Non Conventional Sources of Energy- Applications of Solar Energy in Architectural Buildings

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ABSTRACT
Electric energy plays an important role in our life. From the ancient period human being utilizing various natural resources to develop electricity. To achieve different goals, we started to utilize conventional as well as non-conventional energy resources. But there is uncertainty of the conventional energy resources, as they are depleting fast. These upcoming scarcities of conventional energy resources and climatic changes increase the significance of non-conventional energy resources.

Non-conventional energy resources like sun, wind, hydro etc. have tremendous potential to meet the energy demand. Out of these sun is the ultimate energy resource for electricity generation in India. As it is going to last for unpredictable time and is available in abundance throughout the year in India, a tropical region. Solar energy can be use in architectural buildings, as it is major dimension for electric consumption in the world. In India electric energy consumption in building industry is around 40% which is maximum of all and can be generated by non conventional-solar energy. Solar techniques which are used to conserve electric energy can be integrated in buildings as an architectural element.

So this paper is an attempt to maximize the use of non conventional solar energy in architectural buildings by using different techniques as an integrated part of building for the India region**.**

General Terms

Non conventional sources of energy, solar techniques.

Keywords

Solar energy, architecture, building sector, energy consumption, active solar techniques, passive solar techniques.

1. INTRODUCTION
Energy gives a vital contribution in development of human life. Its' a great offering of nature, which is available in various forms and is utilizing the human being since ancient times. Its need increases with the development and with ever growing population. The demand, form and need of energy changes after industrial revolution and expected to increase more in upcoming future. Industrial revolution results in many revolutionary changes in technology. Its result is the increased in demand of energy sources like oil and coal, which has been taken from crude oil, whose primary resource is fossil fuel. Fossil fuel is of exhaustible nature and going to deplete one day and causes severe environmental damages like green house effect, water and air pollution etc. These conventional resources are on the verge of vanishing, due to its extreme use and will not be available for future generations. All these calls, the inexhaustible non conventional resources such as wind, sun, water, biomass etc. These are available in abundance and can meet our future needs without damaging the environment when harnessed properly.

As India is located in the equatorial sun belt of the earth, (tropical region) due to which India receives abundant radiant energy from the sun. The majority of India experienced clear sunny weather for 250 to 300 days a year.

Out of all non conventional sources of energy, solar energy is available in abundance. With its best use, electric energy can be generated and can be used for the different sectors. As building sector is the one in which maximum (40%) of electric energy is used. Proper channeling of non-conventional solar energy resource leads to the energy consrvation and which is the need of the time.

2. NON CONVENTIONAL SOURCES OF ENERGY
To meet the future demands of energy and the pollution free conscious environment for the future population, it is required to adopt non-conventional renewable sources of energy. Following are the different non conventional energies:

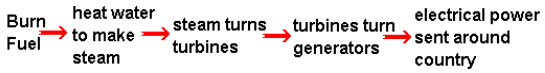
- Tidal energy
- Wind energy
- Hydro energy
- Biomass
- Geothermal energy
- Solar energy

2.1 Tidal Energy
Tidal energy is the energy generated due to the water waves developed in the ocean. The tidal energy is also called hydropower. It is a hydropower due to periodic tides of water wave in ocean. These raising and falling waves rotate the turbines and thus the electricity is produced.
Limitations: It is available on sea coastal areas only.

2.2 Wind Energy
Wind energy is the second available source of energy in abundance. Electrical energy is generated with Wind Mills from beginning of the 20th century. Among the different renewable energy sources, wind energy is currently making a significant contribution to the installed capacity of power generation.
Limitations: The electric generation is totally depends wind speed.

2.3 Hydro Energy

Hydro energy is produced from movement of water in rivers, streams in mountains or from reservoir from where water flows from a high-level down, can be used to generate electricity using turbines. It is a very common resource but depends on its availability of volume. Following is the process for electric generation:



Limitations: Hydro electric power is limited by the location and availability of flowing water.

