.
- If a room can have windows on only one side, use two widely spaced windows instead of one window.

Wing Walls

Wing walls are vertical solid panels placed alongside of windows perpendicular to the wall on the windward side of the house.



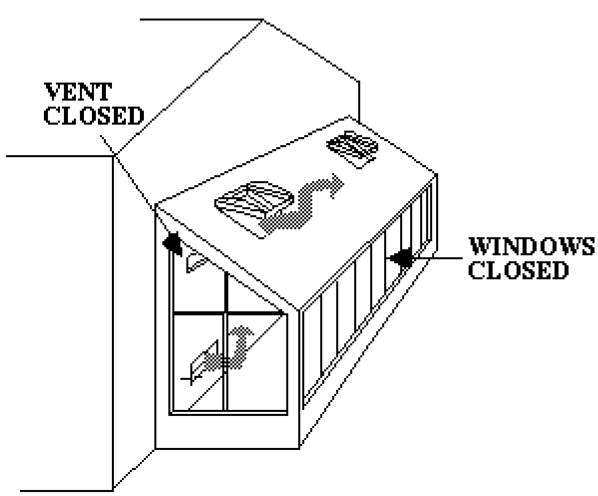
Top View of Wing Walls Airflow Pattern

Wing walls will accelerate the natural wind speed due to pressure differences created by the wing wall.

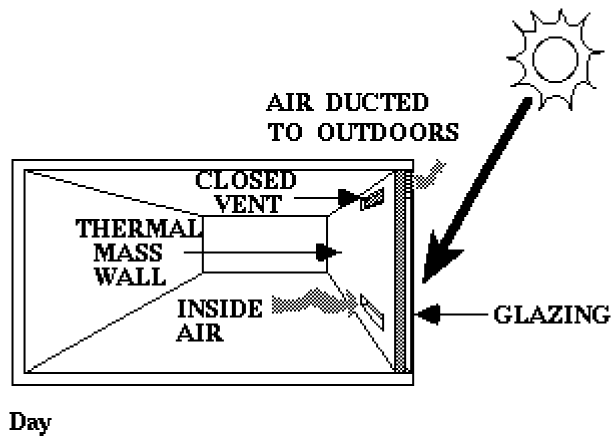
Thermal Chimney

A thermal chimney employs convective currents to draw air out of a building. By creating a warm or hot zone with an exterior exhaust outlet, air can be drawn into the house ventilating the structure.

Sunrooms can be designed to perform this function. The excessive heat generated in a south facing sunroom during the summer can be vented at the top. With the connecting lower vents to the living space open along with windows on the north side, air is drawn through the living space to be exhausted through the sunroom upper vents. (The upper vents from the sunroom to the living space and any side operable windows must be closed and the thermal mass wall in the sunroom must be shaded.)

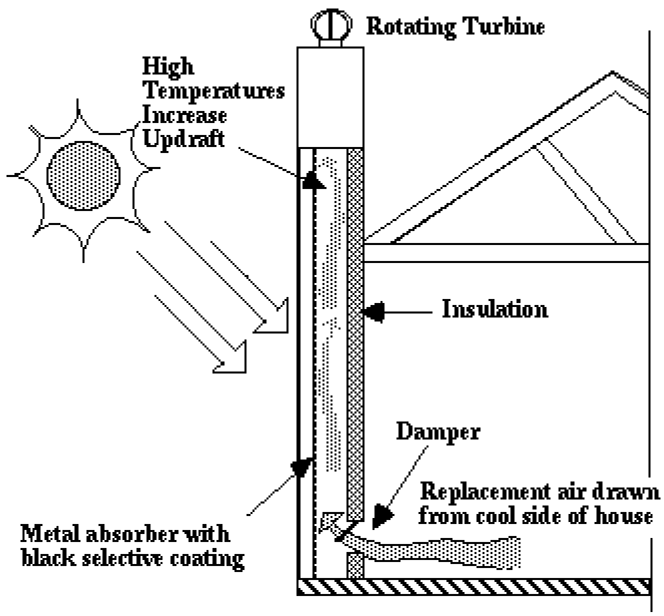


Summer Venting Sunroom



Summer Venting Thermal Mass Wall

Thermal mass indirect gain walls can be made to function similarly except that the mass wall should be insulated on the inside when performing this function.



