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Studies on Zero Energy Building

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Abstract

It is reported that 30 to 40% of all of the primary energy used worldwide is used in buildings. This high energy use may directly or indirectly affects the environment. Also it causes climatic changes, degrades the environment and increases the air pollution. Hence it is necessary to reduce the energy consumption in the building and necessary steps to be taken to make the buildings more environmentally sustainable. In recent years, zero energy building concepts is developed to overcome this problem. The zero energy building uses natural energy sources to meet the energy requirements of the building. In this work, we have carriedout a study to analyze the performance of a zero energy building and found that it is possible to have such building in India.

Keywords : Building, energy consumption, climatic change, zero energy building

1. INTRODUCTION

India is the developing country and has become one of the major energy consumers in the world. This is due to industrial growth and globalization which increases the energy demand of the consumers. It is reported in the literature that the urban areas contribute 70% and the housing construction and estate development contribute 40% to the GHG emissions. Few researchers reported that the buildings contribute approximately 50% of the world's air pollution, 42% of GHG emissions, 50% of water pollution and 48% of solid waste to the environment [1].

2. LITERATURE REVIEW

A statistics provided by the Ministry of Statistics and Programme Implementation, Government of India indicates that the per capita energy consumption has increased almost five folds in three decades during 1980-2010 [2]. This is due to the improved urban living standards and advanced means of energy consumption from households to industrial sector. The energy use in Indian buildings are responsible for at least 30-40% of total energy consumption and this demand is growing annually at 11-12% [4]. Most of this energy is consumed for heating, cooling, lightning and other appliances [5].

It is suggested that the buildings are also prime generators of Green House Gases (GHG), thus posing a threat to the environment. This is an alarming issue and hence it is necessary to develop energy efficient building which would facilitate minimization of energy consumption and reduces GHG. In recent years, buildings in India are designed to reduce the energy consumption, water requirements and technologies are developed to recycle used water for secondary usage.

Nicolae Bajenaru et al carriedout a simulation work regarding the design of a net zero energy office building with a mixed-mode ventilation system which assures the thermal comfort of the occupants according to the ASHRAE 55/2010 Standard In India, with a rational consumption of energy and a minimal environmental impact. The study relied on the use of easily accessible building materials and customary Air Conditioning (AC) equipment, in order to meet the requirements [6]. Isamu Ohta et al suggested that the idea of a zero-$LCCO_2$ home is to reduce the annual energy consumption and increase solar energy use so that photovoltaic (PV) energy generation substantially exceeds the total energy consumption of the home. He reported that the annual CO_2 absorption by PV generation exceeds the annual CO_2 emissions owing to energy use. He simulated the annual energy use and CO_2 balance of the house and evaluated the embodied CO_2 of the house using an input–output analysis and accumulation method. His reported that the material added for better energy efficiency and CO_2 emissions generated during the manufacturing and construction periods have a positive effect on reducing the $LCCO_2$ of homes [7].

Reshmi Banerjee suggest that the Net Zero Energy Building (ZEB) do not increase the amount of greenhouse gases in the atmosphere. In the building-grid interaction, the Net ZEBs become an active part of the renewable energy infrastructure and he observed that an increasing number of buildings are meeting this standard, raising confidence that a ZNE goal is realistic given current building technologies and design approaches [8]. Masa Noguchi et al developed Eco-Terra housing prototype which was designed to be energy-efficient to minimize negative impact on environment. The analysis indicates that the house experiences nearly net-zero energy consumption and the house provides its occupants with comfortable and healthy indoor living environment [9].

Mansi Jain work aims to assess the governance context for adoption and uptake of NZEBs through niche formation in

India. They reported that the governance context is marginally supportive towards NZEB niche formation and this is due to qualities of flexibility, moderate extent and intensity. They also reported that the instruments and strategies related to energy efficiency and renewable energy integration in buildings are available; however they are not part of a holistic program [10]. The energy consumption of residential buildings has grown fast in recent years, thus raising a challenge on zero energy residential building (ZERB) systems, which aim at substantially reducing energy consumption of residential buildings. Thus, how to facilitate ZERB has become a hot but difficult topic. In the paper, we put forward the overall design principle of ZERB based on analysis of the systems' energy demand. In particular, the architecture for both schematic design and passive technology is optimized and both energy simulation analysis and energy balancing analysis are implemented, followed by committing the selection of high-efficiency appliance and renewable energy sources for ZERB residential building. In addition, Chinese classical residential building has been investigated in the proposed case, in which several critical aspects such as building optimization, passive design, PV panel and HVAC system integrated with solar water heater, Phase change materials, natural ventilation, etc., have been taken into consideration [11]

3. MATERIALS AND METHODOLOGY

In this work, we want to study and analyze the zero energy building available in India. The study will be carried out based on the need of zero energy building and method of reducing the building energy consumption and energy conservation. We have identified zero energy building located in BIEC, Bangalore for our study. This building is energy sufficient building and uses renewable energy sources for heating and power generation to operate the electrical and electronic appliances.