2.4 Biomass Energy

Biomass energy is the energy stored in garbage, other renewable waste and organic materials from the forest, agricultural and industrial sectors.

Limitations: It is depends upon the sufficient quantity of waste and availability of huge space.

2.5 Geothermal Energy

Geothermal Energy is referred to the heat embedded underneath the earth. This heat is brought to the surface of the earth and can be used for power generation. And other direct heating applications are heating the building etc. The most active geothermal resources are usually found along major plate boundaries where earthquakes and volcanoes are concentrated.

Limitations**:** It is not a active every where on earth surface.

2.6 Solar Energy

Solar energy is the energy which is derived directly from the Sun, it is the most predominant source of energy on Earth. The earth receives 1.6 × 1018 units of energy from the Sun annually, which is 20,000 times the requirement of mankind on the earth. Solar energy has the greatest potential of all non conventional sources still its use is very less**.** Sun remains most important supplies of energy especially when other sources in the country have depleted. It gives non polluting environmental friendly output and available throughout the year in abundance in India. Also it is long lasting inexhaustible source of energy.

So it is to conclude that from all non conventional energies sources, Solar energy source is most reliable for the future use tropical zone of India.

3. ENERGY CONSUMPTION SCENARIO IN ARCHITECTURE

Electrical energy plays a significant role in our lives. There is a greater demand of energy in developing countries. People are more technology based, that consume energy both in their manufacturing as well as in their applications, which is generated from conventional energy source. As non conventional solar energy source is available in abundance, still its utilization is only 1% on world level as well as India level. This has a scope to meet the need for future energy demand. Energy consumption scenario at World level and India level is shown in Fig. -1.

3.1 What is Architecture?

Architecture is the art and science of designing and constructing a buildings, structures, and spaces. The architect design from the macro-level (urban design, town planning, environmental planning, landscape architecture, etc.) to the micro-level (construction details and furniture). Thus architecture is a very large field and maximum energy is used here. An architectural building consumes maximum energy in all stages from manufacturing to operational. So the application of non conventional sources of energy in building conserves more energy.

3.2 Electrical energy used in buildings

The 40% of electric energy is utilized in building sector (Fig. -2). It is in different ways from manufacturing of materials to the building construction and even more in actual operation. The building sectors includes domestic, commercial, Industry and following fig. shows its future utilization in this industry.

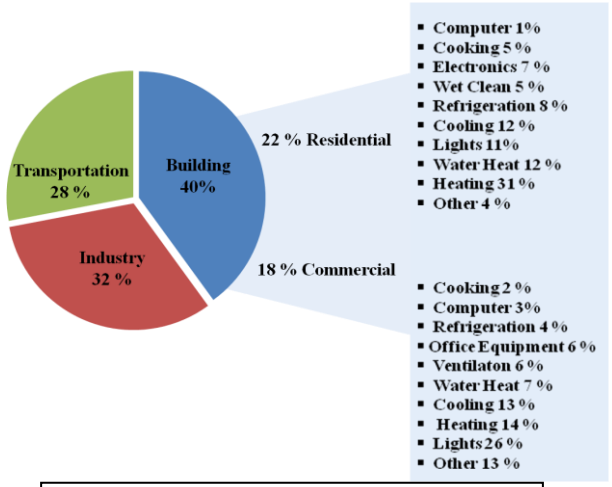


Fig 2: Consumption of Energy In Buildings

Source: www.wrsc.org/total-energy-consumption 2007

Solar energy has a potential to meet the above demand for architectural buildings. So, India should utilize the solar heat and harvest the benefits of its energy.

