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Analysis of Net Zero Energy Building using PV System Software

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Abstract: The net zero-energy building (NZEB) concept recently gained importance worldwide. Large scale adoption and implementation of NZEBs will potentially contribute greatly to greening of the building sector. Most of the power generated by the utilities is consumed by the domestic loads and with urbanization; energy demand is continuously increasing in developing countries like India. To meet the ever-growing demand, generation has to be increased and thereby transmitted over long distances which results in increased system losses reducing the overall system efficiency and reliability. Generation addition by non-renewable sources would increase the greenhouse gas emissions caused by the additional consumption of fossil fuels. Towards addressing this problem, there is a lot of scope for researchers to increase the overall system efficiency and reliability and also to preserve the fossil fuels for future generations. One solution is by adopting Net Zero Energy Building (NZEB) concept which includes integration of renewable energy generation, intelligent controllers, Internet of Things (IoT), for home energy automation. NZEB concept ensures that the loads of a building are controlled in such a way that the net energy consumed from the utility grid over a period of time will be close to zero. The net energy is the difference of the energy imported from grid to the energy exported to grid over a period of time.

Keywords — Energy Consumption, Photovoltaic cell (PVC), Solar energy, Zero Energy Buildings (NZEB)

I. INTRODUCTION

Net or nearly zero energy buildings (NZEB) are highly efficient buildings with extremely low energy demand, which meet by renewable energy sources as much as energy uses over the course of year. In order to achieve their net zero energy goals, NZEBs must first sharply reduce energy demand using energy efficient technologies, and then utilize renewable energy sources (RES) to meet the residual demand. In such buildings, efficiency gains enable the balance of energy needs to be supplied with renewable energy technologies. This is the most logical approach to reach NZEB goal.

Educational Buildings have to give maximum Payback for their teaching and non teaching staff and students in limited budget. Increase in energy cost due to replacement of equipments adds extreme stress on it.

In addition to above things, schools also give their students to create environment which will give suitable sound, temperature and light which indirectly helps to learn. In many cases, improving these attributes can also reduce energy use. Productivity increases of 2% to more than 25% from improved indoor air quality, acoustically designed indoor environments, and high-performance lighting systems [1]. Research studies have shown that studies day lighting, which makes maximum use of sunlight to produce high-quality, glare-free lighting, will definitely improve academic performance by at least 20%. Day Lighting plus Energy efficient electric lighting systems contribute to Quality lighting systems. These go hand in hand by reducing visual strain and providing better lighting quality. Advanced, energy-efficient heating and cooling systems will create clean, healthy indoor atmosphere that will reduce student and staff absentee rates and will improve teacher retention; this results into higher test scores and reduced staff costs.

Educational institutes that incure energy efficiency and renewable energy technologies strongly believe the importance of protecting the environment. These institutes also give opportunities for students to get educated about these technologies importance of energy conservation.

1.1 NEED TO GO FOR NZEB

There are various benefits and advantages of NZEB. At first, initial investment in design and construction is mostly, but there is long-term return on initial investment.

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1. Creates value: It can be achieved through multiple avenues by mitigating risk, value is improved and occupant's health and well being is improved.

2. **Economical:** These buildings are more than 60 % energy efficient. Money will be saved over entire life cycle of its equipment, energy and maintenance costs.

3**. Education**: People involved during various phases of design, construction, operations and maintenance will be educated about net zero-energy and energy efficiencies. People using this facility also come to know how to use these in limits

4. **Reduces greenhouse gases**: Fossil fuels dependence o should be limited which will create a more resilient future. It will be beneficial for society.

Objectives

1. To find the most suitable method to attain net zero energy in case of college building.
2. To make effective implementation of green building model parameters for achieving energy efficiency
3. To Reduce Electricity demand, Water demand and Carbon emission.
4. To optimize use of lightening energy to achieve a net zero goal.

II. LITERATURE REVIEW

Residential and commercial buildings account for about 40% of the total electricity used in India. Over 1.2 billion sq.m of new commercial floor space, which is about twice of what exists at present, will be added in India over the next 20 years [8]. This will lead to a further straining on electricity demand.

A hybrid power system for building which is technically feasible and economically optimal. The system is environment friendly and beneficial for sustainable development which leads to 6.18% annual cost savings and reduces CO2 emissions by 38.3%[7].

Study of model of a hybrid power system for building which is technically feasible and economically optimal. The building is located in southern India. Building is associated with 3.4MWh/day priority load as well as 3.3Mwh/day deferrable load. The system is modelled and the optimal system configuration is estimated with the help of hybrid optimization model for electric renewable (HOMER) [7].