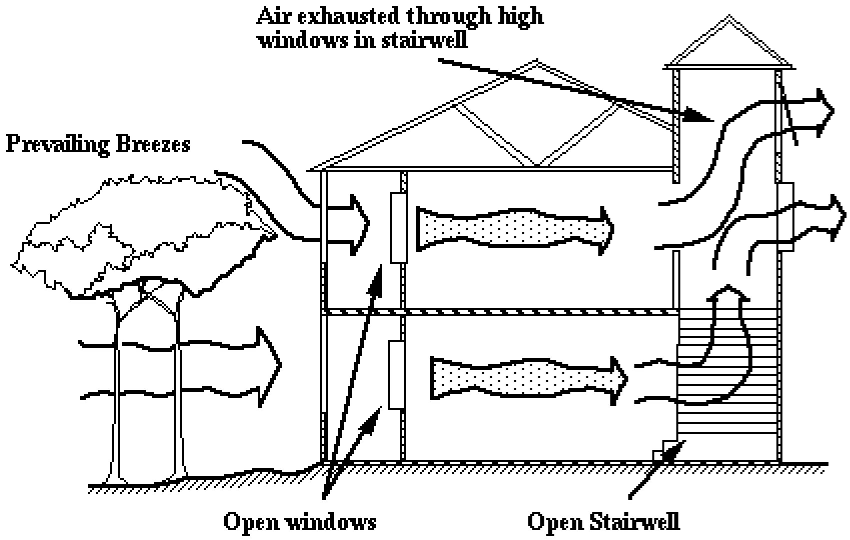
Thermal Chimney

Thermal chimneys can be constructed in a narrow configuration (like a chimney) with an easily heated black metal absorber on the inside behind a glazed front that can reach high temperatures and be insulated from the house. The chimney must terminate above the roof level. A rotating metal scoop at the top which opens opposite the wind will allow heated air to exhaust without being overcome by the prevailing wind.

Thermal chimney effects can be integrated into the house with open stairwells and atria. (This approach can be an aesthetic plus to the home as well.)

Other Ventilation Strategies

- Make the outlet openings slightly larger than the inlet openings.
- Place the inlets at low to medium heights to provide airflow at occupant levels in the room.



Thermal Chimney Effect Built into Home

- Inlets close to a wall result in air “washing” along the wall. Be certain to have centrally located inlets for air movement in the center areas of the room.

- Window insect screens decrease the velocity of slow breezes more than stronger breezes (60% decrease at 1.5 mph, 28% decrease at 6 mph). Screening a porch will not reduce air speeds as much as screening the windows.

- Night ventilation of a home should be done at a ventilation rate of 30 air changes per hour or greater. Mechanical ventilation will usually be required to achieve this

- High mass houses can be cooled with night ventilation providing that fabric furnishings are minimized in the house.

- Keep a high mass house closed during the day and opened at night.

Solar active thermal Systems

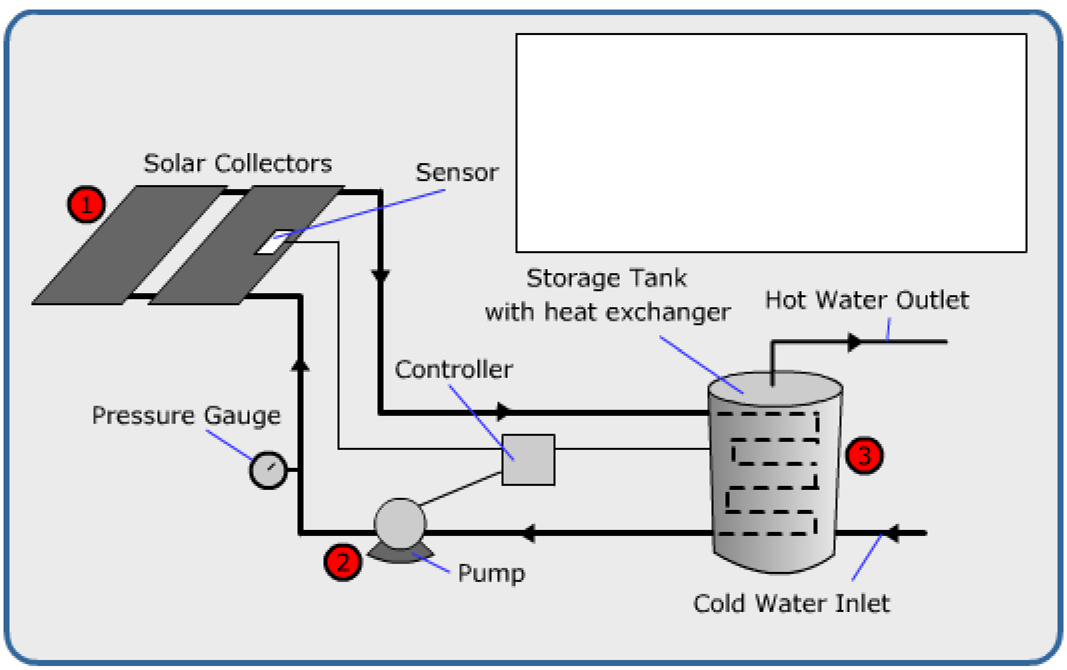
Active solar design uses outside energy and equipment—like electricity and solar panels—to help capture and utilize the energy of the sun. Passive solar design doesn’t use any outside energy or require much special equipment, but simply takes advantage of existing natural phenomena, like the direction of the sun or the insulating properties of concrete.

Solar Active Heating System

Active solar heating systems are comprised of collectors, a distribution system and a storage device.

Active solar heating systems operate as follows:

- Flat plate collectors are usually placed on the roof or ground in the sunlight. The top or sunny side has a glass or plastic cover to let the solar energy in. The inside space is a black (absorbing) material to maximize the absorption of the solar energy.
- Cold water is drawn from the storage tank by pump #1 and is pumped through the flat plate collector mounted on the roof of the house.
- The water absorbs the solar energy and is returned back to the tank.
- Warm water from the tank is pumped by pump #2 though the heating coil.
- The fan blows air (from the room) over the heated coil, and the heated air then passes into the room and heats the room.
- Cold air sinks to the bottom and is recirculated over the heating coil.



