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An Alternative for Sustainable Development: Net Zero Energy Building

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Abstract

Buildings and construction together account for 36% of global final energy use and 39% of energy-related carbon dioxide (CO_2) emissions when upstream power generation is included. The energy intensity per square meter (m^2) of the global buildings sector needs to improve on average by 30% by 2030 (compared to 2015) to be on track to meet global climate ambitions set forth in the Paris Agreement. For this reasons Net Zero Energy Buildings can play vital role. This paper tries to cover the emerging field of NZEBS. It provides information about the need of NZEB in present situation and how it can reduce the energy usage by use of various techniques which will cause less harm to the environment.

Keywords— Net Zero Energy Building (NZEB), Carbon emission, Green buildings, Green materials

I. INTRODUCTION

With structures the world over representing almost 33% of worldwide energy requests and the accessibility of non-renewable energy sources continually on the decline, there is a need to guarantee that this energy request is proficiently and viably overseen utilizing sustainable power sources now like never before. Consistently, our species bites its way through in excess of a million terajoules of energy. That is generally proportional to what we would utilize if all 7.5 billion of us bubbled 70 pots of water an hour nonstop. With the worldwide populace growing and industrialization on the ascent in creating countries, mankind's strive after energy has arrived at exceptional levels. The greater part of our energy originates from petroleum derivatives extricated from profound inside the Earth's outside layer. It is evaluated that since business oil penetration started during the 1850s, we have sucked up in excess of 135 billion tons of unrefined petroleum to drive our vehicles, fuel our capacity stations and warmth our homes. That figure expands each day. Figure 1 underneath shows the energy use in U.S. business structures.

Consuming of coal, oil and gas has been inseparably connected to the rising degrees of ozone depleting substances in Earth's air and is a main patron of environmental change. For this we need Net Zero Energy Buildings. There are various advantages and focal points to NZEB. From the start, plan and development may appear to be all the more expensive, yet there is long haul return on beginning venture.

Energy imported and sent out to the NZEB is estimated as far as carbon discharges come about because of their age and transmission. Amount of emanations decides the amount of energy to be created for accomplishing net zero status. Carbon discharges are one of the more all-encompassing measurements of

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estimating NZEBs where contrasts in crude energy fuel types and non-energy factors like contamination are reflected. Carbon, sulfur oxides and nitrogen oxides are considered carbon outflows. Inexhaustible sources like atomic, hydro and wind are viewed as zero discharge at age.

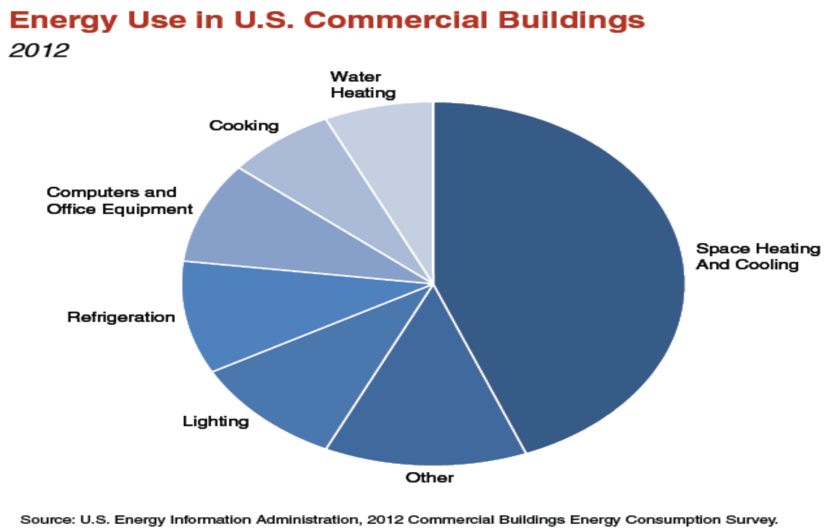

Fig. 1 Energy use in U. S. Commercial buildings 2012

II. DEFINITION OF NET ZERO ENERGY BUILDING

In 2015, the US Department of Energy and the National Institute of Building Sciences mutually finished an investigation to set up normal definitions and terminology for zero energy structures. It characterized a zero energy building (ZEB) as "a energy effective structure where, on a source energy premise, the genuine yearly conveyed energy is not exactly or equivalent to the on location inexhaustible sent out energy" on a yearly premise [1].

