Net Zero Energy Building: Design Strategies

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Abstract – *Energy demand is increases tremendously now a days and its major source is fossil fuel which is responsible for pollution, climate change, etc. For that scenario energy saving plays a very significant role. Buildings have significant impact on energy and environment. Among the various efforts of energy security and sustainability, Net Zero Energy Building can play a vital role which has been addressed in this paper. Here we can discuss about how to achieve NZEB standards by achieving energy efficiency and utilizing various renewable energy sources on-site or off-site. This paper focuses on the various passive solar building strategies for achieving energy efficiency and various renewable energy sources.*

Key Words: Net Zero Energy Building, Energy efficiency, Passive solar building strategies, Green material, Renewable energy sources.

1. INTRODUCTION

For present situation other industries such as cars, ships, planes, paper, metal all kind of industries are priorities for conservation of energy and like to use renewable, reliable use such a kind of energy which has minimum or neglected amount of impact on environment. The building is still view as shelter only combination of steel, concrete, brick but from the present scenario we had like to shift our view about it. Main threats over todays modern era is pollution, global warming and climate change. Share of global energy consumption and CO_2 emission by building sector is more as compare to other sectors. Energy consumption is almost 36% and CO_2 emission is 39% by building sector alone. Net zero energy building is better solution for that scenario.

In concept, a NZEB is a building with greatly reduced energy needs through achieving energy efficiency without compromising occupants comfort and fulfill remaining energy demand by providing renewable energy technologies.

2. NZEB DESIGN STRATEGIES

It includes achieving energy efficiency by passive solar design strategies, using various green materials and using efficient equipment and systems. And then finally utilize renewable energy sources.

2.1Step1–It includes design strategies and features-

That reduce the demand side load as high performance envelopes, air barriers systems, daylighting, sun control and shading devices, careful selection of windows and glazing, passive solar heating, natural ventilation. Passive solar building strategies play a vital role in that step. Passive solar buildings take advantage of local climate. It includes following key strategies which are helpful for achieving energy efficiency without compromising occupants comfort.

1. Form and orientation:-

It affects the amount of solar radiation falling on surface, daylighting measures and direction of wind. Properly provision of form and orientation maximizes amount of solar radiation in winter and minimising the amount in summers.

- Recommendations:-
  - i. Orient longer facades along the north. This will provide glare free light in summer from north without shading and winter sun penetrations from the south.
  - ii. Place building at a 30-40 degree angle to direction of wind for enhanced ventilation. Staggered form in wind direction also achieves the same results.

- Cooling for hot regions:
  - i. Buildings Surface area to volume ratio should be low as possible to minimize heat gain.
  - ii. Square form should ideally orient. Because square plan is more thermally efficient than rectangular plan.

- Recommendations for composite climate:
  - i. Compact form with low surface area to volume ratio is recommended.
  - ii. A square plan with a courtyard would be very effective.
  - iii. A rectangular form with a longer axis along the north-south is the preferred orientation.

- Heating for cold climate:
  - i. Buildings Surface area to volume ratio should be low to avoid unwanted heat loss.
  - ii. Orientation slightly towards east of south. And building with a rectangular form should orient longer axis towards north-south.
  - iii. Greater the perimeter to area ratio greater is the heat gain of the building.

2. Shading:-

Shading devices are essential environmental controls that either prevent or greatly reduce the need for mechanical heating and cooling to maintain thermal comfort inside buildings, by controlling heat gain through openings.

- Recommendations:-
  i. South facing windows are easiest to shade. Overhangs on south oriented windows provide effective shading by blocking summer sun and admitting winter sun.
  ii. Shading is generally not required at the north side. Only cutting the low evening summer sun can be achieved by vertical shades or internal blinds.
  iii. East and west glass is harder to shade so minimize the window area on that sides.

3. Daylighting:-

Daylighting is a building design strategy to use light from sun. Presence of natural light in an occupied space brings healthy indoor condition and also increases energy saving potential with reduced dependence on artificial light. Appropriate use of windows, skylights, clerestories, and other apertures in the building provide means to harvest daylight. Daylighting strategies vary with location and climate.

