IFERP connecting engineers... developing research

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 7, July 2022

Review & Study of Design Inputs for Establishing nZEB in Indian Temperate Zone

[1] Saket Rusia*, [2] Sumit Kesharwani, [3] Asmita Singh

[1] Assistant Professor, Civil Engineering Dept., Rajkiya Engineering College, Uttar Pradesh, India.
[2] [3] Final Year B.Tech. Scholar, Civil Engineering Dept., Rajkiya Engineering College, Uttar Pradesh, India.
Corresponding Author Email: [1] saketrusia123@gmail.com, [2] iamsumitkesharwani@gmail.com,
[3] asmitasingh5147@gmail.com

Abstract— ***The continuous increase of emissions of greenhouse gas and mankind's reliance on exploiting fossil energy accumulation generated an urge to enhance the efficiency of buildings. The main aim of the power industry is to develop a building which consumes least possible energy and to produce low level gas. Consequently, green and energy proficient buildings such as nearly zero energy building (nZEB) has become a global trend. There are various design performance inputs and the prediction by which one can optimize the energy consumption to attain zero energy building. This paper mainly focuses on the optimization of the energy consumption of nZEB. This concept of nZEB has been implemented in various developed countries at a mass level, but India has not taken any significant measures towards achieving the zero-energy concept. This paper investigates significant measures that are currently practising in different countries to achieve a goal of zero energy building and then provide a suggestive measure that should be implemented in India.***

Index Terms: design performance inputs, nearly zero energy building, energy saving ratio, window-wall ratio

I. INTRODUCTION

One of the biggest challenges that the whole world is facing today is Climate change. It has become a strategic choice for every country to effectively react to worldwide warming, reducing emission of greenhouse gases, declining the consumption of non-renewable fuels sources and replacing it with green energy. 31% of the total primary energy is consumed by building in the developed countries and it contributes to roughly 29% of the greenhouse gas emission [1]. This shows that there is a huge effect of the building sector on the natural energy balance. So various measures are taken to reduce the energy needs of buildings and to produce the energy from renewable sources. One of the areas where we can achieve energy saving and reduce carbon emission by building nearly zero energy buildings (nZEB). Today it is a new universal trend and the basic way to attain the goal.

ZEBs are designed in such a way that it generates an equivalent amount of energy as it consumes in the whole year. They operate in coordination and synergy with the smart grid and maintain a strategic distance from additional push connected on the control foundation. It requires implementing efficient actions to reduce the consumption of energy requirements and utilizing a renewable energy source, a grouping of optimized and adjusted forms between utilization and generation related with effective smart grid employment. Smart grids are a remarkable establishment in the building sector, they allow to optimize the power quality and the dependability of energy sources. It can decentralize the supply and keep adjusting between supply and requirement. Therefore, execution of smart grid is essential to finishing the already laid out ZEB goals.

This concept is widely used in different developed countries. In China there are nearly one hundred zero energy projects by the end of February 2016. Governments implement new rules and set long term goals to achieve the goal. In 2010 Energy Performance of Buildings Directive (EPBD) [2] introduced the concept of nearly zero energy buildings in the European Union (EU) legislative framework. The European Union has decided to cut the consumption of building energy and greenhouse gas emission by 20% by the year 2020 [3].

Now if we take the case of India, it joined the Paris accord in the year 2015, but still, we are the third largest producer of greenhouse gas after the US and China. India has seen a huge increase of 335% in the emission of greenhouse gas by 1990[4]. Therefore, it is the need of the hour that we have to make progress towards nZEB in India. India pledged to reduce the emission by 33 to 35 percent as compared to 1990 in the year 2030. As a step towards that direction, the Nalanda University in Bihar and UHBVN Headquarter in Haryana dedicated to building a net zero energy campus. But this is very little progress as compared to energy consumption by our buildings. In this paper we want to provide suggestive measures that should be implemented in India towards achieving a zero-energy concept.

We have to reduce the energy consumption and optimize the parameters to get the zero-energy building. There are various parametric design parameters in parallel that can be optimized. Among several design concepts WWR is one of the important parameters that has a huge effect on buildings energy efficiency.

This research investigates the impact of different parameters on the energy utilization of zero energy buildings that can optimize the buildings in India as per climatic variation. We reviewed different papers based on different parameters to build nZEB and gathered the results to derive a method for India. In design optimization studies we have to consider winter and summer impacts to avoid the alteration of imperfect design from a sustainable point of view. And try to take progressive steps towards green energy building.