Active solar heating system

1 Solar collectors the flat panels mounted on roof to collect and absorb the solar radiation or energy and transfers into a fluid

2 Solar pumps or fans transfer and distribute the solar heat in a fluid from the collectors directly or indirectly throughout the house

3 An energy storage system that stores and provides heat when the sun is not shining.

Solar Active Cooling System:

It can be necessary to provide cooling to buildings during warm weather, or where there are significant thermal gains (such as solar gain, people and equipment). This cooling is sometimes referred to as comfort cooling. Cooling may also be necessary for refrigeration or for some industrial processes.

Active cooling

Active cooling can be provided by:

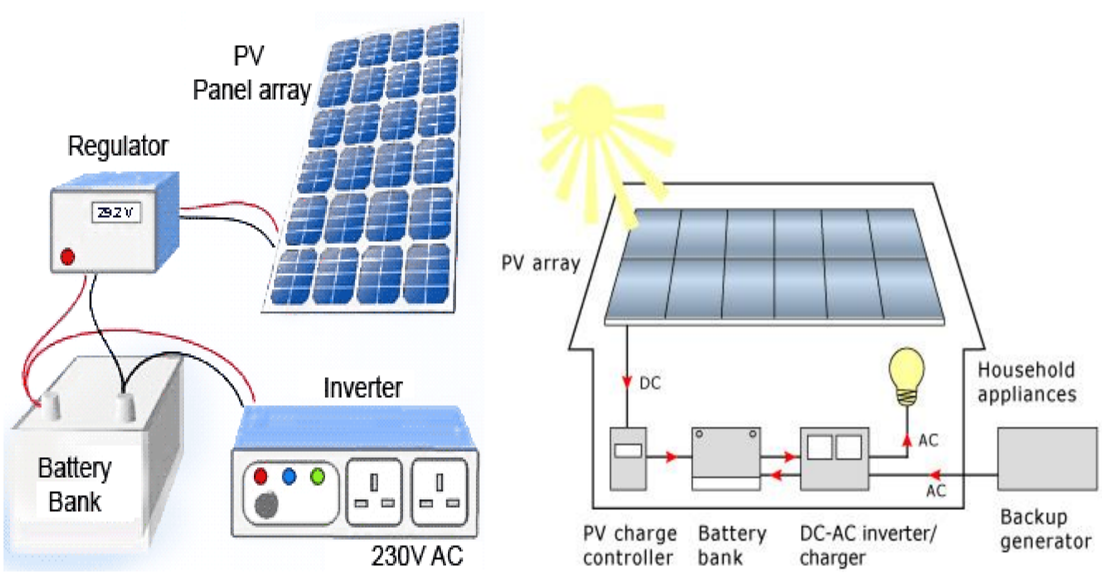
- Earth-to-air heat exchanger (ground coupling), which draws ventilation supply air through buried ducts or tubes (sometimes referred to as earth tubes). As the temperature of the ground below 3m is practically constant, it can be use to substantially reduce ambient air temperature fluctuations, with the incoming air being heated in the winter and cooled in the summer. See Earth-to-air heat exchanger for more information.
- Open or closed loop water to air heat exchangers, which exploit the relatively stable temperature of the earth to provide water that can cool in the summer and heat in the winter. See Ground energy options for more information.
- Mechanical or forced ventilation, driven by fans. This might be cooled below outside air temperature by the use of refrigerants, or by thermal mass, such as thermal labyrinths, or by night time purging. See mechanical ventilation for more information.
- Chilled water. Chilled water is typically provided by chiller units using refrigeration or compression refrigeration. It can then be used to provide cool air, in air handling units (to be ducted around the building), chilled beams, chilled ceilings and so on. Chiller units use are frigerant that boils at a low temperature and pressure, removing heat from the chilled water, and then condenses to release that heat, which is rejected to the outside (or recovered). See Refrigerants for more information. NB The use of chilled water to cool the building fabric itself is sometimes described as 'active thermal mass'.
- Refrigerants can be used to provide cooling directly to spaces in variable refrigerant flow(VRF) systems. This is based on the flow of refrigerant between an external condensing unit and multiple internal evaporators (typically fan coil units). See variable refrigerant flow for more information.
- Evaporative cooling can be provided by simple systems, such as misting fans and by spraying water over the roof of a building, or by more complex packaged units that draw hot, dry air through a continually dampened pad and supply cool, humid air to the building. Indirect evaporative cooling can be provided by the incorporation of heat exchangers, by the use of cooling towers, or by spraying water over the cooling coils of conventional chiller units. Typically, evaporative cooling is best suited to hot, dry climates. See evaporative cooling for more information.

- Ice can be used as an effective means of thermal storage, storing 'coolth' in colder parts of the day to provide cooling during warmer parts of the day. See Thermal storage for cooling for more information.