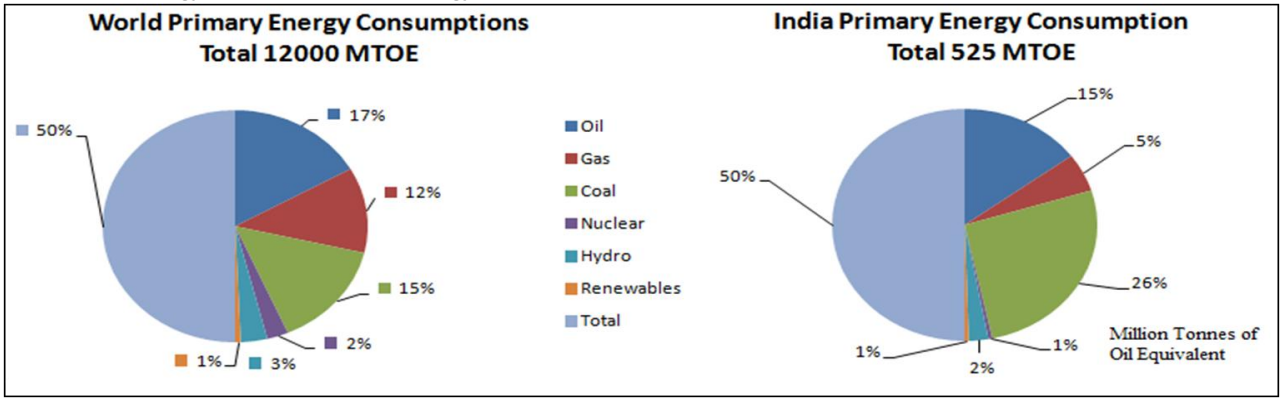


Fig 1: Energy Consumption scenario In Different Sectors

Source: BP Statistical Review – June 2011

4. APPLICATION OF SOLAR ENERGY IN ARCHITECTURE

Solar energy is the light and radiant heat from the **Sun** that powers the earth's climate and weather and sustains the life.
Solar energy in the architectural building works on the principle of Heat Transfer. Heat flows from warm to cold (because of temperature difference) and continue until temperature become equal. Heat always transfers in three ways by conduction, convection, radiation. And Earth gains solar energy through radiation which can be utilized in a building to minimize load on conventional systems (heating, cooling, ventilation and lighting).
The Photo thermal (light and heat) energy of sun in the form of short & long waves can be used in the buildings in active (direct) and passive (indirect) ways and is called as solar techniques.

4.1 Solar techniques

4.1.1 Active solar techniques

Active solar technologies consist of a solar collecting device that is designed to capture the sun's energy. It is used to store or transfer heat energy in water or air. Active solar incorporates all the elements of a passive solar design with additional mechanical equipment, such as pumps or fans, to take advantage of the heat from the sun. It is a design strategy for high-performance, ultra-energy-efficient buildings.
Following are the active solar techniques:

- Solar photovoltaic system
- Solar water heating
- Solar Space heating
- Solar Space cooling
- Solar concentrators

4.1.2 Passive solar techniques

Passive solar techniques make use of the steady supply of solar energy by means of building designs that carefully balance their energy requirements with the building's site and window orientation. The term "passive" indicates that no additional mechanical equipment is used, other than normal building elements. All solar gains are brought in, through windows with minimum of pumps/fans to distribute heat if required.
Following are the passive solar techniques:

- Thermal Mass : Trombe wall, Water wall
- Solarium
- Solar chimney
- Day lighting

Passive solar techniques works on any of the three principles:
Direct gain principle
Direct gain is the capture of the solar passive energy directly through doors and windows to heat the room and it's mass. Also provides residual warmth even for the evening hours.(Fig.-3)

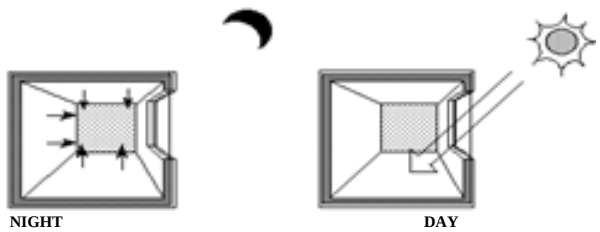


Fig 3: Direct Gain

(Source: www.passivesolar.weebly.com)

Indirect gain principle
This system has a heat collector-accumulator in the form of a wall, painted in a dark color and full height, with a ventilator at the top and bottom. Heat enters the building through windows and is captured and stored in thermal mass (e.g. water tank, masonry wall) and slowly transmitted indirectly to the building through conduction and convection.(Fig.-4).