The idea is basic: a net zero energy building is a structure with altogether decreased energy needs delivering as much energy as it expands. However this is no simple accomplishment. These kinds of structures necessitate that consideration be paid to the manner in which the space is worked to guarantee energy utilization is limited, and frameworks must be planned so the structure additionally delivers energy.[2]

NZEB doesn't have a fixed definition where as it can be defined in variety of definitions in various literatures. The definition of NEZB are briefly as below. [3]
TABLE I
TERMS AND DEFINITIONS OF ZEB

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Terms	Definition
Zero energy building (ZEB) or net zero energy building (NZEB)	A building that produces as much energy on-site as it consumes on an annual basis
Net zero site energy building (site ZEB)	Amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building
Net off-site zero energy building (off-site ZEB)	Similar to previous one, but consider purchasing of energy off-site from 100% renewable energy sources
Net zero source/primary energy building (source ZEB)	It produces as much energy as it uses in a year, when accounted for the source. For electricity, only around 35% of the energy used in a fossil fuel power plant is converted to useful electricity and delivered. Site-to-source conversion multipliers are used to calculate a building's total source energy
Net zero energy cost building (cost ZEB)	The cost of purchasing energy is balanced by income from sales of electricity to the grid of electricity generated on-site
Net zero energy emissions building, zero carbon building (ZCB),	The carbon emissions generated from the on-site or off-site fossil fuel use are balanced by the amount of on-site renewable energy production

1.Need of NZEB

a) NZEB can improve or keep up your upper hand, improve the estimation of the property, alleviate showcase hazard, and advance the wellbeing and prosperity of inhabitants
b) Saves cash: A task will set aside cash over the whole life pattern of its gear, and in energy and support costs.
c) It is instructive: Anyone required during the structure, development, activities or support courses of events serves to increase significant information and comprehension about net zero-energy and energy efficiencies. Indeed, even the individuals who utilize the office can make associations, and figure out how to confine their own energy use.
d) Reduces ozone depleting substances: Limiting or liberating structures from their reliance on non-renewable energy sources, we a making a stronger future. It benefits our kids, the world and us.[2]

2. GOALS OF NET ZERO ENERGY BUILDING

1. Efficiency Energy & greenhouse gases. Minimize the use of household energy and increase the use of renewable energy while reducing the emissions of carbon dioxide and other greenhouse gases from producing electricity. These initiatives also offer a hedge against higher energy costs.
2. Small Energy Incarnate. Minimize the house 's energy by using products and materials with minimal energy requirements during processing, manufacture and transportation.
3. Conserving water. Reduce the use of water via low-flow fittings and efficient appliances. This results in energy and resource savings by lowering requirements for supply and wastewater services, and reducing needs for water storage. Water management results in a house that is more

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capable of meeting its own water needs and reduces the cost of water supply and waste water disposal.

4. Health & coziness. Ensure a warm and dry building with good daylight and fresh air supply which increases occupants' comfort, happiness and health. It also has the ability to slash medical expenses and take days off.
5. Minimizing Waste. Deposit waste can be reduced by efficiently using materials, adopting on-site recycling and reuse practices and selecting building materials that are recycled and recyclable.
6. Low-emission contaminants. During building and service pollutant emissions can be reduced by using low emission goods and materials, stormwater management and environmental protection.
7. Longevity. Durable materials and products can help reduce the cost of maintaining and resource. Assessing durability based on lifecycle analysis is important.

3. GUIDING PRINCIPLES

The following guiding principles are used in developing a zero energy building (ZEB) definition for commercial/ industrial/ institutional buildings. The definition should:

1. Create a standardized basis for identification of ZEBs for use by industry.
2. Be capable of being measured and verified, and should be rigorous and transparent.
3. Influence the design and operation of buildings to substantially reduce building operational energy consumption
4. Be clear and easy to understand by industry and policy makers.
5. Set a long-term goal and be durable for some time into the future.[1]

4. STRATEGIES FOR ENERGY EFFICIENT BUILDING

A. Minimizing losses: The transmission of heat losses plays an important role in buildings' energy performance. The transmission losses will have the highest ratio of all losses depending on the form of building (housing, workplace, schools etc.). Then the first important design measure would be to reduce heating losses by reducing the shape-volume ratio.