  Active cooling might be provided as part of a heating, ventilation and air conditioning system (HVAC) which may also include air filtration and humidity control. The cooling process itself can result in dehumidification, as cool air is less able to 'hold' moisture than warm air. The term air conditioning is sometimes take to mean control over air temperature and humidity, rather than just temperature control in the case of comfort cooling.

Photovoltaic system:

Solar panels collect the sun's energy and convert it into direct current (DC) electricity. A solar inverter converts the DC electricity from the panels into the type of electricity we use at home: alternating current (AC). This electricity can be directly used for any application and will cost nothing. If the panels do not generate enough power, the solar inverter is capable of extracting additional power from the grid.

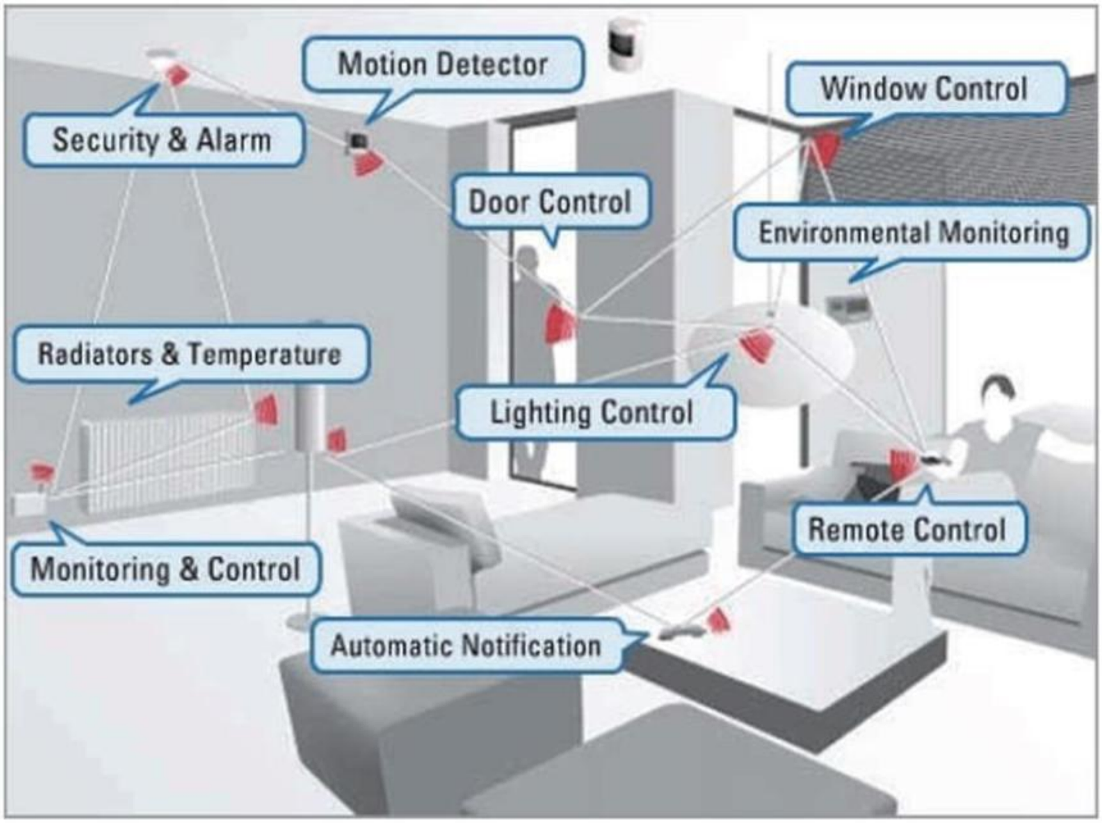


Photovoltaic power system

This way it can progressively become more independent from conventional energy by expanding the solar installation when convenient. The use of a battery pack will allow to create an uninterrupted power supply system (**UPS**).

Building Management System:

Building Energy Management Systems (BMS or BEMS) are computer-based systems that help to manage, control and monitor building technical services (HVAC, lighting etc.) and the energy consumption of devices used by the building. They provide the information and the tools that building managers need both to understand the energy usage of their buildings and to control and improve their buildings’ energy performance.



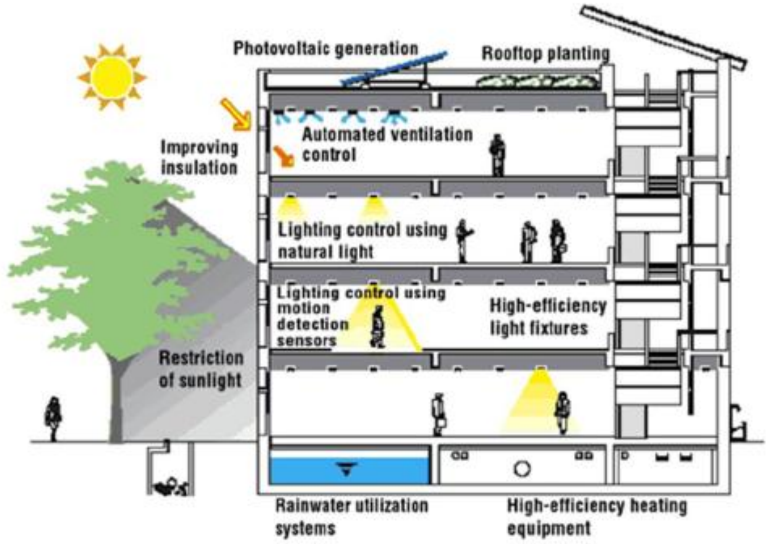
A very basic BMS consists of software, a server with a database and smart sensors connected to an Internet-capable network. Smart sensors around the building gather data and send it to the BMS, where it is stored in a database. If a sensor reports data that falls outside pre-defined conditions, the BMS will trigger an alarm.