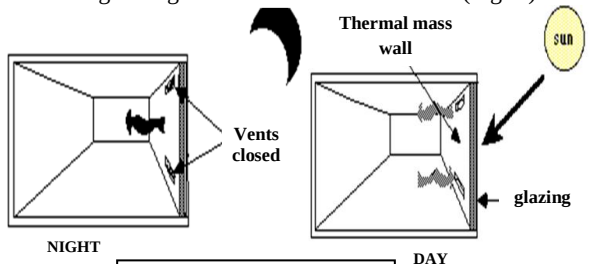


Fig 4 : Indirect Gain

(Source: www.passivesolar.weebly.com)

Isolated gain principle
This system has a heat collector-accumulator in the form of a wall, painted in a dark color and full height, with a ventilator at the top and bottom. The ventilators allow the circulation of the warmed air inside the room.(Fig.-5)

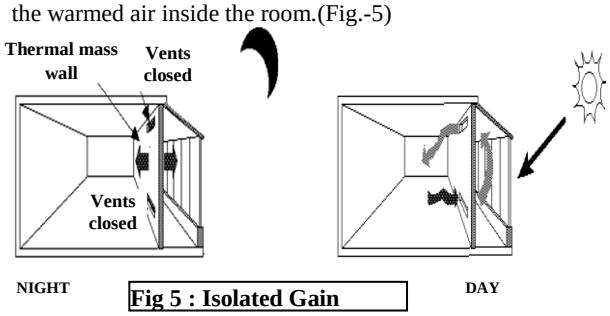


Fig 5 : Isolated Gain

(Source: www.passivesolar.weebly.com)

4.2 Implementation of solar techniques in buildings

Use of non conventional solar energy in active and passive way in buildings will definitely reduces the operational cost of building and saves energy. By integrating these techniques while designing the building as an architectural element we can enhance the beauty of building instead of treating it as separate part.

Following are the techniques and their implantation in buildings

4.2.1 Solar photovoltaic system (active solar technique)

Photovoltaic system is the solar energy system that produces electricity directly from light. Photovoltaic means getting electricity from light. This technique is applicable all parts of India
Working principle
The components of Photovoltaic system includes a battery charge controller, batteries, an inverter or power control unit (for alternating-current loads), safety disconnects, grounding circuit, and wiring.
Photovoltaic modules also called solar modules, are the main components used to convert sunlight into electricity. They are made of semiconductors used to create integrated circuits. Light striking the silicon crystals induces the "photovoltaic effect," which generates electricity (DC) and can be used immediately to stored in a battery. And that can be used for

water pumping, lighting, communications, refrigeration, house hold appliances etc.

Energy conservation

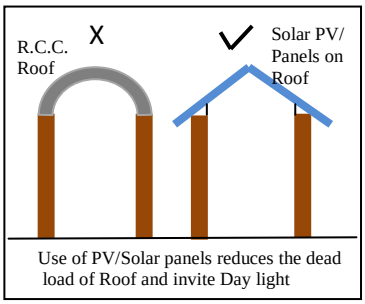
There will be a saving between 30%- 40% on current electric consumption. Solar electric energy demand has grown consistently by 20-25% per annum over the past 20 years

Architectural implementation of PV panels:

Modules of photovoltaic panels which are mainly used in electricity generation are available in various sizes like 3'x 6', 3'x 4' etc. As it is required more space to installed, so PV panel can be integrated in the building as an architectural element. And the battery part should be kept in a separate space for the power supply.

Following are the architectural use:

- As a building façade
- As a shading device above windows
- As a roofing material(Skylight)
- Solar electric lamp



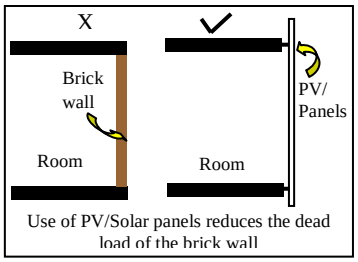
(Source : Author)

4.2.1.1 PV as a building façade

To trap the maximum solar heat gain PV panels can be implanted on the southern or south-west façade of building envelope.