- Recommendations:-
  i. Sidelight is the most common method of allowing daylight into the building. Glare from direct sunlight can be prevented by using light shelves.
  ii. Use skylights and roof monitors to areas without easy access to windows.
  iii. Use of light coloured interior surfaces reduces luminance contrast and improves coverage.
  iv. The use of heliostat mirrors which are moved automatically to reflected sunlight in a constant direction as the sun moves across the sky, is going popularity as an energy efficient method of lighting.

4. Insulation:-

Thermal insulation in walls and roofs reduces heat transfer between the inside and outside and helps maintain comfortable indoor temperature. It provides healthier environment, adds sound control, and most important lowers the electricity bills. Insulation helps keep indoor space cooler in summer months and warm during winters.

- Recommendations:-
  i. Insulation should be placed at the hotter side of the surface (in case of summer cooling, insulation should be on outer side, while in case of heating the building, insulation should be placed on the internal side).
  ii. Providing insulation beyond 100mm thickness does not provide a much further benefit in terms of energy efficiency. Provision of the initial 25mm of insulation, provides the highest incremental energy saving. As the insulation material becomes incrementally thicker, the incremental energy saved becomes smaller and smaller until it is almost insignificant, especially after an insulation thickness of 100mm onwards.

5. Fenestration:-

Fenestrations windows, skylights, & other openings in a building etc. allow daylight and the prevailing wind inside the building when needed. From NZEB design perspective, building fenestrations can affect lighting and air-conditioning loads considerably.

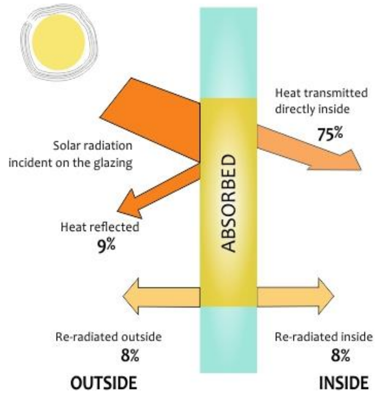

Fig -1: Fenestration

- Recommendations:-
  i. Reduce Solar Heat Gain Coefficient (SHGC) as less heat will be transferred into the building. It should be lower for warmer climates and vice versa.
  ii. For dayligting purpose Visual Light Transmission (VLT) is higher.
  iii. Lower U-value means less heat is conducted.
  iv. In colder climate when A.C. is generally not considered SHGC=0.30-0.60
  v. In mixed climate SHGC<0.40 (In warmer months when A.C. becomes high SHGC<0.30)
  vi. In warmer climate for windows SHGC<0.27 and for skylights SHGC<0.30

6. Natural ventilation:-

Fresh air in a building brings health benefits and increased comfort level to its occupants. Fresh air provision is considered as an efficient and a healthy solution as it reduces the need for mechanical means to ventilate a building.

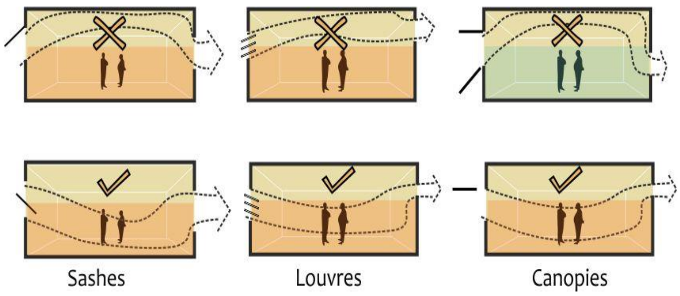

Fig -2: Opening Controls

- Recommendations:-
  - i. Maximum air movement is achieved by keeping the sill height at 85% of the critical height.
  - ii. Total area of openings should be a minimum of 30% of floor area.
  - iii. Window-wall ratio (WWR) should not be more than 60%.
  - iv. Greatest flow per unit area of opening is achieved by keeping the inlet and the outlet of nearly same sizes at nearly same levels.

