Net Zero Energy Building

Mr.Sachin Jadhav[1], Mr.Pratish Siddheshware[2], Mr.Mahadevi Jagdale[3], Mr.Yadnyaeshwar Bhatikare[4]
[1, 2, 3, 4] Dr. D. Y. Patil Institute Of Engineering, Management And Research Pune, India

Abstract- *A net zero-energy building (ZEB) is a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies. Despite the excitement over the phrase "zero energy," we lack a common definition, or even a common understanding, of what it means. In this paper, we use a sample of current generation low-energy buildings to explore the concept of zero energy: what it means, why a clear and measurable definition is needed, and how we have progressed toward the ZEB goal. The way the zero energy goal is defined affects the choices designers make to achieve this goal and whether they can claim success. The ZEB definition can emphasize demand-side or supply strategies and whether fuel switching and conversion accounting are appropriate to meet a ZEB goal. Four well-documented definitions—net-zero site energy, net-zero source energy, net-zero energy costs, and net-zero energy emissions— are studied; pluses and minuses of each are discussed. These definitions are applied to a set of low-energy buildings for which extensive energy data are available. This study shows the design impacts of the definition used for ZEB and the large difference between definitions. It also looks at sample utility rate structures and their impact on the zero energy scenarios Zero Energy Homes are very crucial because they produce energy that is beneficial for the environment and cost effective for the owners of the house. These types of homes generate equivalent amounts of input and output energy leading to a selfsustaining house with zero net energy. For this project, we were asked to utilize and apply the engineering design processes we learned in class in order to build a zero energy home that meats a certain customer needs analysis. Working in teams of three, we each researched and familiarized ourselves with the topic of Zero Energy Homes (ZEH). We used the information we acquired by doing some research to design, within a 5 week period, a ZEH model that exploits several passive solar design strategies for facilitating the most heat retention with the slightest possible heat loss*

I. INTRODUCTION

In India most of the energy used today is produced from fossil fuels like coal, oil, natural gas, and a direct consequence of using these fuels is that greenhouse gasses are released into the atmosphere, with one of the most significant being carbon dioxide (CO2). These gasses emitting infrared radiation, contribute to global warming and climate change. In response to this threat, governments across the world have committed to reducing greenhouse gas emission and increasing renewable energy production. India is the sixth largest CO2 emission country (6.6%) in the world and continued to increase by 7.8%. The increase in CO2 emission was mainly caused due to consumption of energy which is primary demand of building sector. Buildings have a significant impact on energy use and the environmental impact. Buildings use almost 40% of the primary energy and approximately 70% of the ele ctricity. The energy used by the building sector continues to increase, primarily because new buildings are constructed faster than old ones are demolished. Power consumption doubled in the building sector between 1980 and 2000, and is expected to increase another 50% by 2025. Energy consumption in the commercial building sector will continue to increase until buildings can be designed to produce enough energy to offset the growing energy demand of these buildings. Toward this end, Indian government promotes Zero Energy Buildings concept, which greatly reduced energy needs through efficiency gains such that the balance of the energy needs can be supplied by renewable technologies. A building may be considered a ZEB if 100% of the energy it purchases comes from renewable energy sources, even if the energy is generated off the site.

Currently, there is almost no doubt about the processes of global warming on Earth in the scientific community Partly, this is confirmed, including changes in regulatory documentation. So in an updated version of the standard building climatology (SP 131.13330) compared with the previous edition of this standard (SNIP 23- 01- 99*) for a large number of settlements, including Moscow and St. Petersburg, the calculated parameters of the climate were revised upwards the design temperature of outer air and decrease the duration of the heating season. In the history of our planet periodically climate change has happened before but for the first time these changes associated with human activities .

Carbon dioxide (CO2) that is emitted during the combustion of fossil fuels changes the composition of our atmosphere. The uncontrolled use of fossil energy leads to the depletion of world reserves of non-renewable energy sources. The area, where it is possible to reduce the consumption of fuel and, consequently, energy consumption and emissions into the atmosphere, is the housing stock, which according to various estimates consumes 30 to 40 % `, to improve the degree of building automation when adjusting the parameters of the coolant that enter the building, to install systems heat recovery of exhaust air and a more efficient heating system.