Following are its advantages:

- It can be act as a curtain wall.
- It reduces the dead load of building
- Replace the masonry wall, results in cost reduction



(Source : Author)

- If it executed on the wall then total heat gain in the building through wall will be less which results in energy saving.
- Increases the aesthetic value of building.

PV Curtain Wall

PV Facade

(Source :www.solarecathlon.upm.es)

4.2.1.2 PV as a shading device

PV Panel chajja

PV panel poarch

(Source : www.awesomesolarpanel.com)

Shading device is the horizontal projection to protect against the weather condition. Shading device may attached to the building or may be connectivity between two buildings/ spaces. Module of PV cell can use for windows, porch, entrance foyer, canopy, shading over the pathways.

Following are its advantages:

- Replaces the existing elements.
- Reduces the cost of dead load of concrete.

4.2.1.3 PV as a roofing material

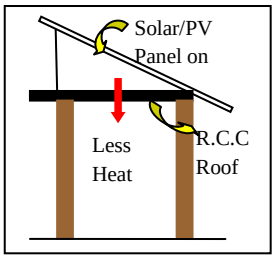
Tilted roofing is more effective to generate electricity than perpendicular roofing of PV panels.

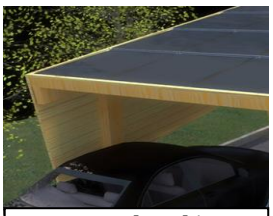
Following are its advantages:

- It can be act roof to covered parking area.
- It can be act as shading against weather condition to atrium.
- It reduces the dead load of masonry roof.
- If implemented on slab then PV act as a good heat insulator for slab.

PV Panel atrium

PV Panel roof





PV Panel parking

(Source : Author) *(Source : www.awesomesolarpanel.com)*

4.2.1.4 PV as Solar electric lamp

PV panels are installed above the electric pole with a small box for battery may be at the bottom of pole for power supply. Light poles can be executed in landscaped area, circulation pathways, in and around the building.

Following are the advantages

- No need to run electric line throughout the campus, so flexibility in design.

Solar Lamp

(Source: www.energynext.in)

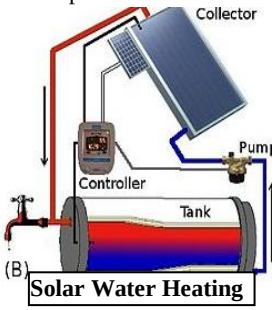
4.2.2 Solar water heating (active solar technique)

Solar water heating is the process in which the solar energy is directly used in heating the water for most of the year.

In Indian scenario hot water from solar panel is available all the time except in cloudy days. During the low sunny days of the year, heat trapped in the panels is sufficient for normal heating. This technique is applicable in all parts of India.

Working principle

There are five main components of a solar water heater namely solar panels (collecting panels & backup heating system), storage tanks,



Solar Water Heating

(source:www.solarcontact.com)

circulation system, and control system. As water in collector is heated, it becomes lighter and naturally rises into tank above. Meanwhile the cooler water in the tank flows downwards into the collector this cause circulation throughout the system. Inclination of solar panel depends on altitude angle appox. 20 degree.

Energy conservation

There will be a saving between 80%- 90% on current electric heating bill.

Architectural implementation of solar panels:

Solar panels are place in the modules and can be implemented in the same pattern as solar photovoltaic.

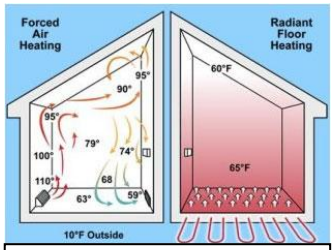
4.2.3 Solar space heating (active solar technique)

Space heating is a system in which solar's thermal collector is the basic device which transfers sun energy into thermal energy. This technique is applicable in composite and cold and cloudy climatic regions of India.

