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PASSIVE SOLAR ENERGY

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Abstract

In passive solar building design, windows, walls, floors are made to collect, store, and distribute solarenergy in the form of heat in the winter season and reject solar heat in the summer season. This is called passive solar design because, unlike active solar heating systems, it does not involve the use of mechanical and electrical devices.The key to design a passive solar building is to take the best advantage of the local climate performing an accurate site analysis. Elements to be considered includes window placement and size, and glazing type, thermal insulation, thermal mass, and shading. Passive solar design techniques can be applied most easily to new buildings, but existing buildings can be adapted or "retrofitted".Thermal mass is another vital and complimentary component of passive solar design. A material that has the thermal mass is one that has the capacity to absorb, store and release the sun's heat energy. In this manner, they can store and release the sun's heat energy. Objects with thermal mass will also keep a building cool.The passive solar system should always be built to conserve high energy conservation standards. Also, it must be carefully planned and designed to balance the glass area and the storage mass. Otherwise, the house may overheat, under heat, or have undesirable temperature swings. Without systematic planning, your passive solar system could end up using more energy than it collects. There are several types of passive solar systems that can be used in buildings and homes. The most common are direct gain, indirect gain, and isolated gain.

Index Terms: *solar energy , solar heating , site analysis, thermal insulation, thermal mass.*

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1. INTRODUCTION

The idea of passive solar is so simple, but applying it effectivelydoes require information and attention to the details of the designing and for construction. Some passive solar techniques are modest and low-cost. and requires only small changes in a builder's standard practice. At the other end of the spectrum. Some passive solar system can almost eliminate a house's need. for purchased energy, but probably at arelatively high first cost.

In between are a broad range of energy conservating passive solar techniques. Whether or not they are cost effective,practical but attractive enough to offer a market advantage to any individual builder depends on very specific factors such as local costs. climate and marketcharacteristics.

2. PASSIVE ENERGY GAIN

Passive solar technologies use sunlight without active mechanical systems (as contrasted to active solar). Such technologies convert the sunlight into usable heat (in water, air, and thermal mass), cause air-movement for ventilating, orforfuture use, and with the little use of other energy sources. A common example of polar energy gain is a solarium on the equator-side of a building. Passive cooling is the use of the same design principles to reduce the summer cooling requirements.

Some passive solar systems use a small amount of conventional energy to control dampers, shutters, night insulation, and other devices that enhance the solar energy collection, storage, and use, and reduce the undesirable heat transfer.

Passive solar technologies include the direct and the indirect solar gain for the space heating, solar water heating systems based on the thermo siphon, use of thermal mass and phase-change materials for slowing the indoor air temperature swings, the solar cookers, the solar chimney for enhancing natural ventilation, and the earth sheltering.

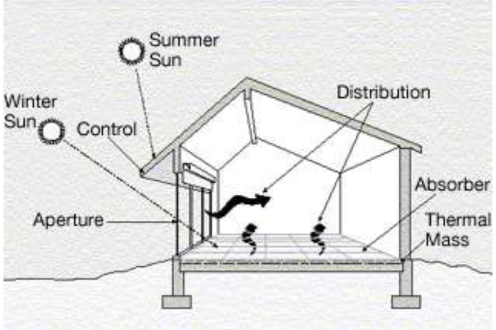

Fig (i): Elements of passive solar design, shown in a direct gain application

3.PASSIVE SOLAR HEAT TRANSFER PRINCIPLES

Personal thermal comfort is a function of personal health factors such as medical, psychological, sociological and situational, ambient air temperature, mean radiant temperature, air movement such as wind chill, turbulence and relative humidity such as affecting human evaporative cooling. Heat transfer in the buildings occurs through convection, conduction, and thermal radiation through the roof, walls, floor and windows.

3.1 Convective Heat Transfer

Convective heat transfer can be beneficial or detrimental. Uncontrolled air infiltration from poor weatherization / weather stripping / draft-proofing can contribute up to 40% of heat loss during winter; however, strategic placement of operable windows or vents can be enhanced through convection, cross-ventilation, and summer cooling when the outside air is of a comfortable temperature and relative humidity. Filtered energy recovery ventilation systems may be useful to eliminate undesirable humidity, dust, pollen, and microorganisms in the unfiltered ventilation air.

Natural convections causing rising warm air and falling cooler air can be result into an uneven stratification of heat. This may cause uncomfortable variations in temperature in the upper and the lower conditioned space, serve as a method of venting hot air, or be designed as a natural-convection air-flow loop for the passive solar heat distribution and the temperature equalization. Natural human cooling by perspiration and evaporation may be facilitated through the natural or forced convective air movement by fans, but ceiling fans can disturb the stratified insulating air layers at the top of a room, and can accelerate the heat transfer from a hot attic, or through nearby windows. In addition, high relative humidity inhibitstheevaporative cooling by humans.