4. RESULTS AND DISCUSSION

Prana is India's first energy efficient home office exhibit that will now stand tall at Bangalore International Exhibition Centre (BIEC) and is spread over an area of 3000 sq. ft. It consists of an entrance deck and a Lobby, Conference Room, Living and Dining room, Bed Room and Toilet. It is developed such that this building minimizes the consumption of water and electricity for comfort requirements as well as for lighting etc. This building utilizes the natural resources to minimize the burden on infrastructure and utility systems keeping the emissions less. It also has renewable energy devices such as solar PV panel unit, solar power refrigerator added to low water fittings, rain water harvesting and greener landscaping. Figure 1 shows the elevation of prana building.

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Figure 1 :Prana Building

Prana is developed by ISHRAE, to create awareness about the use of sustainable resources for developing the building more energy efficient. It also demonstrates how every individual can contribute in reducing the carbon footprint without compromising on the comforts and aesthetics one aspires in a home or office space. This building can be used as home or office as it has air-conditioning systems that use geo thermal energy i.e earth air tunnel system, radiant flooring, efficient water and lighting fixtures and it uses local and recyclable material. Figure 2 shows the interiors of prana.

Figure 2: Interiors of the Prana

Figure 3: Solar PV Panels on the roof

Lighting of the building of HVAC System

This unit is provided with solar PV panels of 3 kW capacity and these panels are mounted on the roofs tilted south direction to get maximum solar energy. However addition of more number of solar panels will make the building more sustainable. Each room in the building has LED lights which reduces the energy consumption. The glass blocks in the roof allows the sun light enter the building. The bamboo pergolas provided in the building make an efficient, cost effective and environmental friendly shading device. The recycled door and windows are punctured through the clay brick walls and the porotherm bricks provides the thermal insulation. The steel frame was used in the building construction as it helps to complete the building in short period. Figure 3 shows the PV solar system used in the building which supplies electrical power to the building..

The HVAC system of a building is designed fully during the final stages of the building design. However, it is necessary to integrate the passive solar systems with the HVAC systems to achieve comfortable conditions while saving energy. Hence it is essential to lay the foundations for the selection of an appropriate HVAC system at the conceptual stage of the design. The prana has solar water heating systems to provide hot water requirement of heating. The building has chiller which supplies chilled water for cooling purpose. For refrigeration purpose, a solar refrigerator is installed in the building. In pranna radiant cooling systems are used as it is low energy cooling method. The inlet chilled water temperature is around 16 deg C which makes the chiller 20 to 30 % more energy efficient. Also the chiller is provided with a variable speed compressor that will modulate speed based on the demand of chilled water and it reduces the energy consumption of the chiller. An earth air tunnel system of passive cooling is used and it uses low earth temperatures year round and provides a very low

energy consuming comfort cooling system. The openings have deep cantilevered slabs over them to reduce heat ingress into the building. Figure 4 shows the passive cooling system used in the building.

Sewage treatment

The sewage water from the building is treated in BIEC STP Facility and treated water is recycled for landscaping, flushing in toilets and make up water for the Cooling Tower.

Figure 4: Passive cooling system

Interior and furniture

In prana, low volatile organic compounds (VOC) paints are used to reduce the VOC emission. The furniture provided in the building are made of bamboo and other renewable materials. This reduces the carbon foot print.

Rain Water Harvesting System

The building has rain water harvesting system which collect the rain water that runs off from the roof of the building and is collected in a recharge tank. Hence it recharges the water table beneath. The roof pipes are embedded with radiant cooling pipes with chilled water flowing through them giving the place a natural air cooing effect.

CONCLUSION

The zero energy concept will reduce global warming and helps to retain the nature. The specialty of the zero energy building, Prana project, is that the whole building is made keeping sustainability and green building in mind. The every aspect of the building was planned with 'green' approach, showcasing the latest in HVAC technology alongside recycled materials. Also it is necessary to optimize the usage of water, chilled water and hot water and STP and solar energy conversion using suitable energy conversion devices. The building automation system will help in optimizing the above said parameters. The prana building is developed to demonstrate the feasibility of constructing zero energy building and demonstrate the functionality of zero energy building in energy saving.

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