Working principle

There are two basic types of active solar heating systems based on the type of fluid (liquid or air) which is heated in the solar energy collectors. Both of these systems collect and absorb solar radiation, then transfer the solar heat directly to the interior space or to a storage system, from which the heat is distributed.

Active solar space heating systems collect and absorb solar energy then use electric fans or pumps to transfer and distribute that heat. Passive solar space heating capitalizes on warmth through the sun through design features as well as materials in the walls or floors that absorb heat during the day and release that heat at night



Solar space heating
source :www.solardynamix.com

Energy conservation

Residential regular heating system to reduce heating cost up to 60%.

Architectural implementation

Following are the architectural use:

- Flooring
- Walling
- Ceiling

4.2.4 Solar Space cooling (active solar technique)

Space cooling is the absorption chillers, a closed-loop system that converts solar heated water into air cooling. This technique is applicable in hot and dry and humid climatic regions of India.

Working principle

Water heated by the sun is passes through the tube loops with low pressure with lithium bromide (a phase change catalysts) which reduces the temperature up to 44 degrees F. This cooled water runs through copper piping & forced air passing over the coils which produces air conditioning.

Energy conservation

For regular cooling system savings on electricity bills upto 80%.

Architectural implementation

Solar thermal cooling is used in commercial & residential applications for the following:

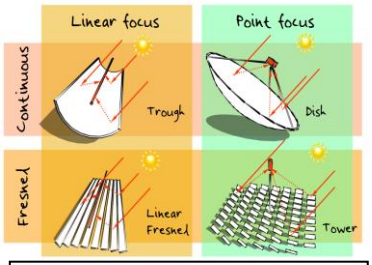
- Flooring
- Walling
- Ceiling
- Act as a reinforcement for floors

4.2.5 Solar concentrators (active solar technique)

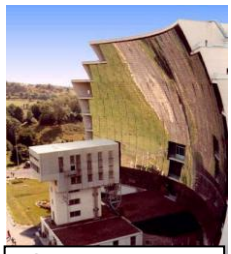
Solar concentrators are a concave mirror which reflects the incident sunrays & focus on one target to produce electricity. This technique can be applicable everywhere in India.

Working principle

Solar concentrators are stationary devices and major components of solar concentrators are mirror(s), absorber within a receiver, and heliostats. Conventional solar concentrators are mirrors that collect a large area of the sun's light and direct it onto a smaller area of solar cells. This technology not only increases the power of solar panels but reduces the overall cost of solar power.



Types of solar concentrators
Source: csirosolarblog.com/ about/solar thermal energy)



Concentrators as building façade
(source:www.emerald ecocity.com)

Energy conservation

By maximizing the amount of light hitting on the concentrator, the efficiency of solar power systems can be improved up to 70 percent.

Architectural implementation

[1] Following are architectural use:

- As a building façade
- As a curtain wall

4.2.6 Thermal Mass (passive solar technique)

Heat enters the building through walls or windows and is captured and stored in a wall and slowly transmitted indirectly to the building through conduction and convection is called thermal wall. Thermal mass acts as a thermal battery. Thermal wall are Trombe wall and Water wall.

Trombe Wall

A Trombe wall is a thick dark painted wall may be of glass or brick or stone. These absorbs the sun's energy throughout the day and releases it during the night time to maintain a constant and comfortable temperature within the building.(Fig. 5)