Study of overview of NZEBs energy calculation methodologies proposed by organisations representing eight different countries. All methodologies were analyzed and created into one interactive spreadsheet [6]. The supplied NZEB calculation methodologies give a significant insight on different possibilities for writing the balance of NZEB. They studied that some discrepancies exist between the different energy calculation approaches to NZEBs.

Study of relationship between climate and building design considering design criteria and construction techniques [4].

Research work focuses on the utilization of alternative sources of renewable energy, mainly solar energy, for satisfying the energy demand in buildings. One such possibility is through Building Integrated Photo voltaic (BIPV) and improving energy efficient features through passive solar design in the buildings. The research team has studied two design cases, an existing building of 2011.12 m^2 and a new building of 100 m^2 ground area suitable for BIPV installation in Central Gujarat region of Western India[3].

Studied the consumption of the energy by the normal building, their integrated building design and delivery process. The cost of each panel is estimated and total cost is taken into consideration. Further the result produce was that the value is recovered after 5.5 years. After 5 years it will be free [2].

Zero energy constructions are not a new concept. An area of focus is self-governing building energy options. Technologies are being directed to accomplish net zero energy intake and net zero carbon emissions. Buildings that produce an excess of energy over the year may be called energy-plus buildings and buildings that consume somewhat more energy than they produce are called near-zero energy buildings. This study focuses on accomplishing NZE building goal by applying passive solar design, energy competent appliances, and application of renewable energy resource and repayment period of PV panel.

III. METHODOLOGY OF WORK

Applying Various Strategies for Energy Efficiency to Model

- Glazing Window
- LED Tube lights
- Ceiling Fans
- Cool Roofs
- HVAC System
- Solar Photovoltaic System

1. Glazing Windows: The single-glazed window, which located in the center of the external wall, has a size of $1.5\times1.5m^2$ and a solar transmittance of 77%.

2. LED Tube lights: Light emitting diodes is a solid-state lighting system based on p-n junction semiconductor crystal where photons are generated through radiative recombination through charge carriers (electrons and holes).

3. Ceiling Fans: The BEE star labelling program for ceiling fans is applicable for 1200 mm sweep and a minimum air delivery of 210 cu. m/min.

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4 **Cool Roofs:** Cool Roofs reduce annual air conditioning energy use of a single-story building by up to 15%.

5. HVAC (Heating, Ventilation and Air Conditioning) System: HVAC systems have significant effect on the health, comfort, and productivity of occupants. Issue like user discomfort, improper ventilation and poor indoor air quality are linked to HVAC system design and operation and can be improved significantly by better system design.

6 Solar Photovoltaic System The process of generation of electricity from solar cells is a two – step process. The first step is the physical process and involves the photoelectric effect in which the photons strike the metal surface and provide energy to the electrons in the metal. The next step involves the electrochemical process in which the excited electrons are arranged in a series, thereby creating an electric voltage and generating electric current. The generated electricity can be consumed instantaneously on site, stored in batteries for later use, or sold to power utilities according to local government regulations and prevalent tariffs.

IV. SOLAR ELECTRICITY GENERATION SYSTEM

A complete solar electricity generation system consists of components to produce electricity, convert generated DC into AC that can be used by equipment installed in the building, and store excess generated electricity.

Inverter – The inverter converts the DC produced by the solar panels into AC that can be fed into the grid or used for the operation of electrical appliances.

Solar PV panels – Solar panels are the basic part of a solar electricity generation system.

Storage Batteries – Storage batteries are used to store excess electric energy generated by the PV system for future use. Batteries are typically employed in PV systems which do not intend to sell excess electricity to power utilities.

Electricity Meter – The meter counts the number of units of electricity generated by the PV system. They are essential for calculating the proceeds from the sale of electricity to the grid.

V. SOLAR SYSTEM DESIGN

The designer will need to know the following types of questions about the system. (1) Power Requirements, (2)Solar Data Availability, (3)Type and Size of Solar Power Plant Required, (4) Cost of Energy Produced, (5) Solar Power Viability, (6) System Characteristics, (7) System Requirement, (8) Evaluation Criteria, (9) Design Optimization, (10) Economic Viability and (11) Prospects of Cost Reduction.

Components Used in Solar Power Plants:

Major components

- Solar PV Model
- Power Conditioning Unit/grid tie inverter
- Utility Grid/Grid System

Minor components

- DC array junction box
- AC bus bar (LT and HT Switch gear)
- Control room
- Cables
- Mounting structures
- Earthing and lightening
- SCADA (Supervisory control and data accusation system)

Solar PV Technology

Solar PV Technology converts sun's natural energy to useful electrical energy. Photo Voltaic modules are made of mono crystalline / polycrystalline solar cells connected in series and parallel modes.