II. NEARLY ZERO ENERGY BUILDING CONCEPT

The nearly-zero technique is known to be a strategy associated with fulfilling agreement between the resource drawn from the characteristic environment like water and energy and its utilization at residential buildings and offices, pieces or communities at a pre-defined time span, ordinarily each year.

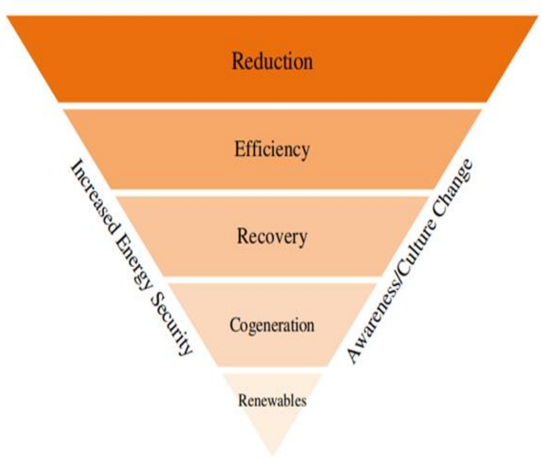

Fig. 1 : nZEC Pyramid Info

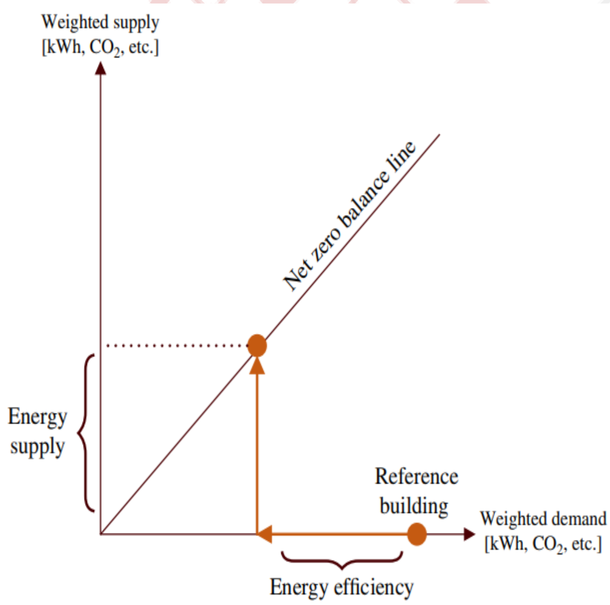

Fig. 2 : nZEB Balance Info

Triangle in Fig. 1 depicting nZEC (nearly zero energy concept [5]

Graph in Fig. 2, Depicting nZEB balance concept [6]

These buildings are self-sufficient to decrease the energy consumption (optimize energy efficiency, decrease final energy, energy recovery and cogeneration activities).

III. SELECTION CRITERIA

We reviewed the paper based on the concept of zero-energy building. Different parameters are discussed under different papers by which we can attain the zero-energy building.

IV. REVIEWS

Guohui Fenga et al. [7] conducted a study in an amazingly cold locale, WWR is one of the productive energies sparing arrange for the energy utilization of about zero energy building. This research takes one normal nZEB in a seriously cold region of Shenyang city as a prototype. The impact of diverse orientations' WWR on energy utilization of NZEB was examined at long last through the simulation strategy of double energy utilization impact variables with a single variable, and the simulation program of EnergyPlus.In this paper, SketchUp is utilized to set up a demonstration of normal exhibit NZEB in typical cold regions. EnergyPlus simulation is dependent on the Thermal Zone.

This paper concludes that the more prominent effect of the arrangement of diverse orientations' WWR in a serious cold zone on NZEB energy utilization is east (west) > south > north. Increment the east (west), south WWR will increment cooling energy utilization more essentially than the heating energy utilization. The average heat gain rate is 16 to 20% of the loss rate; this is the reason for significant use of cooling energy. Most energy-saving WWR plan consisting of NZEB in extreme cold range is that the east WWR is between 10%-15%, the south WWR is between 10%-22.5%. And diminish the north WWR fittingly when the light and ventilation conditions permit it.