7. Evaporative cooling:-

Evaporative cooling lowers the indoor air temperature thus lowers the energy cost for air-conditioning in buildings.

- Recommendations:-
  - i. Cooling towers the cooling tower may be used to evaporate, precooling ventilation air for one or more air handling units (AHU), reducing the load on the mechanical cooling system.
  - ii. Use of porous materials- roof materials can cause evaporative cooling effect.

2.2Step2–Use of green materials-

For further reduction of load use various green materials. Which is also helpful in achieving energy efficiency also it has lower environmental impact as compare to conventional materials.

1. Bricks:- AAC blocks are use because it has various advantages such as better indoor air quality, energy efficient K-value=0.12w/m.k, material efficiency, CO2 reduction, water conservation.
2. Cement:- PPC is used in construction, it will be green material because PPC contains fly ash as main ingredient.
3. Green paint:- Paints with reduced levels of VOCs are more eco-friendly than conventional paints.
4. Green wood/Engineering wood:- Engineering wood products made from a combination of wood fibres, strips and veneer sheets. Engineering wood products also called composite wood.
5. Cool roofs:- Cool roofs are able to maintain a temperature difference of 6-8 degree Celsius between ambient and indoor air temperature due to high thermal emittance and solar reflectance.

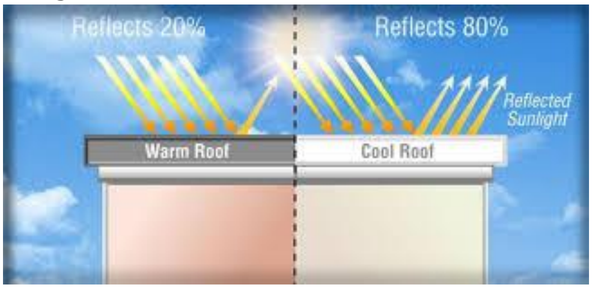

Fig -3: Cool Roof

2.3Step3–Use of efficient equipment and system-

Once building loads are reduced, the loads should meet with efficient equipment and systems. This include energy efficient lighting, electric lighting control, high performance HVAC.

1. Lighting:- Lighting energy demand is more than quarter of total energy consumption in building. Therefore it is important to optimise lighting energy use to achieve net zero goals.

   LEDs is the best option for lighting, it reduces energy demand very significantly. LEDs have high luminous efficacy 90-120 lumen/watt also long lamp life 20000-30000 hrs. It has low heat load and good colour rending index.

Fig -4: LEDs

2. Lighting control:- Lighting control system can reduce energy use by switching or dimming lamps when spaces are unoccupied or sufficient natural daylighting is available.
   - i) Stand alone system (Occupancy sensors or daylight sensors)-

     This system use time switches or photocells to switch lights. Photocells can monitor the level of useful daylight and turn off in rows adjacent to windows.
   - ii) Network control system (Time schedule, central monitoring etc.)-

A Network control system is termed as intelligent system which uses one or more central computing network to control the lighting operational requirement in indoor and outdoor lighting through manual inputs or programmed inputs.

3. HVAC:- Select the correct system applicable based on the functional requirement, energy efficiency concerns and operational use.
   Integrate systems like demand controlled ventilation and energy recovery system to reduce the system size.
4. Standards and labelling provision:- Use of energy labelling equipments and systems is one of the most cost effective policy tool for improving energy efficiency and lowering energy cost of appliance or equipment for the consumers.

2.4Step4–Use of renewable energy source-

Once efficiency measures have been captured the remaining energy needs can be met using renewable energy sources.

1. Whirlpool turbine:-

It is a type of micro hydro vortex turbine system which is capable of converting energy in a moving fluid to rotational energy using a low hydraulic head of 0.7-3m. In this type of turbine an artificial vortex is formed. The technology is based on a round basin with a central drain. System range in size from less than 500W to 100KW and series of units can be installed in a serial or parallel configuration along the river to increases power production.