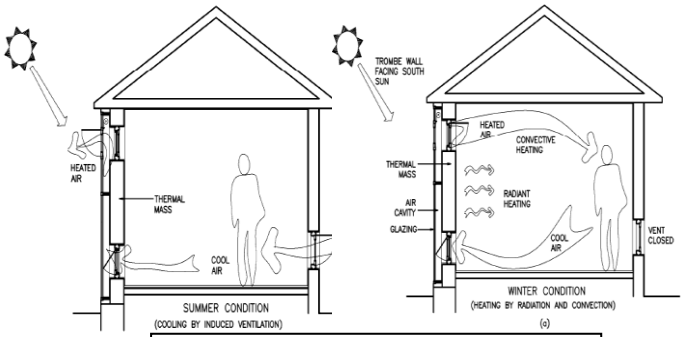
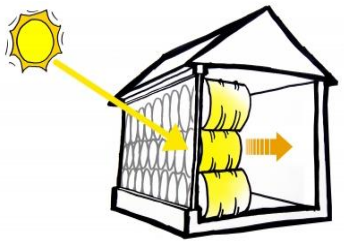


Fig 5: Trombe wall
Source : www.passivesolar architecture/pdf

Water wall

A water wall consists of a water barrel painted with black polyethylene kept between the masonry wall and a glazed façade that absorbs the sun's energy throughout the day and releases it during the night time to maintain temperature within the building



Water wall
(Source: sustainabilityworkshop /trombewal and attach sunspace)

Working principle

The temperature increases in the air space behind the glazing and in front of the wall due to the effects of solar radiation. The heat radiations are stored in thermal mass which are reradiated during night. The wall then stores the energy and transfers its heat to the interior of the home. Vents in the lower and upper parts of the insulated wall result in the circulation of warm air into the room at the top of the these walls.

Energy conservation

Trombe wall contributing 20% of the total heating to the building. These passive solar house heating techniques, gives 30% yearly savings in space heating costs.

Water wall contributes about the 30% of the night heating cost in the building.

Architectural implementation:

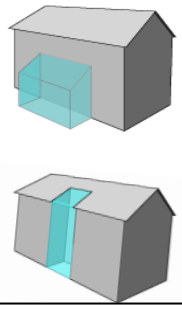
- Used as a building envelop.
- Textured and glassy surfaces increase building aesthetics.
- Water wall act as water storage tank.

4.2.7 Solarium (passive solar technique)

A solarium is a glazed room which is designed to collect sunlight and heat. It is also known as solar room, sunroom, sunspace, green house.

Working principle

Sun rays entering the glazed room are preserved in the thermal mass and air of the room. Sun's heat gets in by means of conduction and stored into the mass wall rear of the solarium. The vents within the wall allow the air between the solarium and building's interior to be exchanged by convection.(Fig- 6)



Sunspace
(Source: www.greenspec.co.uk)

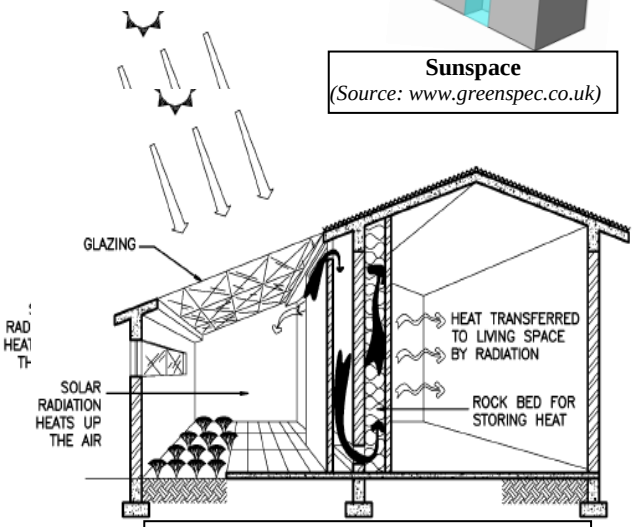


Fig 6: Solarium
Source:www.engineersgarage.com

Energy conservation

A solarium contributes 30% more heat gain when compared with a direct gain in the buildings.

Architectural implementation

- Additional living space.
- Aesthetic perspective.
- Glass façade on south side reduces dead load.
- As a buffer space.

4.2.8 Solar chimney (passive solar technique)

A solar chimney (or thermal chimney) is a passive solar ventilation system and a way of improving the natural ventilation of buildings by using convection of air heated by passive solar energy (natural stack ventilation).This type of technique is used in a composite & cold climate.