In this paper Cheng Zhang et al. [8] gives the impact of U-values on windows and U-values of walls and window- to-wall ratio by sensitivity analysis. To begin with, of all, the base model of a building was made by BIM and the properties of the building were characterized within the model. Base model is used for the calculation of energy baselines including operational energy (OE) and embodied energy (EE). BIM gives an easy way of material so as to calculate the EE. The energy examination was run repeatedly by shifting one or more design variables whereas all other variables were set to be consistent. Results show that during the lifetime operational stage of a building the energy consumed should be optimized. This figure shows the impact of U-values of wall and window on operational energy of building-

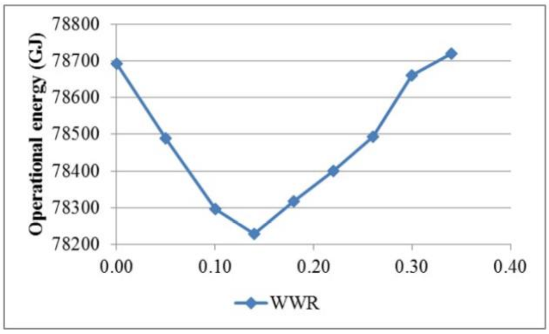

Fig. 3 : WWR vs Operational Energy

This Fig. 3, shows the impact of WWR on operational energy of building-

The outcome shows that reducing U-values of windows will improve the OE-EE relationship of WWR and OE of building is more sensitive to the variation of EE due to U-values of windows changes.

In this research, solar irradiance prediction and optimization of building energy were performed to reach the nearly -zero energy concept by A. Naveen et al. [9]. This model appeared to have RMSE values of 11% to 24% for different regular determinants utilizing the Arbitrary Forest Calculation in Waikato Environment for Knowledge Analysis (WEKA), which gave the yearly irradiance that comes about closer to the PV Solar energy determining outcomes. The R-value was within the run of 0.8 to 0.9 for different climatic conditions which is great.

Optimization of building energy was accomplished by utilizing the BEopt 2.8 computer program outlined by NREL. At first, they performed solar irradiance forecasting for collecting the average monthly GHI value for the next consecutive year and then studied the correlation and sensitivity analysis then energy and performance evaluation of the PV system was done after collection of data building energy optimization was done.

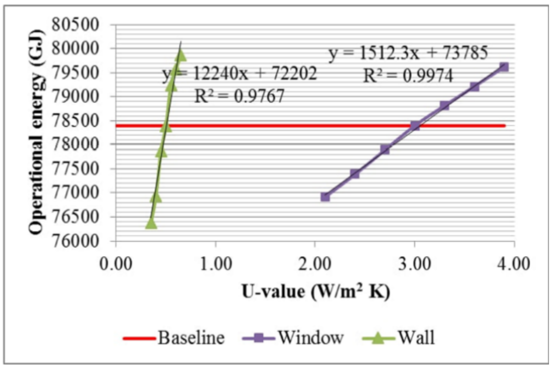

Fig. 4 : U Value Vs Operational Energy

Within the paper, Geovanni Murano et al. [10] explored for a few Italian climatic zones the connection between the ideal window-to-wall proportion (WWR) and the energy required in residential zero-energy buildings (nZEBs). Here we use the dynamic simulation tool Energy Plus to assess the energy performance.

As the analysis shows increasing WWR has a negative impact and the orientation of windows had a significant impact on energy performance of buildings. Within the plan of nZEBs, it is critical to consider the introduction fronts of glazed surfaces, the sun-powered and thermal properties of windows, and the shading gadgets properties in expansion too to the diminishment of inner heat loads.

In this paper Sadaf Alam et al. [11] characterize the cooling, heating, and power request of a household in a cold climate locale. Here we are trying to optimize the facade parameter to get the best conceivable energy execution. The dynamic simulation software that is used in this research study is IES-VE [12].

The variants of glazing used in the study is shown in below figure.

S.no	Glazing Type	Gas filling	U-Value, W/m²-K)	g-Value	Visible Transmittance
1	Double pane +low E, clear glazing with no shading	Argon	1.1	0.61	0.78
2	Double pane +tinted solar protection windows, with no shading	Argon	1.0	0.27	0.51
3	Triple pane + clear glazing with no shading	Argon	0.54	0.49	0.7
4	Triple pane + low E, clear glazing with shading	Argon	0.54	0.49	0.7
5	Triple pane + low E, clear solar glazing with no shading	Argon	0.54	0.36	0.6
6	Triple pane + low E, tinted solar glazing with no shading	Argon	0.54	0.24	0.45

Fig. 5 : Different Variants with Correspondings

By improving the number of panes, low emissivity coating and by improving U-values of windows we can balance the energy efficiency in the conventional windows of office buildings. The best result was found with the low emissivity glasses and the next best is given with clear solar protection glasses which can be used in minimum daylight required for minimum sized windows.