Introduction to Green Buildings Concepts:

The Green Building Movement in India has been spearheaded by IGBC (part of CII) since 2001, by creating National awareness**.** Green concepts and techniques in the residential sector can help address national issues like water efficiency, energy efficiency, reduction in fossil fuel use in commuting, handling of consumer waste and conserving natural resources.

Green Building Concept

- Sustainable site planning
- Building Design optimization
- Energy performance optimization
- Renewal energy utilization
- Water and Waste management
- Solid waste management
- Sustainable building material and construction technology
- Health, well being and environmental quality



Conceptual Drawing of Green Building

The concept of Green Building concentrates mainly on five points:

a) Site Selection and Planning
b) Water efficiency
c) Energy Efficiency
d) Materials and Resources
e) Indoor Environmental Quality
f) Innovation and Design Process

- Increasing the efficiency with which buildings use energy, water and materials
- Reducing building impacts of human health and the environment, through better site selection, design, construction, operation, maintenance, and removal throughout the complete life cycle.

Against this background, the Indian Green Building Council (IGBC) has launched **IGBC Green Homes Rating System** to address the National priorities. By applying IGBC Green Homes criteria, homes which are sustainable over the life cycle of the building can be constructed. This rating programme is a tool which enables the designer to apply green concepts and criteria, so as to reduce the environmental impacts, which are measurable.

Green buildings ratings for certification:

Green building rating system is a tool which enables the designer to apply green concepts and criteria, so as to reduce the environmental impacts, which are measurable.

IGBC has developed the following 9 green building rating systems in India:

i. IGBC Green Homes
ii. IGBC Green New Buildings
iii. IGBC Existing Buildings
iv. IGBC Green Townships
v. GBC Green Factory Buildings
vi. IGBC Green SEZ
vii. IGBC Green Schools
viii. IGBC Green Landscaping
ix. IGBC Green Mass Rapid Transit System

IGBC Green Homes is the first rating programme developed in India, exclusively for the residential sector. Green homes can have tremendous benefits, both tangible and intangible. The most tangible benefits are the reduction in water and energy consumption right from day one of occupancy. The energy savings could range from 20 - 30 % and water savings around 30 - 50%. Intangible benefits of green homes include: enhanced air quality, excellent daylighting, health & well being of the residents, safety benefits and conservation of scarce national resources. Green Homes rating system can also enhance marketability of a project.

National Priorities to be considered in Green Building Rating System:

The Green Homes Rating System addresses the most important National priorities which include water conservation, handling of house-hold waste, energy efficiency, reduced use of fossil fuels, lesser dependence on usage of virgin materials and health & well-being of residents.

a. **Water Conservation:**

Most of the Asian countries are water stressed and in countries like India, the water table has reduced drastically over the last decade. Green Homes Rating System encourages use of water in a self-sustainable manner through reducing, recycling and reusing strategies. By adopting this rating programme, green homes can save potable water to an extent of 30 – 50%.

b. **Handling of House-hold Waste:**

Handling of waste in residential buildings is extremely difficult as most of the waste generated is not segregated at source and has a high probability of going to landfills. This continues to be a challenge to the municipalities which needs to be addressed. IGBC intends to address this by encouraging green homes to segregate the house hold waste.

c. **Energy Efficiency:**

The residential sector is a large consumer of electrical energy. Through IGBC Green Homes rating system, homes can reduce energy consumption through energy efficient-lighting, air conditioning systems, motors, pumps etc., The rating system encourages green homes which select and use BEE labeled equipment and appliances. The energy savings that can be realized by adopting this rating programme can be to the tune of 20 – 30%.

d. **Reduced Use of Fossil Fuels:**

Fossil fuel is a slowly depleting resource, world over. The use of fossil fuel for transportation has been a major source of pollution. The rating system encourages the use of alternate fuels for transportation and distributed power generation.

e. **Reduced Dependency on Virgin Materials:**

The rating system encourages projects to use recycled & reused material, and discourages the use of virgin wood, thereby, addressing environmental impacts associated with extraction and processing of virgin materials. Reduced usage of virgin wood is also encouraged.

f. **Health and Well-being of Residents:**

Health and well-being of residents is the most important aspect of Green Homes. IGBC Green Homes Rating System ensures minimum performance of day lighting and ventilation aspects which are critical in a home. The rating system also recognizes measures to minimize the indoor air pollutants.

