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PATHWAY TO NET-ZERO ENERGY BUILDINGS

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Abstract

Buildings have noteworthy effect on energy use and the environment. Building sector alone is consuming 40 percent of total energy utilization. There are significant opportunities of 30-40 percent energies saving has been achieved through retrofitting of existing buildings and in new building construction. Various organizations namely, The Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (GRIHA) and U.S Green Building Council (USGBC) are promoting Green Building Certification, have numerous impacts on new construction, needs more understanding of the green building concept and technologies. The concept of Net-Zero Energy Buildings (NZEB) is a solution for the reduction of GHG emissions. In the search of energy security and sustainability, NZEB can play a fundamental part. NZEB need grid power just for synchronizing and makeup power on the occasion of non availability of renewable power. This paper discusses the descriptive case study investigating an existing green building towards a pathway for NZEB. The attempt has been made to evaluate the concept and technologies demonstrated in the existing building of Indira Paryavaran Bhawan, New Delhi. It shows the path to achieve NZEB integrating renewable energies.

Key words: Net-Zero Energy Building, Green Building, GHG emissions and Renewable Energy.

Introduction

According to the present scenario climate change and environmental degradation by the release of greenhouse gases (GHG) emissions into atmosphere, building division is one of the biggest consumer of energy and responsible for a considerable energy related carbon dioxide emissions worldwide. Rapid growth of population and urbanization is leading to enormous demand of buildings in India. A large variety of mitigation measures are being taken up by various organizations and government for sustainable building construction (Ali *et al.*, 2016). Three organizations namely IGBC, GRIHA and USGBC are promoting Green Rating system for different types of buildings and claiming 30-40% energy saving resulting carbon dioxide emission reduction. Govt. of India has also developed Code for Energy Conservation of Buildings (ECBC- Energy conservation building code) for industrial buildings whose connected load is 100 kW or more according to the Energy Conservation Act-2001 (Arlitt *et al.*, 2012). This code is being implemented through concerned state government departments in India. Recently, (BEE) Bureau of Energy Efficiency has launched revised ECBC 2017 with the provision of super ECBC integrating renewable energy installation during construction and leading towards Net-Zero energy buildings in future. Via this background, there are many projects which have been developed at the cutting edge of sustainable building construction and are developing a new exemplar of self-sufficiency. One of such buildings is the Indira Paryavaran Bhawan (IPB) at New Delhi (India). This building is GRIHA-Five Star rated and Platinum rated by IGBC. It is also a leading project on the way to Net-Zero Energy Buildings (NZEB) in the India. IPB is a new and innovative office building constructed for the Ministry of Environment and Forest (MoEF). Special consideration is given on strategies to reduce energy demand by incorporating theample natural lighting into the building, shading, landscaping to cut off ambient temperature specially for all the weather conditions, and by executing the activedesign strategies (Kurnitski *et al.*, 2011). Numerous methods have been adopted for conservation of energy to reduce the energy loads exerting on the building. The left over demand was matched by producing energy from high efficiency solar panels which have been installed on the site itself to achieve the Net-Zero Energy criteria (Shady *et al.*, 2013). As per the study IPB is consuming almost 70 percent less energy as compared to non-energy efficient buildings. This buildingis designed as per the green building concepts including conservation of resources, energy and optimization of water consumption by recycling waste water on the site itself. An NZEB criterion is achieved by energy saving tactics with passive and active energy designs and technologies. The building will respond according to its design, orientation and also on site conditions (Berggren *et al.*, 2013).

This further helps to make a building or project cost effective. Effective energy efficient projects/buildings require thoughts about designing and planning in a different ways. Maximizing the utilization of passive designed resources for instance natural day lighting and adequate ventilation can made a building more energy effective (Bartlett *et al.*, 2003). To comply with active renewable resources such as wind energy and solar energy is collected and used to replace the grid-energy system consumed by this building. Framework has been made for the spare energy usage, balanced by reducing waste, maximizing efficiency of the building and by

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using energy management control systems (Besser *et al.*, 2017). With this, all the spaces become healthier, satisfying to live, to work happily or to play.

Advantages of NZEB

1. Creates the market value: Net-Zero Energy Buildings have the potential to improve or maintain the competitive advantage in the market, it improves property values, market risks reduction,and itpromotes the physical condition and wellbeing of the residents.
2. Cost Effective: NZEB are more than 60-90% energy efficient. A Building/ projectcan save more money over its entire life cycle.
3. Learning: If a person involved at the designing stage, construction stage, operations or in maintenance stage it serves a valuable knowledge about Net-Zero energy buildings and energy efficient or smart building construction.
4. It reduces greenhouse gases: NZEB Limits or release the dependency on fossil fuels (Iwaro *et al.*, 2010).

