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Simulation of NZE Green Building Design through Optimization of HVAC Systems

V. Baby Shalini, Rajesh Merugu

Abstract: ***Around 40% of the electrical energy produced worldwide is consumed by the Buildings of Residential as well as Commercial types. Efficient usage and optimization of electrical energy leads to Nearly Zero Energy (NZE) Green Buildings and it helps in Economic growth and Social development in all countries. Apart from providing reduced energy consumption, Building energy optimization also minimizes the total energy costs, maximizes energy savings and consequently contribute less greenhouse gases to the environment. Though the installation cost of NZE Green building is quite high, the investment can be regained within the payback period with savings in the energy consumption. In this paper an Eco-friendly, Energy optimized, NZE Green building is designed by using efficient building simulation program known as BEOpt through HVAC technologies by considering various designing parameters at the designing stage and the distinguishments in the energy consumption, energy saving per year and CO_2 emissions between conventional building and the designed prototype of NZE Green building are addressed.***

Keywords**: *BEOpt tool, Cost saving, Distinguish, Efficient use, Green Building, HVAC-Heating Ventilation Air Conditioning, Installation, Nearly Zero Energy-NZE, Optimization, Payback Period***

I. INTRODUCTION

An NZEB (Nearly Zero Energy Building) refers to a building with a very high energy performance that it generates part of its electrical energy requirement through renewable energy sources which produce on site or nearby the region.

Green Building refers to the building with reduced usage of electrical energy in a smart way with a significant reduction in greenhouse gas emissions into the atmosphere.

Fig.1 NZE Green building prototype

In this paper, the building is designed in BEOpt simulation program in such a way that it consist of both the characteristics of NZEB and Green building by which it generates part of its energy through PV system and its electrical energy usage is optimized, greenhouse gas emissions are reduced to a significant level.

Various designing parameters of building which play vital role in achieving reduced electrical energy consumption, and reduced greenhouse gas emissions are

1. Building Architecture design
2. Space conditioning systems
3. Lighting system
4. Water heating systems
5. Optimum selection of Electrical Appliances and fixtures
6. Localized Power generation

Building Architecture: It includes Orientation of building with respect to sun, Neighbor building distances which cause shading effects, Walls and wall sheathings, Ceilings/Roof materials, Foundation/Floor materials, size and types of Windows and Doors, Air flow scenario in building.

Space conditioning: It consists of Cooling and Heating of the space in the building by using central Air condition, Room air conditioners, Furnaces, Boilers, Ceiling fan, Ducts Natural Ventilation.

Lighting system: Major lighting systems consists of Incandescent lamps, CFL lamps, Discharge lamps and LED lamps.

Water Heating: This includes conventional Water heaters, Solar water heating systems.

Electrical Appliances and fixtures: This is the Optimum selection of Cooking systems, Refrigerator, clothes washer, clothes dryer, dish washer etc.

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* Correspondence Author
Mrs. V. Baby Shalini*, Assistant Professor, Dept of EEE, Jawaharlal Nehru Technological University Hyderabad College of Engineering, Jagtial, T.S., INDIA, Email: shalini815@yahoo.com
Mr. Rajesh Merugu, P.G. Scholar, Electrical Power Systems, Dept of EEE, Jawaharlal Nehru Technological University Hyderabad College of Engineering, Jagtial, T.S., INDIA, Email: rajeshmeruguu@gmail.com

II. DESIGN AND ITS ARCHITECTURAL CONSIDERATIONS

The design of NZE & GREEN BUILDING can be achieved in three stages

i. Reduced energy requirement by architectural design
ii. Energy utilization optimization
iii. Reduced CO_2 emission

The first stage can be accomplished by Architectural considerations such as Building facing with respect to sun and wind directions,

Doors and Windows their overhangs and eves, shadowing effects due to neighbor buildings, wall, ceiling and foundation materials which plays a vital role in heating and cooling conditions in building. The energy consumption can be substantially reduced by providing renewable energy generating system onsite or nearby premises of the building. The second stage can be achieved through the optimization of Electrical appliances. The Third stage can be made possible by selecting high reliable HVAC technology enabled space conditioning equipments, refrigerators, lighting systems etc which emits less percentage of green house gases.

A. Design

The design of NZE Green building is carried in Building Energy Optimization simulating program known as BEOpt 2.8 version in which the design can be done in four screens known as Geometry screen, Site screen, Options screen and Output screen.

In Geometry screen site area, number of floors, living spaces, garage space can be given as inputs. In this model a 500 sqft living area with 2 floors and 130 sqft garage area are selected as inputs. Fig.2 shows the design of building in Geometry screen.