The various levels of rating awarded are:

Certification Level	Individual Residential Unit	Multi-dwelling Residential Units	Recognition
Certified	38 – 44	50 – 59	Best Practices
Silver	45 – 51	60 – 69	Outstanding Performance
Gold	52 – 59	70 – 79	National Excellence
Platinum	60 - 75	80 – 100	Global Leadership

IGBC Green Homes® Project Checklist

		Points Available: Individual Residential Unit	Points Available: Multi-dwelling Residential Units
Site Selection and Planning			
SSP Mandatory Requirement 1	*Local Building Regulations*	*Required*	*Required*
SSP Mandatory Requirement 2	*Soil Erosion Control*	*Required*	*Required*
SSP Credit 1	Basic House-hold Amenities	1	2
SSP Credit 2	Natural Topography or Vegetation : 15%, 25%	2	4
SSP Credit 3	Heat Island Effect, Non Roof : 50%, 75%	NA	2
SSP Credit 4	Heat Island Effect, Roof : 50%, 75%	4	4
SSP Credit 5	Parking Facilities for Visitors : 10%	NA	1
SSP Credit 6	Electric Charging Facility for Vehicles : 5%	NA	1
SSP Credit 7	Design for Differently Abled	1	2
SSP Credit 8	Basic Facilities for Construction Workforce	1	2
SSP Credit 9	Green Home Guidelines, Design & Post Occupancy	NA	1
		9	**19**
Water Efficiency			
WE Mandatory Requirement 1	*Rainwater Harvesting, Roof & Non-roof, 25%*	*Required*	*Required*
WE Mandatory Requirement 2	*Water Efficient Plumbing Fixtures*	*Required*	*Required*
WE Credit 1	Landscape Design: 20%, 40%	2	4
WE Credit 2	Management of Irrigation Systems	1	1
WE Credit 3	Rainwater Harvesting, Roof & Non-roof: 50%, 75%	4	4
WE Credit 4	Water Efficient Plumbing Fixtures: 25%, 35%	4	4
WE Credit 5	Waste Water Treatment and Reuse: 100% & 50%, 95%	NA	4
WE Credit 6	Water Metering	NA	1
		11	**18**
Energy Efficiency			
EE Mandatory Requirement 1	*CFC-free Equipment*	*Required*	*Required*
EE Mandatory Requirement 2	*Minimum Energy Performance*	*Required*	*Required*
EE Credit 1	Enhanced Energy Performance : 3%, 6%, 9%, 12%, 15%,18%, 21%, 24%, 27%, 30% (or) 2%, 4%, 6%, 8%, 10%,12%, 14%, 16%, 18%, 20%	10	10
EE Credit 2	On-site Renewable Energy: 5%, 10%, 15% (or) 2.5%, 5%, 7.5%	6	6

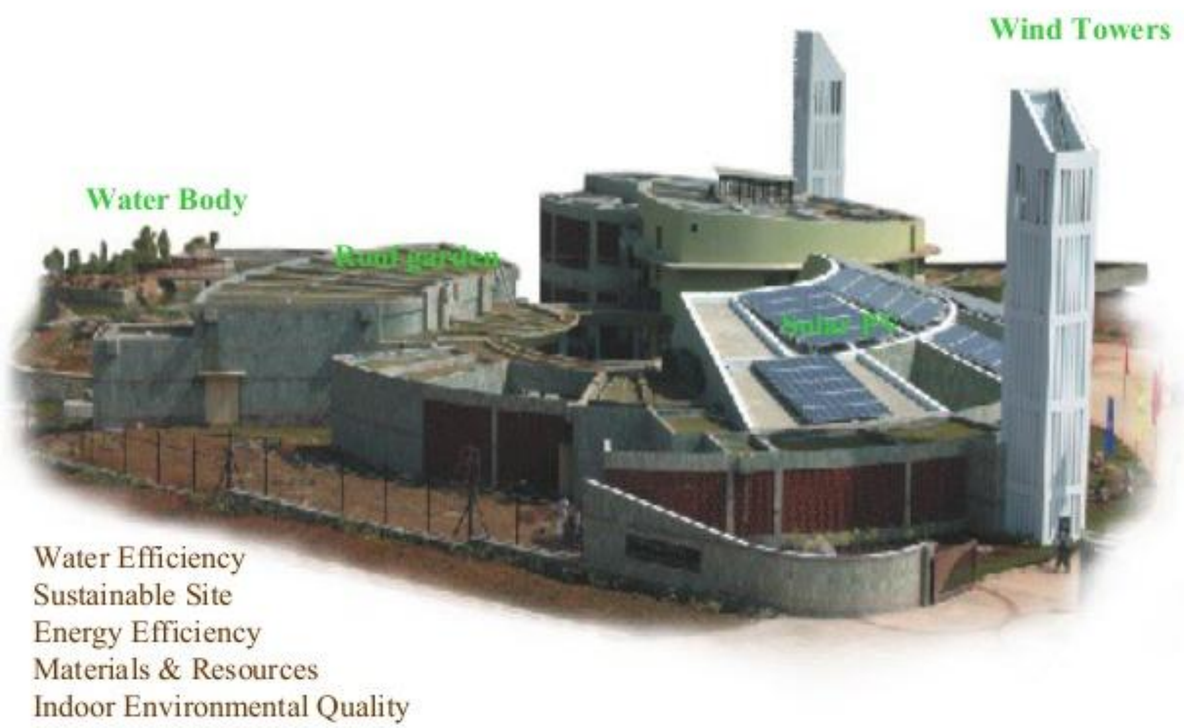
EE Credit 3	Solar Water Heating System : 50%, 95% (or) 25%, 50%	4	4
EE Credit 4	Energy Saving Measures in Other Appliances & Equipment	2	2
EE Credit 5	Distributed Power Generation	NA	2
EE Credit 6	Energy Metering	NA	1
		22	**25**
Materials & Resources			
MR Mandatory Requirement 1	*Separation of House-hold Waste*	*Required*	*Required*
MR Credit 1	Organic Waste Management, Post Occupancy : 95% (or) 50%, 95%	2	4
MR Credit 2	Handling of Construction Waste Materials : 50% (or) 50%, 95%	1	2
MR Credit 3	Reuse of Salvaged Materials : 2.5%, 5% (or) 1%, 2%	2	4
MR Credit 4	Materials with Recycled Content : 10%, 20%	2	2
MR Credit 5	Local Materials : 25%, 50%	2	2
MR Credit 6	Rapidly Renewable Building Materials & Certified Wood : 50%, 75%	4	4
		13	**18**
Indoor Environmental Quality			
IEQ Mandatory Requirement 1	*Tobacco Smoke Control*	*Required*	*Required*
IEQ Mandatory Requirement 2	*Minimum Daylighting: 50%*	*Required*	*Required*
IEQ Mandatory Requirement 3	*Fresh Air Ventilation*	*Required*	*Required*
IEQ Credit 1	Enhanced Daylighting : 75%, 95%	4	4
IEQ Credit 2	Enhanced Fresh Air Ventilation	2	2
IEQ Credit 3	Exhaust Systems	2	2
IEQ Credit 4	Low VOC Materials, Paints & Adhesives	2	2
IEQ Credit 5	Building Flush-out	1	1
IEQ Credit 6	Cross Ventilation : 50%, 75%	4	4
		15	**15**
Innovation & Design Process			
ID Credit 1	Innovation & Design Process	4	4
ID Credit 2	IGBC Accredited Professional	1	1
		5	**5**
	Total	**75**	**100**