1.1 Why Net Zero Energy Building (Nzeb)

A site ZEB produces as much energy as it uses, when accounted for at the site. Generation examples include roof-mounted PV or solar hot water collectors. Other site-specific on-site generation options such as small-scale wind power, parking lot mounted PV systems, and low-impact hydro, may be available. As discussed earlier, having the on-site generation within the building footprint is preferable. A limitation of a site ZEB definition is that the values of various fuels at the source are not considered. For example, one energy unit of electricity used at the site is equivalent to one energy unit of natural gas at the site, but electricity is more than three times as valuable at the source. For all-electric buildings, a site ZEB is equivalent to a source ZEB. For buildings with significant gas use, a site ZEB will need to generate much more on-site electricity than a source ZEB. As an example, the TTF would require a 62-kWDC PV system to be a site ZEB, but only a 45-kWDC PV system for a source ZEB; this is because gas heating is a major end use. The net site definition encourages aggressive energy efficiency designs because on-site generated electricity has to offset gas use on a 1 to 1 basis. 6 A site ZEB can be easily verified through on-site measurements, whereas source energy or emissions ZEBs cannot be measured directly because site-to-source factors need to be determined. An easily measurable definition is important to accurately determine the progress toward meeting a ZEB goal.

1.2 Scope For Nzeb

As NZEB have been recently introduced worldwide, most designers and consultants have limited experience. Thermal comfort is the priority in NZEB. The case studies revealed that there is an overestimation of passive cooling strategies. Natural ven tilation is limited in NZEB if high IEQ is required. Dynamic building modeling can produce accurate estimates of energy consumption and provide good estimates of thermal comfort, air quality, and overheating risk. The key lesson is to take all of the simulation estimates with a grain of salt and to apply some rudimentary overheating risk analysis to any claims of the passive cooling effectiveness in NZEB, absence of any static simulation result and use only dynamic simulations. Design reviews can bring a better quality to the early design stages and make sure to size SASs, envelope thermal resistance, glazing to wall ratio, shading, and other common issues related to the building geometry and envelope. Another key lesson is to perform rigorous design reviews and apply some design checklists to make sure that heat gains are minimized. Make sure that key design elements of NZEB, such as SAS, shading devices, thermal bridge free walls, and PV friendly roofs are integrated in The Design And Sized Properly.

1.3 Advantage Of Nzeb

- isolation for building owners from future energy price increases
- increased comfort due to more-uniform interior temperatures (this can be demonstrated with comparative isotherm maps)
- reduced total cost of ownership due to improved energy efficiency
- reduced total net monthly cost of living
- reduced risk of loss from grid blackouts
- Minimal to no future energy price increases for building owners reduced requirement for energy austerity and carbon emission taxes
- improved reliability – photovoltaic systems have 25-year warranties and seldom fail during weather problems – the 1982 photovoltaic systems on the Walt Disney World EPCOT (Experimental Prototype Community of Tomorrow) Energy Pavilion were still in use until 2018, even through three hurricanes. They were taken down in 2018 in preparation for a new ride.[45]
- higher resale value as potential owners demand more ZEBs than available supply
- the value of a ZEB building relative to similar conventional building should increase every time energy Costs Increase

1.3 Disadvantages Of Nzeb

- initial costs can be higher – effort required to understand, apply, and qualify for ZEB subsidies, if they exist. • very few designers or builders have the necessary skills or experience to build ZEBs
- possible declines in future utility company renewable energy costs may lessen the value of capital invested in energy efficiency
- new photovoltaic solar cells equipment technology price has been falling at roughly 17% per year – It will lessen the value of capital invested in a solar electric generating system – Current subsidies may be phased out as photovoltaic mass production lowers future price
- challenge to recover higher initial costs on resale of building, but new energy rating systems are being introduced gradually.

- while the individual house may use an average of net zero energy over a year, it may demand energy at the time when peak demand for the grid occurs. In such a case, the capacity of the grid must still provide electricity to all loads. Therefore, a ZEB may not reduce risk of loss from grid blackouts.
- without an optimised thermal envelope the embodied energy, heating and cooling energy and resource usage is higher than needed. ZEB by definition do not mandate a minimum heating and cooling performance level thus allowing oversized renewable energy systems to fill the energy gap.

II. LITERATURE REVIEW

In the literature, over the decades, different ZEB's were described and evaluated, however almost in every paper the ZEB either was defined differently or no exact definition was used. Very often, the ways the zero energy goal was achieved have significantly affected the ZEB definition. Recently, the lack of common understanding and common definition for ZEB became noticeable, since this building concept is thought to be an effective solution for decreasing the energy use and greenhouse gas emissions from the building sector.

The main objective of this report is to give an overview of existing ZEB definitions. The review has shown that Zero Energy Building is a complex concept described with the wide range of terms and expressions. Based on the similarities and differences of the definitions from the existing worldwide literature, various approaches for ZEB definitions are differentiated.