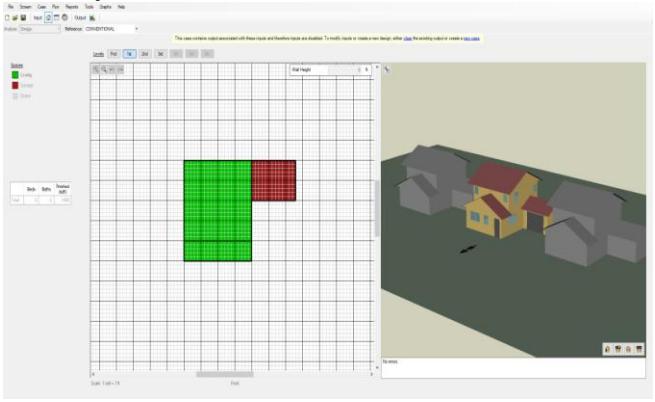


Fig.2 Design of Green Building in Geometry Screen

B. Optimization of NZEB for climate impacts

While designing the NZEB, the knowledge of weather conditions is very important to model HVAC systems efficiently. The climate impacts of the particular site in which the building is to be constructed should be taken into consideration for energy optimization.

Fig. 3, 4, 5, 6 shows the daily wise weather data of Temperature, Humidity, Wind flow direction and Wind speed respectively in a year taken from Data Viewer software for Hyderabad city of Telangana State, India and this can be given as input in the SITE screen of BEOpt program. This weather data plays significant role in selecting the HVAC systems in the building design so that the energy can be optimized to a great extent.

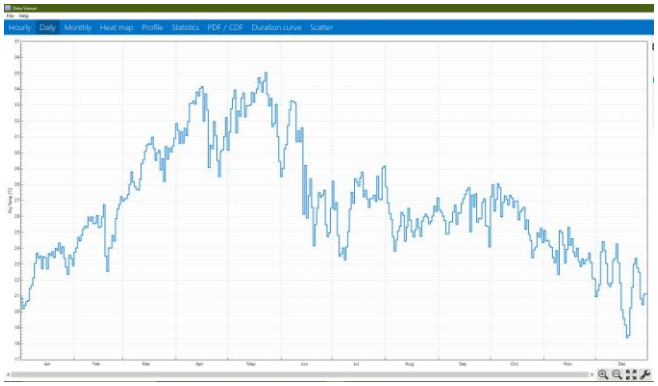


Fig.3 Daily wise Temperature curve

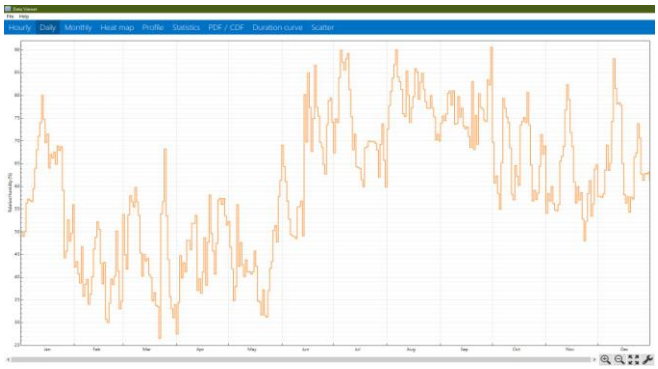


Fig.4 Daily wise Humidity curve

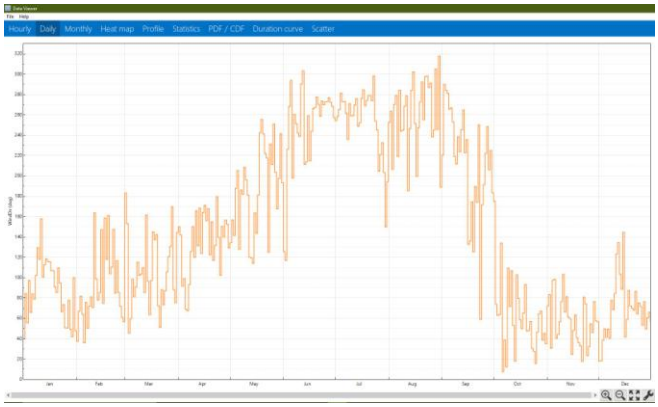


Fig.5 Daily wise wind direction curve

Fig.6 Daily wise wind speed curve

C. Selection of Electrical Appliances and Fixtures

This can be obtained in OPTION screen by the selection of Electrical Appliances and fixture. In this, 100% LED lamps are used instead of Incandescent or CFL lamps.