B. Maximizations of solar gains (Heating case) – Maximization of passive solar gains during the heating period should be the main target for reducing the demand for heating energy. The key elements are optimized orientation interaction, window size and the disposable thermal mass. The use of passive solar energy and mechanical ventilation with heat recovery for heating, special window design and a special reflector sunblind (reflecting sunlight to the ceilings, etc.) allows for the building to maximize solar heat gains. For storing solar energy, massive floors, walls and specially designed ceilings (ribbed concrete slabs with a large surface area) are used.

C. Minimization of solar gains (cooling case)-The orientation and size of transparent building elements (windows) has a significant influence on the demand for cooling. The North-South orientation is the best approach for heating reduction and cooling energy demand. External steps for minimizing solar benefits are intelligent lighting elements with different orientations (e.g. south windows with west horizontal

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elements and east windows with vertical elements). Passive cooling without mechanical energy can be handled in office building up to two thirds of the total cooling charge (around 200 to250 WH / m2 / day).

D. Minimizing the need for electricity for artificial lighting – In addition to heating and cooling, the need for artificial lighting is of concern for energy-efficient buildings. Buildings with huge overall widths like office buildings tend to require considerable energy for artificial lighting. Developing revolutionary daylight ideas is the most effective technique for the reduction of the energy demand for lighting.[4]

5. ENERGY PRODUCTION METHODS

Energy creation techniques are the last zone of NZEB's required to be characterized; be that as it may, it could be considered the most significant as though done erroneously could bring about the net zero objective being missed. In Table II, there are various instances of energy creation strategies given.

TABLE II.
THE COMPARISON BETWEEN ON-SITE AND OFF-SITE ENERGY PRODUCTION [3]

Sr. No.	Site supply	Options	Examples
1	ZEB site supply	Reduce site energy use through low-energy building technologies.	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, etc.
2	On-Site supply	Use renewable energy sources available within the building’s footprint.	PV, solar hot water, and wind located on the building.
3		Use renewable energy sources available at the site	PV, solar hot water, low-impact hydro, and wind located on-site, but not on the building.
4	Off-Site	Use renewable energy sources available off-site supply to generate energy on site.	Biomass, wood pellets, ethanol, or biodiesel that can be imported from off-site, or waste streams from on-site processes that can be used on-site to generate electricity and heat.

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5		Purchase off-site renewable energy sources.	Utility-based wind, PV, emissions credits, or other "green" purchasing options. Hydroelectric is sometimes considered.

The typical solutions that can be used in various types of buildings are shown in table III. Passive house and low energy house concepts are combined in the area of small residential buildings with solar thermal systems, heat pumps, and photovoltaics. The use of energy-efficient HVAC-technology and home appliances for power saving can be found here more frequently than in other typologies. However, large residential projects use at least energy-efficient HVAC technology and in combination with CHP and PV systems make up for reduced energy demands through passive house principles. The solutions are slightly more extensive in the non-residential sector. Passive house ideas and the use of mechanical ventilation at least in heated dominated countries are also increasingly achieving the intended efficiency in typologies except residential buildings. The higher electricity loads and the mostly unfavorable relationship of suitable solar surfaces on the roof or facade to the building floor area are offset by on- and off-site CHP (only in some cases with biomass), as well as participation in external wind turbines or even "green" power supplies.[5]

TABLE III
TYPICAL SOLUTION SETS USED IN INDICATED NET ZEBS

Type of Buildings	Efficiency heat/cold	Efficiency electricity	Heat/cold supply	Electricity generation
Small residential buildings	Full Passive house concept with Solar thermal collectors	Efficient appliances	Heat pump	PV
Apartment buildings	Full Passive house concept with Solar thermal collectors	Efficient HVAC	CHP	PV / CHP
Non - residential buildings	Mechanical ventilation with heat recovery, passive cooling	Low energy artificial lighting / day lighting, controls	Heat pump	PV / Wind off-site / CHP (in factories)

6. ENERGY EFFICIENT GREEN MATERIALS USED IN NZEB BUILDING

1. Grit wash

A mortar of Birla white cement, dolomite powder and chips in a ratio of 2.5:1:6 is perfect for grit wash. Before the application, the surface should be leveled with a float. After an initial setting of 1-2 hours, the grit wash surface should be scrubbed gently with a nylon brush and water to remove the cement on top of the chips and to expose the aggregates. The grit washes have applied on the walls of case study building to provide cover/thickness to walls and keep cool inside the envelope.