In the literature dedicated to Zero Energy Building the authors frequently emphasize the lack of common understanding of what should be equal to 'zero'. This issue has been widely discussed in numerous publications however, the question: should "zero" refer to the energy, the exergy or the CO2 emissions or maybe energy costs, still has not been unambiguously answered. Kilkis, (2007) in his work refers to Torcellini, et al. (2006) however, his review on ZEB definitions, takes slightly another direction. Kilkis indicates that in balancing the 'zero' both quantity and quality (exergy) of energy should be taken into consideration. Kilkis, (2007), explains that: "…although ZEB definition seems logical, it falls short recognize the importance of exergy in assessing the complete impact of buildings on the environment. For example if a ZEB is connected to a district energy system and receives high temperature heat as well as electrical energy and provides heat in the same quality at a lower temperature and at the same quantity of electrical energy to the district, the building is not balancing the exergy of heat it receives and provides. This ZEB is still impacting the environment because the negative exergy balance must be made up by the district at a cost of additional fuel spending and harmful emission even though energy amounts of the heat and power flow across the building-district boundary are balanced… If the district generates power in the thermal power plant, and the ZEB generates electric power in a micro-combined heat and power (CHP) unit, and or by using wind turbine, all have different environmental impacts and exergy".

Therefore, author proposes a new definition for the ZEB a Net-Zero Exergy Building and defines it as: "a building, which has a total annual sum of zero exergy transfer across the building-district boundary in a district energy system, during all electric and any other transfer that is taking place in a certain period of time". Moreover, Kilkis, (2007) points out, that taking into consideration the exergy balance instead of energy balance enable to quantify the compound carbon emissions of a building, thus accurately rate building impact on the environment. By compound CO2 emissions author understands the direct carbon emission from the building and avoidable secondary carbon emission that is the consequence of the exergy mismatch. According to Kilkis, (2007): "… engineers, architects, decisions makers must recognize that the harmful emissions and global warming issues cannot be fully addressed by simple net zero energy building concept. Exergy dimension of the balance must be absolutely taken into account in order to fully reveal the magnitude of the problem and at the same time draw solution roadmaps"

Esbensen, et al. (1977) describe an experimental ZEB house in Denmark and point out: "With energy conservation arrangements, such as high-insulated constructions, heat recovery equipments and a solar heating system, the Zero Energy House is dimensioned to be self-sufficient in space heating and hot-water supply during normal climatic conditions in Denmark. Energy supply for the electric installations in the house is taken from the municipal mains." Saitoh, (1984) and Saitoh, et al. (1985) in their studies present a Natural Energy Autonomous House in Japan. According to authors: "… a multipurpose natural energy autonomous house will meet almost all the energy demands for space heating and cooling as well as supply of hot water for standard Japanese house in 10-15 years. For this purpose, solar energy, the natural underground coldness and sky radiation cooling are utilized." On the other hand, in number of papers total energy demand of a building is fully dominated by electricity demand, thus in the ZEB definition only electricity is considered. One of the reasons for this situation is simply the lack of district heating in many countries. However this issue is not commonly mention in the definition, which makes it imprecise. Gilijamse, (1995): “A zero energy house is defined here as a house in which no fossil fuels are consumed, and the annual electricity consumption equals annual electricity production. Unlike the autarkic situation, the electricity grid acts as a virtual buffer with annually balanced delivers and returns”

Noguchi, et al. (2008): “In this paper, a net zero-energy home (NZEH) is defined as a house that consumes as much energy as it produces over a year” and after few pages authors describe: “The BIPV/T system is an on-grid application accompanied with an inverter for the AC/DC conversion. The system allows for redirection of the locally generated electricity surpluses to the grid.” The studies with clear grid-connected ZEB definition belong to: Gilijamse, (1995), Parker, et al. (2001), Iqbal, (2003), Laustsen, (2008). Gilijamse, (1995): “A zero energy house is defined here as a house in which no fossil fuels are consumed, and the annual electricity consumption equals annual electricity production. Unlike the autarkic situation, the electricity grid acts as a virtual buffer with annually balanced delivers and returns” Parker, et al. (2001): “During times of peak demand, a Zero Energy Home generates more power than it uses, thereby reducing power demand on the utility provider. During times of power outage, the home generates its own power, allowing the homeowner essential energy security. In a Florida study, a prototype Zero Energy Home outperforms a conventional model by providing almost all of its own power needs throughout the year.”