Need of NZEB in Present Day Scenario

Net-Zero Energy Buildings (NZEBs) are targeting to push the envelope further, by being self-efficient, not just in terms of electrical energy consumption but with an overall minimal dependence on the other resources. As global warming issues are arising and natural resources are depleting year by year, this needs a huge concern to save natural resources. Simultaneously the demand for natural resource consumption in buildings sector is bound to increase (Scofield *et al.*, 2013). These buildings have the highest rate of energy saving efficiency which is being projects at the higher level by the government agencies. These green designing constructions has recently got a lot of attention from the research communities, government organization of construction and innovations. As well as rating systemsorganizations are coming up, that is Leadership in Energy and Environment Design (LEED), GRIHA and IGBC are continuously planning the ambitious targets to modifythe construction sector by adopting sustainable designing concepts. In India till 2030, it has been planned to construct of energy efficient buildings at large extent. When looking at the prediction plan-2030, 70% of remains to be constructed of the building volume (Kolo Kotsa *et al.*, 2014). According to the analysis boosting up the NZEBs concept can be viewed as a game changer. In India total energy consumption is nearly 33 percent for which construction section is responsible. As indicated by this observation, development of NZEBs everywhere can possibly manage future energy difficulties and furthermore to ensure about energy security for the nation, which is particularly critical in urban settings (Aelenei *et al.*, 2014). In any case, this requires auxiliary changes and advancements in arrangement, guidelines, client rehearses, mindfulness just as new innovation to defeat the current boundaries for green markets.

Sustainabile Technologies- Renewable Energy Systems

For a building to be sustainable, most of the focus should be given on the use of energy in building operations. The energy consumption in operations of the buildings overshadows that of the building construction (Li *et al.*, 2014). Approximately 90% is devoured in operation over the life expectancy of the structure. The most significant renewable sources for on-location energy generation for feasible green structures are sunlight based, twist, little hydroelectric (for provincial uses close to a waterway or stream) and geothermal (the Earth's heat) (Marszal *et al.*, 2011). These renewable energy technologies help to create renewable energy utilizing renewable common assets, therefore help in monitoring energy. The renewable energy system supplies a larger percentage of the building's total energy requirement for the same cost than in less-energy efficient buildings (Gul *et al.*, 2015). The consolidation of renewable energy technologies in green structure have been talked about in with the assistance of following site investigation.

Case Study: Indira Paryavaran Bhawan, New Delhi (India)

The Indira Paryavaran Bhawan-IPB is a workplace for Ministry of Environment and Forest (MoEF) sets a major change from a conventional building sector. IPB is presently India's most elevated green rated assembling. The structure has just won numerous honors, for example, the Adarsh/GRIHA of MNRE for brilliant execution of Renewable Energy Technologies (Source-httpd://nzeb.in/case-studies/detailed-case-studies-2/ipb-case-study/).

Table 1: Brief summary of the building

· Location	:	New Delhi
· Geographical coordinates	:	28˚North, 77˚East
· Typology	:	New Construction
· Occupancy Type	:	Office (MoEF)
· Project Area	:	9565 m.sq
· Climate Type	:	Composite Climate
· No. of Floors	:	G+7 & 3 Basements
· Energy Performance Index	:	43.75 kWh/m.sq/year

Passive Design Strategies

Orientation: This Building is oriented from the North-South directions with separate blocks naming Prithvi, Akash, Jal, Vayu and Agni, connected with corridors and a huge court-yard at the center of the building. Orientation of the building leads to reduce heat absorption. Optimum window-wall ratio (WWR) has been maintained for natural day lighting and ventilation.

Landscape Strategies: Equal or more over 50 percent outside area of this structure is covered with plantation. Out of total 79 existing trees on the site, only 19 were cut and 11 were transplanted. Local species of trees and shrubs are planted of having low water demand in landscaping. Internal connected roads with grass paver blocks are given to allow rain water percolation to increase the water table.

Daylighting and Ventilation: In this building the floor area is day lit by 75%, as a result it reduces the dependence on artificial lighting sources. Central courtyard of this building serves as a light well in the maximum areas. Courtyard helps in fresh air movement as natural ventilation occurs due to stack effects. Windows and jails are installed for cross ventilation.

Fenestration and Building Envelope: To modify building envelope window assemblies are designed as per the code, where U-Value is 0.049 W/m²K, VLT is 0.59, SHGC is 0.32. UPVC. Hermetically sealed Double glazed windows are installed for low heat transmittance. Rock-wool insulation is provided for its significant thermal insulation properties, acoustic and fire protection properties. Insulation is done to lessenthe energy demand by creating a very effective thermal barrier and installation of High efficiency glass. For Cool roof, high reflectance terrace tiles are used for heat access.

Construction Techniques and Materials: Autoclave Aerated Concrete blocks (AAC) with Fly-ash are used to achieve thermal insulation at external and internal area of the building. On the other side for quick and easy construction it also helps to reduce cost of constructions as it demands less steel and concrete for structural components. The maximum utilization of Fly Ash was used in Concrete, Mortars & Brick walls. Stones used are available in nearby area under the reach of 800 meters, which are used for flooring such as Granite Lakha Red, Calcium Silicate tiles, Terrazzo tiles, Dholpur Stones and crazy marble. For composite doors frames, shutters and flooring bamboo jute is used. For appropriate shading high VLT, low SHGC & Low U-value modified glasses are used. Light shelves or chajjas are provided to diffuse the direct sunlight.