Fig -5: Whirlpool Turbine

2. Waterotor energy harvester:-

It is a low cost power from slow moving water. It can operate in very slow moving water as slow as 2mph.Over 71% of earth's surface is converted in slow moving water making many locations viable for using the waterotor.

Fig -6: Whirlpool Turbine

3. Ultra small water power generator:-

It's a spiral blade turbine which utilise unused energy from nature. For 10 watt generation 10 lit/sec flows required with head of 0.1 m. For 500 watt generation 100 lit/sec flows required with head of 0.7 m.

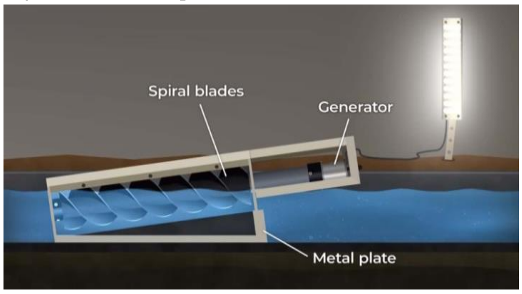

Fig -7: Ultra small Water Power Generator

4. Home biogas:-

It is self assembled biogas system that turned kitchen waste and livestock manure into usable cooking gas and liquid fertilizer. The system produces clean cooking gas up to 3 hrs/day.

Fig -8: Home Biogas

5. Use of sewage (Waste to energy):-

Using waste for energy is cheap, renewable and readily available form of energy for many cities. For sewage treatment plant it allows them to be energy self sufficient.

6. Turning poop into power:-

Rapidly advancing digester technologies make it possible to extract and refine natural gas from the methane in human and animal waste, generating power rather than polluting the environment.

7. Solar energy:-

Solar energy is radiant light and heat from sun that is harnessed using a range of ever evolving technology. These technologies involve solar heating, photovoltaic, solar thermal energy and solar architecture.

8. Wind energy:-

A wind turbine converts the energy in wind to electricity by rotating propeller like blades around the rotor. The rotors turn the drive shaft, which turns an electric generator.

9. Piezoelectric energy harvester:-

The piezoelectric material has the ability to convert the mechanical stress applied on it into electrical energy through suitable mechanical. Human locomotion, machine vibrations are able to generate electricity by using piezoelectric materials. An 'Innowattech' the Israel based company claims that, 1km of piezoelectric road of one lane we can generate around 44,0000kwh/year.

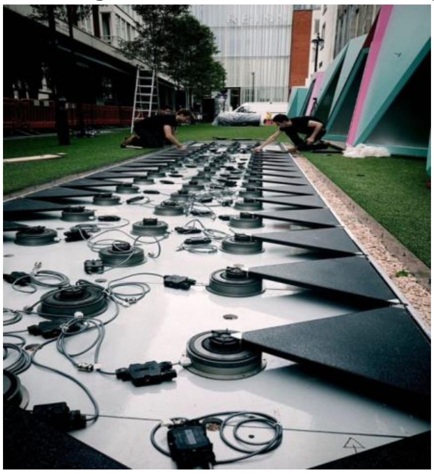

Fig -9: Piezoelectric Pavers Generator

3. CONCLUSIONS

Energy efficiency is generally the most cost effective strategy with the highest return on investment and maximizing efficiency opportunities before developing renewable energy plans will minimize the cost of the renewable energy projects needed. Passive solar building strategies play a vital role in achieving energy efficiency. It will reduce energy demand significantly. Passive solar strategies are simple and reliable tool in NZEB design. NZEBs must sharply reduce energy use and then use renewable energy systems to meet the residual energy needs. These climate specific approaches based on sun, wind, light and micro-climatic considerations can be employed to design energy efficient buildings. Extreme energy efficient must be at the core of NZEB. Use of green materials and efficient appliances also saves energy in greater extent.

Renewable energy systems are the final step to attaining zero energy goals. Once all possible measures to reduce energy demand are deployed, renewable energy systems must step in to balance residual energy demand. Technical advancement in energy sector discovers various on-grid and off-grid renewable energy sources it is helpful for achieving NZEB goals.

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