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.

III. 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. 1.5 MAJOR DESIGN EXPERIENCE Design experience in the following areas has been gained during the course of the project i. Design of slabs ii. Design of footings iii. Design of wall using Hollow bricks iv. Design of solar panels.

This entire project is an planning and design in nature and the methodology followed in this project is listed as below.

i. Selection of site where renewable energy is available ii. Study the climate conditions of area
iii. Aligning the building to utilize maximum amount of renewable resources
iv. Planning and design of proposed NZERB building
v. Comparison of the NZERB building with other conventional building

3.1 Degine

Zero Energy Home requires that a wide variety of small issues be effectively addressed in the design phase, including exploring the most cost effective options and ideas for reaching Net Zero – and the site is the best place to begin The key to designing net zero energy buildings are first reducing energy demand as much as possible, and then choosing good energy sources. Here is a simple order of operations.

A Passive Design

Passive design maximizes the use of natural sources of heating, cooling and ventilation to create comfortable conditions inside buildings. It harnesses environmental conditions such as solar radiation, cool night air and air pressure differences to drive the internal environment. Passive measures do not involve mechanical or electrical systems. An NZEB will only be cost-effective if all the passive strategies Like Form & Orientation, Shading, Cool Roofs, Fenestration, Insulation, Daylighting, Windows, Natural Ventilation, Thermal International Journal of Scientific Research in Science, Engineering and Technology (ijsrset.com) 362 Mass, Evaporative Cooling, Thermal Comfort and Vegetation are adopted in its design and construction.

B. Lighting

Lighting energy accounts for more than a quarter of total energy consumption in buildings. It is therefore important to optimize lighting energy used to achieve net zero goals. Energy efficient lighting fixtures like Light Emitting Diodes (LEDs) are now readily available in the market. These must work in conjunction with day lighting. Building form, orientation, and fenestration design must take channel daylight into the building. Day lighting controls as well as occupancy sensors could further reduce lighting energy use.

C. Size and Shape

Limiting the size of the home will have a direct impact on overall energy required on site, and should help reduce costs The excellent book, The Not So Big House, describes how a small home can be designed to look large, spacious and comfortable.

D. Design To Use Sun

Zero Energy Homes should be designed to use the sun’s energy as much as possible, for such things as: generating electricity, heating hot water, and utilizing passive solar space heating.

E. Design with a Continuous Air Barrier

The house should be designed with a continuous air barrier. All the cracks, holes, and exterior envelope penetrations of the home’s six-sided box must be systematically sealed.

3.2 Efficient Appliances

Selecting the right appliances and good usage practices is reducing half energy load. Solar Appliances, Solar Lighting, Tubular Fluorescent Lamps (TFLs), Ceiling Fans, Electric Geysers and Color Television are the right alternative to conventional appliances

3.3 Renewable Energy Sources

Renewable energy systems are the final step to attaining zero energy goals. Once all possible measures to reduce energy demand are deployed, renewable energy systems must step in to balance residual energy demand. Performance of renewable energy systems determines the success of the net-zero buildings. Total grid connected renewable power capacity in India is 45,065 MW as of August 2016(Ministry of New and Renewable Energy-MNRE) i.e.; wind power: 27,674 MW (61.3%), Solar power: 8,083MW (18%), Bio power: 4,882 MW (10.9%), small hydro: 4,310MW (9.6%) and Waste-to-Power: 115MW (0.3%). Economical Comparison shows that Wind Energy is most economical among all renewable resources. India target 5 time (175MW) increasing renewable energy capacity by 2020

3.4 Heating, Ventilation and Air Conditioning (HVAC)

Comfort systems contribute to nearly 40% of the energy used by commercial buildings in India. Many types of HVAC systems are available in market ranging from low energy comfort systems to conventional systems. Design of a building, climatic zone and operational parameters governs the energy requirement for the comfort system. Reducing heating and cooling loads through passive design and enhancing the efficiency of HVAC systems are steps that are imperative for any building energy efficiency policy. Apart from selecting energy efficient equipment, it is important to select the correct system type, size, and design for optimized energy efficiency

IV. CONCLUSION

Worldwide acceptance of zero energy building technology may require more government incentives or building code regulations, the development of recognized standards, or significant increases in the cost of conventional energy. The zero energy building concepts has been a progressive evaluation from other low energy building designs. Difficulty in finding trained contractors and builders, lack of public awareness, regulation and political agenda, financing are not the barrier to achieve goal. .NZEB’s are the good solution to significantly reducing energy use and greenhouse gas emissions for the life of the building. In 2007 UK Government introduced a policy stating that from 2016 all new homes constructed must meet a Zero Carbon Standard.
With the advancement in renewable technology, Net Zero Energy Buildings are the future. Many governments have framed Zero Energy building laws. Few governments are also providing subsidies to individuals and organizations for creating Zero Energy Buildings. But the goal of zero energy buildings would not be fulfilled till the time all the people don’t understand their responsibility and contribute towards reducing energy consumption.