Solar Water Heating system of 40 sqft/unit is used for providing water heating facility where it is absent in the case of Conventional Building.

For Cooking range Gas cooking system is used instead of using electrical energy for the purpose.

Refrigerator, Dishwasher, Clothes washer, Clothes dryer, HVAC systems like Room heaters and cooling equipments are selected in such a way that those consume energy in a smart way and emit less percentage of greenhouse gases for the same amount of energy consumption.

In this way it can be achieved that less energy consumption with less amount of greenhouse gas emission by spending much more money, as these are costlier than that of conventional equipments.

III. SIMULATION RESULTS

The output of the NZE green building design is obtained in the OUTPUT screen of the used software after running the simulation for certain amount of time. The following figures shows the simulation results of Conventional and NZE Green Building.

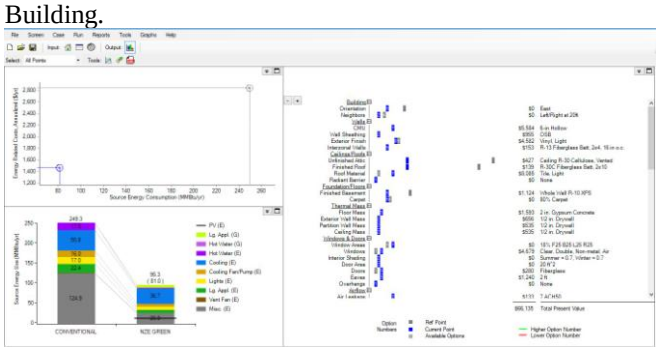


Fig.7 Simulation result in OUTPUT Screen of BEOpt 2.8v

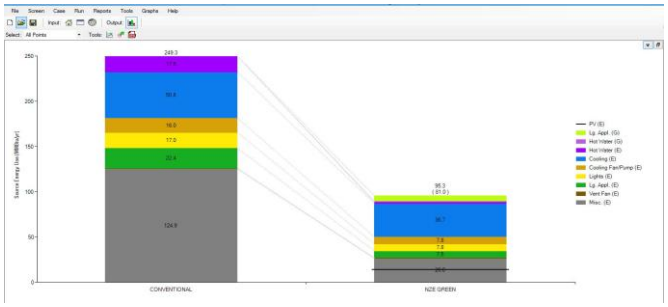


Fig.8 Source Energy use in MMBtu/Yr for Conventional and Green Building

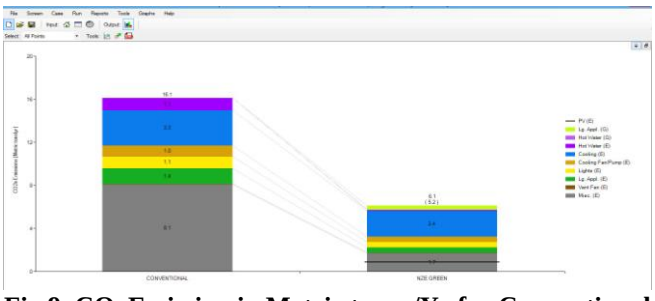
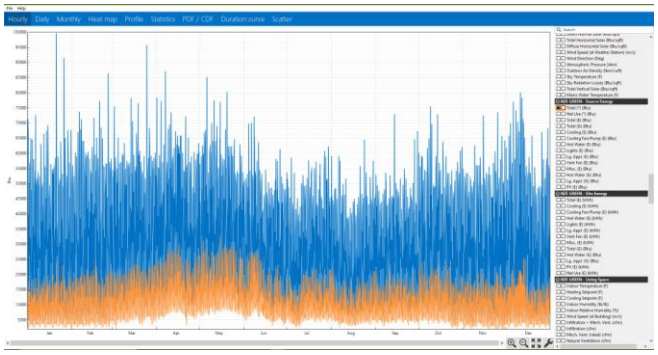


Fig.9 CO_2 Emission in Metric tonns/Yr for Conventional and Green Building



Conventional Building NZE Green Building

Fig.10 Daily energy consumption for Conventional and Green Building

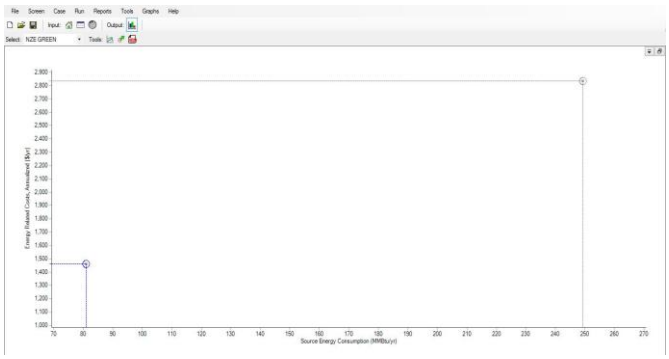


Fig.11 Annualized Energy related costs($/yr) vs Source Energy consumption (MMBtu/yr)