Table 1. Single solar modules specification

Watt	320W
Voltage	58.0V
Current	5.70A
Type	Monocrystalline
No's of module	117
Detail of series/parallel combination	In series
Efficiency	22.09%
Temperature	-40°F to 185°F
Dimensions of single module(mm)	62.6x41.5x1.4 in. (1590x1053x35 mm)
Weight	40.81 Lbs. (18.5kg)
Tilt angle(slope) of PV Module	25 degree
Wind speed rating	150 Km/h
Mounting	Fixed Type

VI. ANALYSIS BY PV SYST SOFTWARE

PV SYST software is one which is able to import data from many different sources of Building components. The software consists of three main design steps. The preliminary design option allows evaluating grid-connected, stand-alone and pumping systems, and using monthly values to perform a quick evaluation of system yield. The program includes predefined values of locations of different parts of the world. The second one is project design option allows to create full-featured study and analysis of grid connected, stand-alone, pumping, and dc-grid systems with accurately system yields computed using detailed hourly simulation data. Different simulation variants, horizon shadings, detailed losses, and real components can be added to make economic evaluations. Reports can be generated after the completion of the project and information can be exported to the clipboard. The last option includes meteorological

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data, components, solar toolboxes, and the analysis of actual data.

Photovoltaic panel sizing

- PV-power tolerance: -10%
- Heat loss: 10% Dirt loss: 2-15%
- Wiring loss: 2-10%
- Inverter/charger loss: 2-15%
- Batteries: 30%
- Here considered average loss PV power loss: 2%
- Heat loss: 10%
- Dirt loss: 5%
- Wiring loss: 3%
- Inverter loss: 7%
- Battery loss: 30%
- Total loss = 57%
- Taking average total loss =50%
- Energy requirement = 56776.00W-hr/day

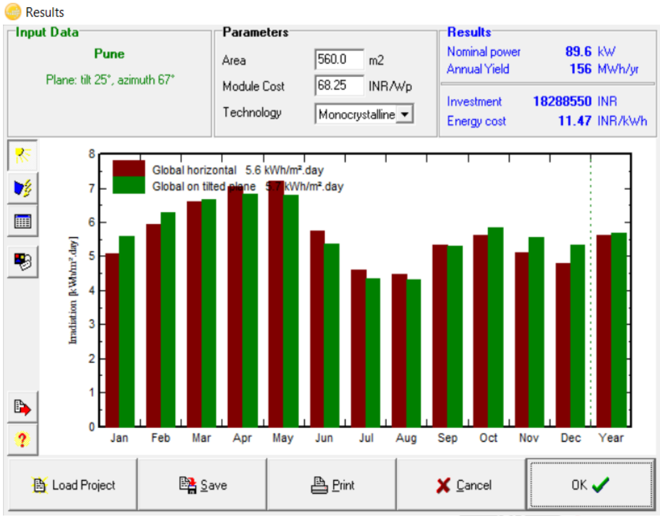

Fig 1. Normalized Energy

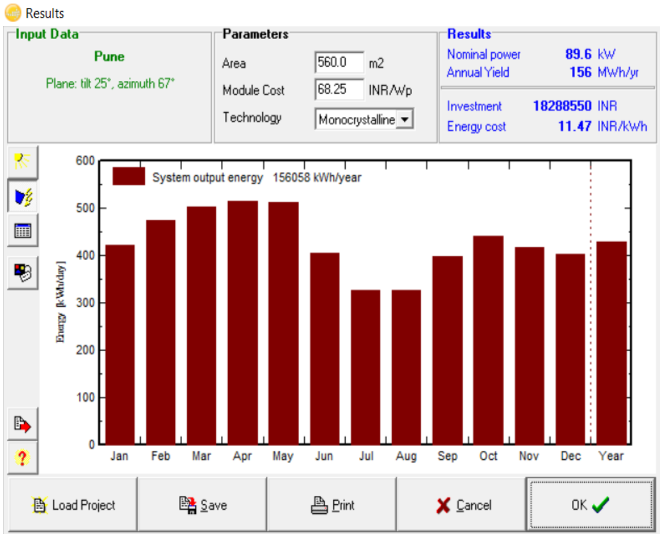

Fig 2. Performance ratio

Formula for calculation of Performance Ratio (PR) is the ratio of final PV system yield (Yf) and the Reference yield (Yr). PR = Yf /Yr

Analysis of one complete year was done and actual reading and nominal plant reading was calculated.

Performance ratio calculated was 69% means approximately 31% was not converted into usable energy.

VII. Conclusion

1. Energy Efficiency of college Building has been achieved by adopting Solar Photovoltaic System, Glazing Window, HVAC system & Cool Roofs
2. Green Building Parameters have been successfully implemented using Solar PV Technology.
3. Project work found Cool Roofs reduces annual air conditioning energy with use of a single-story building by up to 15%.
4. The single-glazed window & LED Tube lights adopted for optimum utilization of Lightening.

VIII. Acknowledgment

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