In this paper Li, J. Zheng et al. [13] investigates the thermal indoor quality of the buildings. The window-to-wall ratio (WWR) altogether influences the indoor warm environment, causing changes in residents' energy demands. This paper combines the TRNSYS and ENVI-met model to forecast the effect of WWR on inner cooling demand in south Hunan.

The explanation comes about to uncover that, on a classic summer day in southern Hunan, an increment in WWR isn't helpful in terms of energy savings. After the study it concluded that in a six-storey residential building with a 24 household the energy requirement to maintain the indoor temperature below the 30 Degree Celsius is as follows

Table I : WWR ratio & corresponding energy usage

WWR ratio	Energy required (KW-h)
0%	0
20%	19.6
40%	133.7
60%	273.1
80%	374.5
100%	461.9

In this paper Xiaolong Xu et al. [14] focuses on reducing the energy utilization of net zero energy building and various methods for optimization presentation of design parameters. The study based on the location Shenyang (China) and the technique used is Artificial Neural Network (ANN) for forecasting the consumption of electrical energy in a year by a net zero energy building.

The simulation and optimization tool used here is Energy Plus [15]. They use SketchUp to design the physical model of nZEB and open studio [16] to establish an HVAC system and control strategy.

Flow chart of research methodology-

The paper concluded that as the external thickness of walls and roof insulation increases, the consumption of total energy reduces. There is a very little change when U-values of glazing variants increase from 0.6 W/(m2-K) to 0.9 W/(m2-K) but see an obvious change when it increases more. The ideal width of the outside wall separator is 280-320 mm, and comparing add up to yearly vitality utilization is 53.75–54.15 KW·h/(m2 ·a). The ESR (energy saving rate) is approximately 0.33%. The ideal width of the roof separator is 260-300 mm, and comparing add up to yearly energy utilization is 53.81–54.09 KW·h/(m2·a). The ESR is approximately 0.22%.

In this paper Dimitrios et al. [17] investigates the evaluation of utilized electrical energy by undesigned loads in net zero energy buildings. They used the artificial neural network technique to investigate the energy consumed by the undesigned load which cannot be maintained by the energy management system of nearly zero energy buildings.

The need is fulfilled by contemplating the climate forecast information and citizens behaviour of the house that can be contemplated by accessing the history of electrical energy utilization of those undesigned machines that can be acquired by smart energy meters of that home. The adequacy and the achievability of the proposed energy utilization estimation calculation are approved and assessed by a few re-enactments that come about in the MATLAB/Simulink environment, utilizing real time electric energy estimations which were obtained by an ordinary family, found in Northern Greece.

In this paper M. Mahdavi et al. [18] investigates the thermal comfort of people living in the net zero energy building. Private and business buildings consume around 60% of worldwide energy power and it is very hard to define thermal comfort because thermal comfort is different for people living in different climatic conditions.

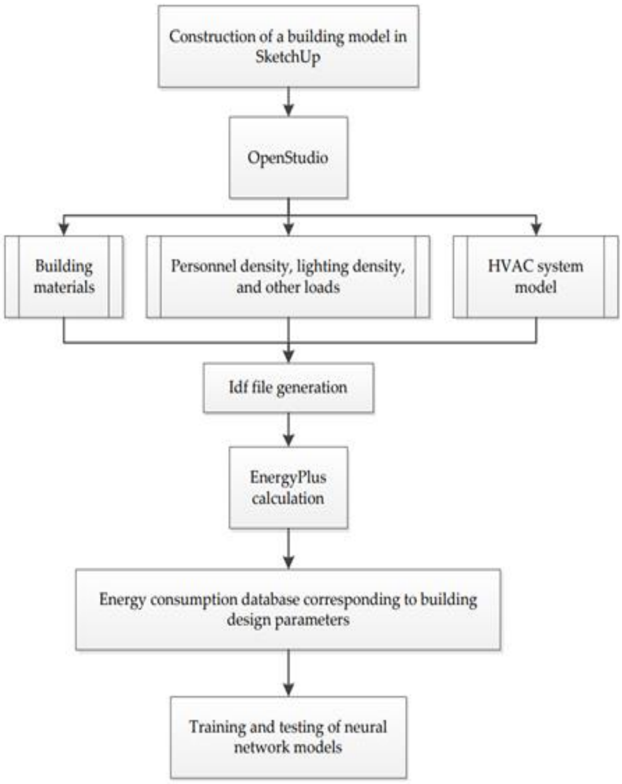

Fig. 6 : Research Methodology

They performed further studies on a net zero energy building model by using a computational fluid dynamics model for computational studies of different temperatures for thermal comfort. Besides, it is seen that ideal thermal comfort is accomplished in moderate climate. On the basis of analysis, it is found that only utilization of photovoltaic panels is not going to meet the hour needs so, they have to use other renewable energy resources like in cold weather photovoltaic panels are not efficient so wind turbines are the best substitute for electricity generation.

