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Redesigning of Existing Commercial Building as A Net-Zero Energy Building

Hinta Thampi
Assistant Professor
Department of Civil Engineering
Viswajyothi College of Engineering and Technology,Vazhakulam
Kerala, India

Adarsh Mathew
B.Tech Student
Department of Civil Engineering
Viswajyothi College of Engineering and Technology,Vazhakulam
Kerala, India

Ajeena Baby
B.Tech Student
Department of Civil Engineering
Viswajyothi College of Engineering and Technology,Vazhakulam
Kerala, India

Akash Jose
B.Tech Student
Department of Civil Engineering
Viswajyothi College of Engineering and Technology,Vazhakulam
Kerala, India

Neenu K George
B.Tech Student
Department of Civil Engineering
Viswajyothi College of Engineering and Technology,Vazhakulam
Kerala, India

***Abstract*— A net-zero energy building (NZEB) is a building with zero net energy consumption, that is the total amount of energy used by the building on an annual basis is approximately equal to the amount of renewable energy produced in the building. This paper is the study of the energy performance of an existing commercial building. The objective was to investigate how to maximize energy savings and reach net-zero energy goals by utilizing renewable energy sources for the building's energy needs. Based on the result of energy modeling, different energy-efficient strategies were incorporated into the building which result in energy-saving and cost reductions.**

Keywords*— Net-zero energy building, renewable energy, energyefficient strategies, energy saving, cost reduction

I. INTRODUCTION

Energy is used in every stage of a building life cycle and they have a profound impact upon the environment. The energy consumption of a building is at a higher rate and it will go on increasing till energy produced in the buildings themselves can make up for their growing energy needs. The commercial building sectors can reduce their energy consumption by incorporating energy-efficient strategies by undertaking retrofits to improve the efficiency of existing buildings. Net-Zero Energy Building (NZEB) concept will improve the energy efficiency levels in existing commercial buildings, by making the buildings to meet all their energy requirements by using low-cost, locally available, non-polluting, renewable sources.

A net-zero energy building is one that produces as much energy as it consumes annually and thus contribute less overall greenhouse gas to the atmosphere. It is important to apply effective techniques to upgrade and develop energy-efficient commercial buildings based on the integration of advanced energy-saving concepts and adaptive reuse methods. The suitable methods for reduction in energy consumption can be ascertained after energy modeling and simulation. We can understand the energy consumption quantities by using suitable simulation software, to build and analyse the energy model of the building. Different energy-efficiency design strategies such as passive design strategies, implementing HVAC systems and renewable energy systems were used nowadays.

II. ENERGY MODELLING AND SIMULATION

Energy modeling and simulation helps to find the energy consumption quantities of the building. Autodesk Revit software is used to create a virtual model of the building and it explores the energy-saving potentials and evaluates different sustainable design alternatives. The results from energy modeling are used to choose better approaches to maximize energy reduction.

Retrofit measures were introduced in the building, including a control of internal loads and Operating schedules, lighting, and improvement in the building envelope. Different requirements of the interior lighting environment and occupancy schedules were taken into consideration during the energy modeling process. Reduction in light power intensity result in energy reduction. Sensors were designed and positioned in rooms, which will minimize waste lighting electricity for unoccupied rooms [1]. The significant reason for energy loss in the building is mainly due to the positioning of the window. Glazing is so crucial to window energy efficiency. Double glazed window with low-E coating and argon gas fill was selected instead of glazing for windows and thus it reduces heat transfer through the building envelope. After applying all the possible energy saving strategies an alternative simulation is done and it shows an improvement in the energy performance in the building.

III. HVAC SYSTEMS

Heating, Ventilation and Air conditioning (HVAC) system is an important energy-efficient strategy for the redesign of the building. An efficient HVAC system were considered to improve the human comforts by increasing the air quality. The Biomass heating system was included in the HVAC system which makes it more economical and it has environmental and

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social benefits. HVAC system is improved by incorporating a wireless temperature monitoring system, which will adjust the temperature based on the occupancy, human activities, and specific requirements. wireless sensor technology allows required real-time data in the building to be collected efficiently by the sensors. Wireless installation is economical compare to the wired system and it has a significant reduction in labor cost [1].

IV. PASSIVE METHODS

Active and passive solar heating and solar cooling methods can be used to reduce the energy consumption in buildings. Passive methods make maximum use of natural energy sources and daylight[1]. These are some passive methods that can be incorporated in commercial buildings for energy use reduction.

A. Vegetative cooling

Trees and vegetation cover the surface of the building and shade the building to direct exposure to the sunlight which helps in keeping the temperature inside the building low as shown in Fig.1. Due to the transpiration of water through leaves, the air around the building also gets cooler. Shaded walls can be 11-25degree Celsius cooler than unshaded areas.