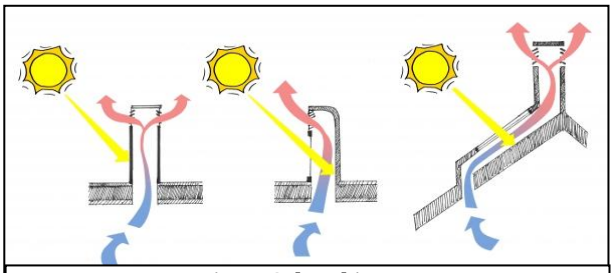


Fig 7 : Solar chimney
(Source:sustainabilityworkshop.autodesk.com)

Working principle

Through convective cooling principles, thermal chimneys allow cool air pushing hot air from the inside out. Designed based on fact that hot air rises, they reduce unwanted heat during day and exchange interior (warm) air for exterior (cool) air. Solar chimney reduces dependency on air conditioning devices indoors.(Fig-7)

Architectural implementation:

- Used with inclined roofs without supporting structure
- Interrogated with stairwells
- Used as a Atria.
- Sky light

Energy conservation

It reduces 25 -30 % consumption of electricity.

4.2.9 Day lighting (passive solar technique)

Day lighting is a system of both collecting sunlight and reflecting the collected daylight deeper inside the rooms with elements such as light shelves.

Working principle

Day lighting is the simple concept to brighten the building's interior naturally and avoid the heat from sun to reduce the electric lighting load. By using static, non-moving, and non-tracking systems such as Windows, Sliding glass doors, skylights, light tubes, light shelves we can achieve this.(Fig 8)

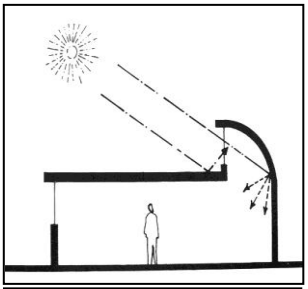


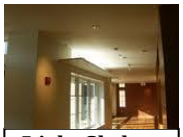
Fig 8 : Daylight
(Source:www.informedesign.org/_news/mar_v03)

Architectural implementation:

For proper Day lighting 5% of the floor area has to be glazed. Day lighting can be implemented in buildings in various ways:

- Windows
- Clerestory windows
- Skylights
- Light reflectors
- Light shelves
- Light tubes
- Saw tooth roof


window


Light Shelves


Clearstory


Light Tubes


Swatooth Roof


Skylight


Light Reflector

(Source :en.wikipedia.org/wiki/Daylighting)

Energy conservation
Efficient Day lighting reduces 45-50 % energy consumption of electricity required for lighting.

5. CONCLUSION

Non conventional solar energy source have high potential to generate electric energy, due to its abundance availability in tropical region of India. And will be use for the high energy consuming sector i.e. architectural buildings. For its optimum use in building, there is need to design the prefabricated building elements which can easily integrate and generate electricity within Architectural building. By using readily available solar electric generating elements like chajja, skylight, louvers, windows, balcony railings, walls etc., we can make the future safe for the energy use.

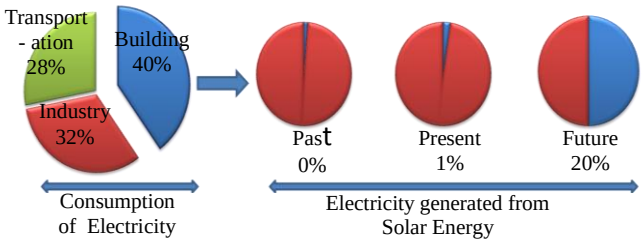


Fig 9: Use of Solar electricity in Architectural Buildings
Source : Author

Current energy used in buildings is. 40% (Fig:9), which can be saved up to half of the actual consumption i.e. 20%, by the use of active and the passive solar techniques.

6. ACKNOWLEDGMENT

Thanks to the associates in Department of Architecture, MIT (E), Aurangabad, Maharashtra, India.

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