3.2 Radiative Heat Transfer

The main source of heat which is transferred is radiant energy, and the primary source is the sun. Solar radiation occurs predominantly through the roof and windows (but also through walls). Thermal radiation moves from a warmer surface to a cooler one. Roofs receive maximum solar radiation in houses and industries. A cool roof, or a green roof in addition to a radiant barrier can help to prevent your attic from becoming thehotter than the peak summer outdoor air temperature (see albedo, absorptivity, emissivity, and reflectivity).

Windows are ready and predictable site for the thermal radiation. Energy from radiation can move into a window in the day time, and out of the same window at night. Radiation uses photons to transmit the electromagnetic waves through a vacuum, or a translucent medium. Solar heat gain can be significant even in winter or rainy seasons but at low conditions. Solar heat gain through windows can be reduced by insulated glaze windows or non-transparent glasses. Windows are particularly difficult to insulate compared to roof and walls. Convective heat transfers through and around window coverings can also degrade its insulation properties. When shading windows, external shading is more effective at thereducing heat gain than the internal window coverings.

Western sun can provides warmth and eastern sun can provides lighting, but are vulnerable to overheating in the summer if not shaded. In contrast, the midday sun readily admits the light and warmth during the winter, but can be easily shaded with appropriate length overhangs or angled louvres during the summer and leaf bearing summer shade trees which shed their leaves in the fall. The amount of radiant heat received is related to the location i.e. latitude, altitude, cloud cover, and seasonal or hourly angle of incidence (see Sun path and Lambert's cosine law).

Another passive solar design principle is that the thermal energy can be stored in certain building materials and released again when heat gain eases to stabilize diurnal (day/night) temperature variations. The complex interaction of thethermodynamic principles can be counterintuitive for first-time designers. Precise computer modeling can help to avoid costly construction experiments.

4. ROOF TOP SOLAR POWER PLANT ATKSCA’S M CHINNASWAMY STADIUM

RenXSol Ecotech Pvt. Ltd. has announced that the 400 kW roof top power plant at KSCA’s M Chinnaswamy Cricket Stadium in Banglore was successfully installed, with successful testing, integration and evacuation to BESCOM grid post CEIG approvals on the April 8, 2015.

Roof top installation of passive solar power plant by KSCA is a novel initiative that has been executed for the first time at any stadium in India and probably also the first cricket stadium in the world to have such a great and sustainable facility. Also, this roof top installation is the first project in Karnataka of this size for any industry or institution being sanctioned under the Net Metering policy of BESCOM announced on November 2014 and such project was installed and commissioned in short time of about 45-50 days.

The 400 kW rooftop solar power plant system has 300Wp(72 cells) multi-crystalline solar panels with 20 kW Grid Tie type String Inverters, 20 nos., evacuated with bi-directional metering to BESCOMat HT level of 11 KV substation under thenew BESCOM Net Metering Solar Policy wasannounced on Nov-14. While RenXSol handled the design, engineering, to project management consultancy (PMC) for the whole project, the execution was done by a KSCA approved vendor under RenXSol and KSCA guidance.

Fig.(ii) : Solar Plant in M. Chinnaswamy Stadium, Banglore.

5. EFFICIENCY AND ECONOMICS OF PASSIVE SOLAR HEATING

Technically, PSH is highly efficient. Direct-gain systems can utilize (i.e. convert into "useful" heat) 65-70% of the energy of solar radiation that strikes the aperture or collector.

Passive solar fraction means percentage of the required heat load met by Passive Solar Heating and hence represents potential reduction in heating costs. RETScreen International has reported a PSF about 20-50%. Within the field of sustainability, energy conservation even of the order of 15% is considered substantial.

Fig(iii) Darmstadt University of Technology in Germany won the 2007 Solar Decathlon in Washington, D.C. with this passive house designed specifically for the humid and hot subtropical climate.

Other sources report the following PSFs:

- 5-25% for modest systems
- 40% for "highly optimized" systems
- Up to 75% for "very intense" systems

In favourable climates such as the southwest United States, highly optimized systems can exceed 75% PSF.

6. CONCLUSION

Passive solar is good for buildings which have low internal heat gains and in which direct solar gain is directed to absorbent thermal mass. The housing market for today may object to hard floorsurfaces out of concern for comfort and impact noise, but increased drywall thickness and concreteceilings may compensate for the lack of hard flooring. Mass is the most effective if it receives direct solar gains, i.e. usually on the floor. However, if this is not possible, a concrete ceiling will absorb much of the energy from the air heated by the floor; this air will berised through liveliness.

The cost of passive solar is minimum and affordable but must be well planned during the initial design stages. Solar domestic hot water can be having a reasonable payback time and it is relatively easy to install in the new buildings and the retrofits.

Glass pane and Trombe wall models are good prediction of actual performance. Natural passive systemscan provide a portion of space heating for well insulated home in colder climate. Insulation patterns have a definite effect on the performance of the glass pane and Trombe wall systems. Presently, photovoltaics (PV) are an expensive way to provide the electricity and are more cost-effective combined with heat recovery as well. However, the cost of building-integrated photo voltaic systems is coming down as competition and market share increase.

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