Active Design Strategies

Lighting Design System: Energy efficient light system has been designed at 5 W/m.sq. This is almost 50% more efficient according to the ECBC requirements. The entire lighting load is being carried out by building photovoltaic system. The Energy efficient lighting appliances are used in this building. LUX (luminous intensity) level sensors are installed for the optimization of artificial lighting in the building, which reduces the 50 percent of energy consumption.

Enhanced Energy Framework-HVAC System: Chilled beam system having the potential to provide healthier thermal comfort because of enhanced air distribution pattern. Therefore 160 ton refrigeration of air conditioning requirement of the building is fulfilled through Chilled beam system. Chilled beam system is taken up from 2nd to 6th floor of the building. This chilled beam system turn down energy usage by 50% as of conventional air conditioning. 40 m.sq/TR is the HVAC requirements, approximately 50% more efficient than the prescribed ECBC code requirements of 20 m.sq/TR. The Chilled water is supplied at temperature of 16°C and the returned at 20°C. During monsoon chilled beams drain pans are provided to drain out water droplets due to condensation. Water chillers, double skinned air handling units with variable speed control drivers are installed. Chilled beams system saves air handling unit fan power utilization by approximate 50 kW. Various frequency drives provided in chilled water pumping area, cooling tower and air handling units. Functional zoning is done to minimize the air conditioning loads. With this the comfortable room temperature is being maintained at 26 ±1°C.

Geothermal Energy Systems: In this building for geothermal heat exchange systems there are 180 vertical bores holes are constructed at the depth of 80 meter all along the building location. Between any two bore holes minimum of 3 meter distance is maintained. Every bore has HDPE pipe with U-loop of 0.32cm external diameter, grouted with Bentonite Slurry. The condenser water pipe system in the central air conditioning plant room is connected to each U-Loop. One U-Loop has 0.9 TR of heat rejection capacities. When they all are combined together, without using a cooling tower 160 TR of heat rejection is obtained.

Renewable Energy Strategies: Roof top of this building is occupied with solar photovoltaic power plant of capacity 930 kW, which is installed during the construction. There are 2844 solar photovoltaic panels having the area of 4650 m^2. The annual energy generation of this plant is 14.3 lakh units. Maximum demand of power is being catered by solar power plant, making the building near to Net-Zero energy building.

Summary of Enrgy and Water Savings

Percent Saving in Electricity: To save electricity solar passive architecture concept is adopted in this building, which includes insulated exterior walls and roof for low heat ingress. Windows installed with exceptional glass transmitting less heating and more lighting. Energy effective LED lights are installed and sensors are installed to lessen the energy demand. Chilled beam system is adopted for AC's with less than 50% of traditional energy utilization. Geothermal heat exchange system is adopted. Regenerative lifts are there which approximately produces 2% energy of the total energy generation. Hot water generation is made through solar. LUX level sensor is utilized to streamline the activity of artificial lighting framework. To make this building more energy efficient, *in-situ* renewable energy efficient systems with solar photovoltaic panels are installed to meet upoverall energy demand of the building.

Water Saving and Zero Discharge: 55% waste water recycling process and after treatment is done to achieve zero discharge and this water is used for irrigation purposes and in HVAC towers. Other than this Geothermal Heat Exchange System, Low flow fixtures, sensor sanitary fixtures and Dual water flow cisterns to save more water and landscaping is done with low water consuming plantation.

Conservation of Water: This building has successfully achieve 55% of reduction in overall consumption of water with the help of Low water discharge fixtures and Less water consuming plants in landscaping andfor drip irrigation. Use of Geothermal Cooling is to be done to maintain temperature of the building in a very efficient manner. Rain water harvesting system is installed and recharge wells are there for the efficient use of water.

Conclusion

Therefore the exploration for accessible renewable energy resources and technologies to connect passive and active strategies, power production from solar radiations, geothermal energy systems, wind energy and their economical and environmental evaluation become extremely important. The implementation of solar energy concept and energy through wind system having the capability to facilitate in emerging energy demand and it also provide variety and consistency in energy production. The commitment of renewable energy is in excess of 35% from wind energy framework while the remaining is from different technologies. Green buildings by good worth of their energy efficiency can benefit from high level of resources and they have to be designed judiciously by incorporating renewable energy technologies. Consolidating these renewable energy technologies in green structures idea will without a doubt decreases our dependence on fossil fuels and it additionally diminishes the natural issues. For this reason the combination of renewable energy technologies and energy efficient green building design leads towards construction of Net-Zero Energy Buildings (NZEB), which are sustainable as well as environment friendly.

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