V. CONCLUSION

As mentioned in different papers, it simply concluded that the nZEB has come as an efficient way by which we can reduce the increasing energy demands and manage the environmental problems. The expansion of concept of nZEB to the society level will diminish the energy utilization of the building division, which speaks to over 30% of the overall last energy utilization, due to its optimized plan through detached and dynamic energy sparing procedures, the combination of renewable energy assets and the implementation of smart energy management calculations. These papers state that there are three main techniques in which energy consumption by zero energy building is dependent.

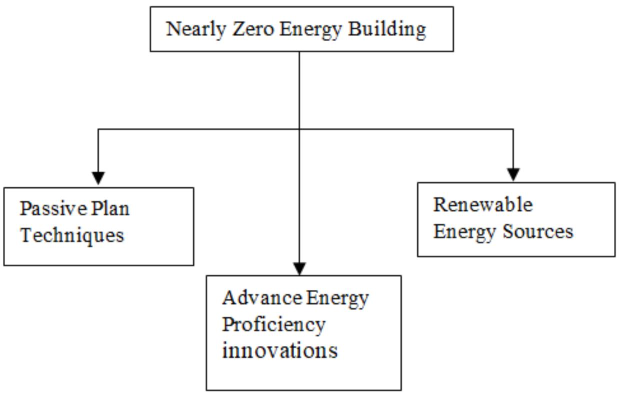

Fig. 7 : Three Techniques for nZEB

Passive plan techniques that we have to take care of: envelope, orientation, geometry & ratio, heating techniques like sunspace, Trombe wall, solar direct gain, cooling techniques like natural ventilation, green roof, solar shading, daylighting and underground storage of Thermal energy.

We have to focus on **advanced energy efficiency innovations** including domestic hot water (DHW) heating, ventilation and air conditioning (HVAC), moisture, smart lighting, temperature, smart plugs, air quality and occupancy sensors, Energy Management System, smart communications protocols and logarithms.

The on-site **renewable energy technologies** that should be implemented are Solar Thermal, Solar photovoltaic, Biomass Boilers and offsite technologies include Hydro turbines, Wind turbines, Geothermal power generation. PV large station,

BENEFITS OF nZEB

1. It reduces the monthly expenses of living.
2. More prominent resale regard as potential proprietors needs more ZEBs than available supply.
3. Better reliability.
4. Increased comfort in living because of enhanced air quality and uniform interior temperature.
5. The total cost of possession is decreased by improving the energy efficiency.
6. Environmentally compatible
7. Lower emission of carbon
8. Isolation from the future energy rate increase

KEY BARRIERS OF NZEB

1. At initial level, the cost of installation is very high. So, nZEB's are not cost efficient.
2. Life of a building should be considered as if one makes today's building energy efficient and that can provide shelter for the next decade to come but not further. So, nZEB concept should be used in new buildings for modification to be made in the right time.
3. Lack of authentic information related to nZEB's consumers are misinformed about energy efficiency related implications for their decision making and purchase.

SUGGESTIVE MEASURES FOR INDIA

1. For the northern side of India which experiences severe cold during winter, the WWR in the east(west) is between 10%- 15%, the south WWR is between 10%-22.5% and diminishes the north WWR.
2. Reducing U-values of windows will improve the OE-EE relationship of WWR.
3. In India if we use a 7 kW Solar PV System the energy utilization has decreased from 192.2 MMBtu/year to 109.1 MMBtu/year.
4. Window's orientation had a remarkable effect on the energy stability of buildings.
5. To achieve the concept of nZEB in India we have to use the low emissivity glasses.
6. By increasing external wall thickness and insulation of the roof, the consumption of total energy reduces.
7. On a typical summer day like in the southern part of India increasing WWR is not effective.
8. In the Rajasthan region where the speed of wind is high, we can build a wind turbine to meet the energy requirements.

VI. ABBREVIATION:

Acronym	Illustration
WWR	window -to- wall ratio
ANN	artificial neural network
nZEB	nearly zero energy building
U-values	thermal transmittance
ESR	energy saving rate
HVAC	heating, ventilation, and air conditioning
PV	photovoltaic
RMSE	root mean squared error
OE	operational energy
EE	embodied energy
GHI	global horizontal irradiance

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 7, July 2022

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