Figure 1 Vegetative cooling

B. Building facades

Building a facade based on climate is a filter used between exterior and interior that creates a comfortable interior living condition as shown in Fig.2. Based on climate such as for hot climate passive cooling, shaded walls and glazing reflected daylighting, light exterior colors, insulation(min) RSI 2.8(R 16) and double glazing can be used. For cold climates passive solar heating, daylighting, insulation(min) RSI 4.1(R 23), double glazing with thermal break or movable insulation can be used[2].

Figure 2 Building Facades

C. Double roof

Double roofing can be used to remove the warm buildup between the structure and roof thereby reducing the temperature. A double roof structure separated by an air cavity and an extended roofline to shade exterior walls to create outdoor living spaces can be used.

D. Green roof

Green roofs are used to provide water retention, improved water, air quality and green space along with energy use reduction. Green roofs can be categorized as extensively provided 60-200mm thickness a green protection layer for roofs with a little load-bearing capacity can be provided. For low maintenance shallow soil suitable for less demanding plants are used. For semi-intensive the thickness is 120-250mm and for intensive 150-1000mm thick roof garden along with permanent irrigation and deep soils, they are suitable for lawns, shrubs and trees, walkways and even playgrounds.

V. RENEWABLE ENERGY

Even after adopting the energy reduction methods the commercial building we choose still required 670MW of energy annually. For meeting the energy need we can rely on renewable energy sources. The main renewable energy sources are:

A. Wind energy

Wind power or wind energy is a method of producing energy from wind. By using the mechanical power of wind through wind turbines for running electric generators and produce the required energy.

B. Biomass energy

Plant or animal waste used for energy production or in various industrial processes as a raw substance for a range of products is called biomass. Solid biomass like wood and garbage can be burned to produce heat. Biomass can also be converted into biogas or liquid biofuels such as ethanol and biodiesel. These fuels can be burned for producing energy as shown in Fig.3.

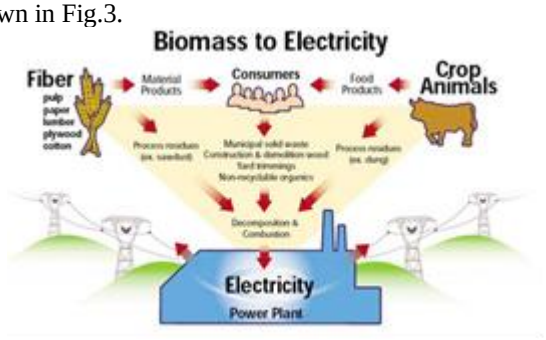

Figure 3 Biomass energy

C. Solar energy

Comprehensive thinking towards energy conservation, feasibility, accessibility, and cost contributed to the decision of selecting the type of energy source, generating energy to support the operation of the building system solar energy was chosen. High-efficiency commercial photovoltaics were considered to be placed on the roofs. Since the applied photovoltaics were integrated in a connected grid system. DC power which is generated by the PV arrays is converted into AC by the power conditioning unit to satisfy the building's energy demand(Fig.4). The working schedule for most spaces in the building are during the daytime, so PV can deliver power during the peak time when utility rates are relatively high. The design of PV arrays contains 570 PV panels to

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provide approximately 670,000 KW annually another set of 200 solar panels of 250 KWP was replaced to solar PV panels. The renewable energy system made it possible to achieve net-zero energy goals[3].

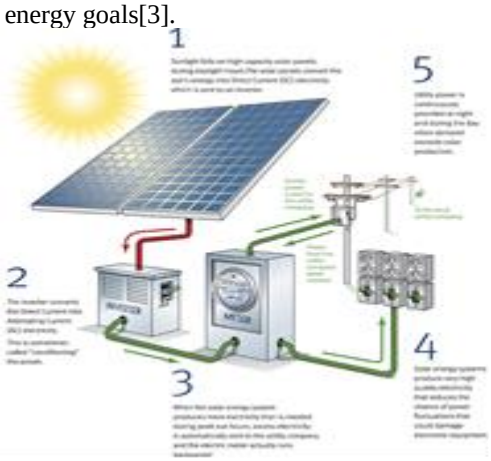

Figure 4 Solar energy

VI. CONCLUSION

This research explores the potentials for achieving the net-zero energy goals by incorporating energy reduction methods and the use of renewable energy on an existing commercial building. This study considered passive building design strategies and energy-efficient building systems to improve building performance and reduce energy usage. The main objective was to investigate how to maximize energy savings and attain net-zero energy goals by using renewable energy sources. Based on extensive energy modeling and simulations various design considerations such as material selection, improvements in building envelope addition of HVAC and lighting systems, occupancy loads as well as the application of renewable energy sources were investigated. From the results, we can conclude that the commercial building can meet net-zero energy use after an appropriate redesign and use of renewable energy sources.

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