Case studies:

I. **CII Sohrabji Godrej Green Business Centre**

CII - Sohrabji Godrej Green Business Centre (CII Godrej GBC), cozily nestled close to Shilparamam, is the first LEED Platinum rated green building in India. The building is a perfect blend of India's rich architectural splendor and technological innovations, incorporating traditional concepts into modern and contemporary architecture. Extensive energy simulation exercises were undertaken to orient the building in such a way that minimizes the heat ingress while allowing natural daylight to penetrate abundantly. The building incorporates several world-class energy and environmentfriendly features, including solar PV systems, indoor air quality monitoring, a high efficiency HVAC system, a passive cooling system using wind towers, high performance glass, aesthetic roof gardens, rain water harvesting, root zone treatment system, etc. The extensive landscape is also home to varieties of trees, most of which are native and adaptive to local climatic conditions. The green building boasts a 50% saving in overall energy consumption, 35 % reduction in potable water consumption and usage of 80% of recycled / recyclable material. Most importantly, the building has enabled the widespread green building movement in India.

GREEN BUSINESS CENTER



Green features and sustainable technologies in Sohrabji Godrej Green Business Centre

1. **Energy Efficiency**

State-of-the- art Building Management Systems (BMS) were installed for realtime monitoring of energy consumption. The use of aerated concrete blocks for facades reduces the load on air-conditioning by 15-20%.

Double-glazed units with argon gas filling between the glass panes enhance the thermal properties.

2. **Zero Water Discharge Building**

All of the wastewater, including grey and black water, generated in the building is treated biologically through a process called the Root Zone Treatment System. The outlet-treated water meets the Central Pollution Control Board (CPCB) norms. The treated water is used for landscaping.

3. **Minimum Disturbance to the Site**

The building design was conceived to have minimum disturbance to the surrounding ecological environment. The disturbance to the site was limited within 40 feet from the building footprint during the construction phase. This has preserved the majority of the existing flora and fauna and natural microbiological organism around the building. Extensive erosion and sedimentation control measures to prevent topsoil erosion have als been taken at the site during construction.

4. **Materials and Resources**

80% of the materials used in the building are sourced within 500 miles from the project site. Most of the construction material also uses post-consumer and industrial waste as a raw material during the manufacturing process. Fly-ash based bricks, glass, aluminum, and ceramic tiles, which contain consumer and industrial waste, are used in constructing the building to encourage the usage of recycled content. Office furniture is made of bagassebased composite wood. More than 50% of the construction waste is recycled within the building or sent to other sites and diverted from landfills.

5. **Renewable Energy**

20% of the building energy requirements are catered to by solar photovoltaics. The solar PV has an installed capacity of 23.5 kW.

6. **Indoor Air Quality**

Indoor air quality is continuously monitored and a minimum fresh air is pumped into the conditioned spaces at all times. Fresh air is also drawn into the building through wind towers.