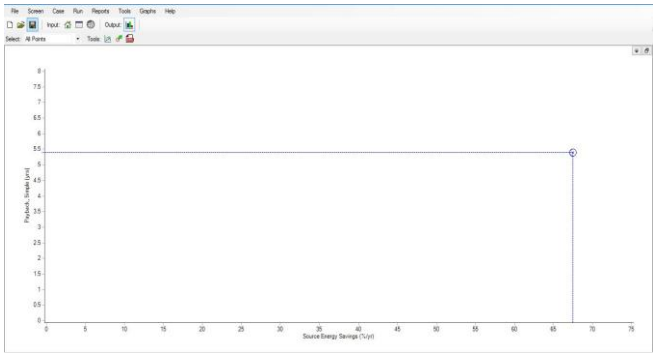


Fig.12 Payback period (yrs) vs Source Energy savings (%/yr)

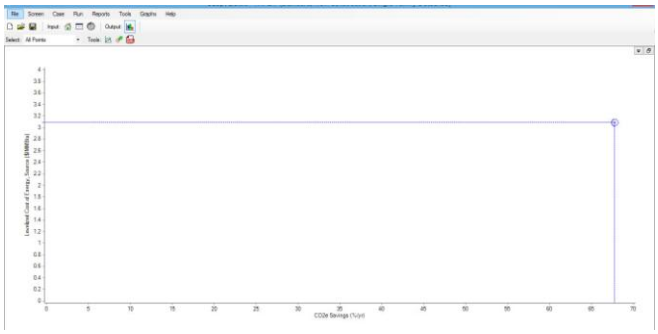


Fig.13 Levelized Energy cost ($) vs CO_2 emission saving (%/yr)

As far as the individual energy consumption for the lighting system is concerned there is 17 MMBtu/yr energy consumption with the usage of incandescent lamps in conventional and 7.8 MMBtu/yr energy

consumption with the usage of LED lamps in NZE Green building for the same amount of illumination which can be observed in fig.8. The CO_2 emission for incandescent lamps is 1.1 metric tonns/yr and for LED lamps it is 0.5 metric tonns/yr which has obtained in fig.9.

The reduction in energy consumption and CO_2 emission for Heating, Ventilation, Air Condition systems can be observed in the simulation results which were shown in fig.8 and fig.9 respectively for Conventional and NZE Green Building.

IV. RESULT ANALYSIS

Table-I Comparisons between Conventional and NZE Green Building

Building	Installation Cost ($)	Source Energy Consumption (MMBtu/yr)	Cost of Energy consumption ($/yr)	CO_2 emission Metric tonn/yr
Conventional	54263	249.34	2833.7	16.1
Green	66135	80.99	1461.31	5.19

From simulation result fig it can be observed that

1. Installation cost of Green Building is increased by 11872$.
2. Electrical Energy required for Green Building is reduced by 168.35 MMBtu/yr i.e., from 249.34 MMBtu/Yr to 80.99 MMBtu/Yr., hence a total of 67.52% of source energy savings per year is obtained.
3. CO_2 emission in NZE Green Building is reduced by 10.91 metric tonns/yr i.e., a total of 67.76% reduction is achieved.
4. Payback Period = 5.336 ≅ maximum of 6 years.

V. CONCLUSION

The proposed NZE Green building is designed in BEOpt 2.8v and the obtained results showed the substantial reduction in net electrical energy consumption with less percentage of greenhouse gas emission into the atmosphere and improved net annual energy cost savings. Though the installation cost of the proposed building is quite high, the money can be regained within 6 years of payback period is also proved in the result analysis. The designed model can also allow the isolation of the building resident from sudden hike in the Electricity charges.

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AUTHORS PROFILE

Mrs. V. Baby Shalini, Assistant Professor, Department of EEE, Jawaharlal Nehru Technological University Hyderabad College of Engineering, Jagtial, T.S., INDIA, Email: shalini815@yahoo.com

Mr. Rajesh Merugu, P.G. Scholar, Electrical Power Systems, Department of EEE, Jawaharlal Nehru Technological University Hyderabad College of Engineering, Jagtial, T.S., INDIA, Email: rajeshmeruguu@gmail.com