Each of these leading-edge case study buildings demonstrates the progress toward achieving ZEB goals in real-world examples. Only the Science House has achieved the site and source ZEB goal because it is a small building with a relatively large PV system. The other one story buildings—Zion, BigHorn, and TTF—could achieve ZEB within their roof areas for all the definitions except cost ZEB. ZEB is not feasible for the two-story buildings unless their loads are further reduced. For Oberlin (currently closest to meeting a

ZEB goal in a two-story building), the annual PV production is still less than the best-case energy consumption scenario. Oberlin is currently installing another 100-kW PV system in the parking lot (total installed DC capacity will be 160 kW), which will be tied into the building's electrical system. We expect that the building will achieve a site, source, and emissions ZEB, but that a cost ZEB will be difficult to reach without further demand management controls. To accomplish a ZEB, the PV system has been extended past the building footprint. None of our sample commercial buildings could clearly be cost ZEBs with the current rate structures.

REFERANCES

[1] Introduction to National Rating System – GRIHA An evaluation tool to help design, build, operate, and maintain a resource-efficient built environment, Ministry of New and Renewable Energy, Government of India & TERI – The Energy and Resources Institute New Delhi, GRIHA Manual Vol. 1 , 2010

[2] Energy Statistics 2011, National Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India

[3] S. Dalwadi, G. Shah, "A framework for Impetus to Energy Efficient Designs", Institute of Town Planners, India, Vol. 9-3, pp. 71-83, July-September 2012-10

[4] Saket Sarraf, Shilpi Anand Saboo, Shravani Gupta, Energy Conservation and Commercialization (ECO-III), ECO-III-1041, Final Report, USAID, September 2011.

[5] Energy Assessment guide for buildings, USAID ECO III project, January 2010

[6] Nicolae Bajenaru, Andrei Damian, Rodica Frunzulica, Evaluation of the energy performance for a nZEB office building under specific climatic conditions, Sustainable Solutions for Energy and Environment, EENVIRO - YRC 2015, 18-20 November 2015, Bucharest, Romania

[7] Isamu Ohta, Embodied CO2 Evaluation of a Zero Life Cycle Industrialized Home, Journal of Asian Architecture and Building Engineering, Volume 16 no.1 , 231-237, 2017

[8] Reshmi Banerjee, Importance of Net Zero Energy Building, International Journal of Innovative Research in Advanced Engineering (IJIRAE), Issue 5, Volume 2, May 2015.

[9] Masa Noguchi, Andreas Athienitis, Véronique Delisle, Josef Ayoub & Bradley Berneche, Net Zero Energy Homes of the Future: A Case Study of the ÉcoTerraTM DYPIEMR, Akurdi xxv Platell, P. & Dudzik, D.A. (2007).

[10] Zero energy houses geoexchange, solar CHP, and low energy building approach. Proceedings of the Energy Sustainability Conference 2007, 2007, pp. 471-476 Pogharian, S., Ayoub, J., Candanedo, J.A. & Athienitis, A.K. (2008). Getting to a Net Zero Energy Lifestyle in Canada.

[11] The Alstonvale Net Zero Energy House. Presented to the 23nd European PV Solar Energy Conference, Valencia, Spain, September 2008 Rosta, S., Hurt, R., Boehm, R. & Hale, M.J. (2008). Performance of a zero-energy house. Journal of Solar Energy Engineering, Transactions of the ASME Vol. 130, Issue 2, May 2008, pp. 0210061-0210064

[12] Saitoh, T (1984). Natural energy autonomous house with underground water reservoir. Bulletin of the JSME Vol. 27, Issue 226, April 1984, pp. 773-778 Saitoh, T., Matsuhashi, H. & Ono, T. (1985).

[13] An energy-independent house combining solar thermal and sky radiation energies. Solar Energy Vol. 35, Issue 6, 1985, pp. 541-547 Stahl, W., Voss, K. & Goetzberger, A. (1995). The self-sufficient solar house Freiburg. Geliotekhnika Issue 1-3, January 1995, pp. 50-80