The use of low volatile organic compound (VOC) paints and coatings, adhesives, sealants, and carpets also helps to improve indoor air quality.

Other Notable Green Features

■ Fenestration maximized on the north orientation

■ Rain water harvesting

■ Water-less urinals in men's restroom

■ Water-efficient fixtures: ultra low and low-flow flush fixtures

■ Water-cooled scroll chiller

■ HFC-based refrigerant in chillers

■ Secondary chilled water pumps installed with variable frequency drives (VFDs)

■ Energy-efficient lighting systems through compact fluorescent light bulbs (CFLs)

■ Roof garden covering 60% of building area

■ Large vegetative open spaces

■ Swales for storm water collection

■ Maximum day lighting

■ Operable windows and lighting controls for better day lighting and views

■ Electric vehicle for staff use ■ Shaded carpark

Cost and Benefits

This was the first green building in the country. Hence, the incremental cost was 18% higher. However, green buildings coming up now are being delivered at an incremental cost of 6-8%. The initial incremental cost gets paid back in 3 to 4 years.

Benefits achieved so far:

■ Over 120,000 kWh of energy savings per year as compared to an ASHRAE 90.1 base case

■ Potable water savings to tune of 20-30% vis-à-vis conventional building

■ Excellent indoor air quality

■ 100% day lighting (Artificial lights are switched on just before dusk)

■ Higher productivity of occupants.

Measurable Results in CII Sohrabji Godrej Green Business Centre:

- **energy savings** : 55% reduction, with ASHRAE 90.1 as the baseline 120,000 kWh / year
- **Reduction in CO2 emissions** : 100 tons / year (building is functional since January 2004)
- **Water savings** 35% reduction in potable water consumption
- **Envelope thermal transfer value** U-value of double glazing: 1.70 Watt/m2 °K U-value of solid wall: 0.57 Watt/m2 °K U-value of roof: 0.294 Watt/m2 °K
- **Air conditioning system efficiency** 0.8 kW/ton (watercooled scroll chiller system with CoP: 4.23 at ARI condition) Installed two 25 TR chillers
- **Energy efficiency index (EEI)** 84 kWh/m2/year

II. Anna Centenary Library building, Chennai:

The pictures of Anna Library is shown below:

Anna Centenary Library building houses a total area of 30,950 square meters (333,140 square feet) and has a capacity to accommodate 1.5 million books. At any given point, the library can accommodate 1200 people, not including an auditorium that can separately seat 1280 people. The project achieved the LEED Gold rating given by Indian Green Building Council under New Construction rating.

Reading areas which are facing North and East are located next to structurally glazed facades which provide abundance of daylight. The Southwest side of the building has thermal buffer zones of service cores and a 9 floor high atrium with an outward sloping glass wall which protect the building from the heat gain. Roof overhangs, Pergolas, and metal louvers are also used to lower heat and glare.

In order to lower heat island effect of the building, the library terrace area is painted with high albedo paints and the Auditorium terrace and Library terrace level at 1st, 2nd and 3rd floor are covered with green roof. The soil used on these surfaces has been collected during the excavation of the project, where top 20 cm (nearly 8 inches) of the soil has been saved for landscaping applications.

The project used building materials with recycled content value of 12 % by cost of the total material cost, and 75 % of the construction waste were reused within the site or sent for recycling. 77 % of the building materials were sourced locally to support the regional economy and reduce the environmental impact.

Although there are many features which lower the building's energy consumption such as LED and CFL lighting, high efficiency motors, pumps and fans, and systems which enable monitoring and control of lighting and ventilation, the building achieves 17.5 % less consumption compared to an ordinary building of equivalent size.

The library has rain water sump and percolation pits which are used for rain water harvesting and increase in ground water table. A collection well/sand filter is provided at the lowest point of the site, which helps to remove the sediments from storm runoff moving out of the site.

The Anna Centenary Library has onsite sewage treatment plant of to treat the wastewater produced from the building, and only treated waste water is used for landscape irrigation and toilet flushing requirements. The water consumption in irrigation is lowered with high efficiency landscape drip and sprinkler system, which combined with water efficient fixtures use 64 % less water compared to a standard building.

The quality of indoor air is ensured with usage of low VOC products (Paints, Adhesives and sealants), CRI certified carpet and MDF & plywood free from urea formaldehyde resins are used in the building. Only eco friendly house keeping chemicals are allowed inside the building premises, and the chemical rooms inside the building are provided with deck to deck partitions and negative differential pressure of 5 pas is maintained.

Further awareness regarding green living among the public is promoted through use of areas where different materials can be stored for recycling, graphics, posters, as well as an artificial tree in the heart of the Children’s Area that promotes the message of nature conservation.

III. **ITC Green Center**

It is located at the city of gurgoan, Haryana was opened in 2005. This building received the LEED platinum certification. This building recycles and reuses all the water that lands on it, results in zero water discharge. This building uses insulated glasses that keeps the heat out and allows the natural light to transmit into the building. This building saves the energy and water by 51 percent and 40 percent respectively. This building has saved Rs.1 crore in power cost annually. The construction of this building uses certified woods. This building uses CO2 Monitoring system to improve the quality of the air to provide the fresh air.