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2. Sand stone cladding

Sandstone cladding was developed to make publicly available a product that we as stone masons have been creating and using for years over 30 year experience. It is not a quality product, but a timeless masterpiece that will stand the test of time, and because it is real Indian sandstone we can rest peacefully knowing that it will still have as much character and charm in 100 years as it does the day it is installed. . In case study building stone cladding is provided on outer exposed wall surfaces to provide cover to the walls, to resist sun rays and to keep cool inside and in this way helpful in energy saving.

3. Gypsum board

Gypsu*m board is the generic name for a family of panel products that consist of a noncombustible core, composed primarily of gypsum and a paper surface on the face back and long edges. Gypsum board is one of several building materials covered by the umbrella term “Gypsum panel “products containing gypsum cores; however, they can be faced with a variety of different materials including paper and fiberglass mats. Gypsum board panels are relatively large compared to other materials; they come in 48” and 54” wide sheets and in lengths of 8’, 10’ or 12’ so they quickly cover large wall and ceiling areas. In the case study building gypsum board is applied in the room area walls and ceilings for achieving thermal comfort.

4. Glass wool

Glass wool or fire glass insulation is an insulating material made from fibers of glass arranged into texture similar to wool. Glass wool is produced in rolls or in slabs with different thermal and mechanical properties. Glass wool is a thermal insulation that consists of intertwined and flexible glass fibers, which causes it to package air resulting in a low density that can be varied through compression and binder content. In the case study building resin bonded fiber glass wool is filled in walls and ceilings behind gypsum board as well as in under deck for achieving thermal comfort and saving valuable energy.

5. Tinted glass

Ordinary tinted glass is popular because it reduces heat gain and carbon emissions, although it also marginally reduces visible light transmission. The tint has little effect on the u-factor but reduces solar heat gain considerably; which can reduce the need for air conditioning in the summer. In fact, tinted glass can reduce the solar heat transmission by 30%-50% when compared to ordinary clear float glass. In case study building tinted glass have fixed in east and west sun facing windows and ventilators to reflect ultraviolet radiation of sun and to obtained energy efficiency and thermal comfort.

6. Energy efficient windows and ventilators

Some of the energy-efficient windows characteristics is that it has double or triple glass layers. These have Low E-coating between glass layers on one or more of the glass surfaces, often Argon or Krypton gas. Another feature of this window is the insulated spacers between the layers of glass.

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Both of the houses need proper ventilation. In 1995 the national building code started setting minimum ventilation standards for new buildings. Natural air leakage is always inadequate to provide decent air quality. Ventilation helps to provide fresh air and to reduce the air pollution indoors. Ventilation during the heating season helps to reduce the humidity. Heat recovery ventilation system (HRV) delivers fresh outdoor air to our home while exhausting outdoor indoor air. A proper installed system will have a balanced air flow in and outside of our house. An HRV recovers heat from the exhaust air to heat the colder outside air coming into our home.[4]

III. DIFFERENCE BETWEEN ZERO ENERGY BUILDING AND GREEN BUILDING

The key aim of green building is to allow effective use of resources and reduce detrimental environmental impacts. NZEB's achieve one key green-building objective of significantly reducing energy use and greenhouse gas emissions for the building 's lifetime. Zero energy buildings may or may not be considered green in all ways, for example recycled building materials such as waste reduction etc. Nonetheless, zero energy buildings appear to have a much lower environmental effect over the life of the building compared to other green buildings that need imported energy and/or fossil fuels to be habitable and meet the needs of the occupants.[6]

IV. Overall Survey on Net Zero Energy Buildings

During the most recent 20 years in excess of 200 legitimate tasks with the case of a net zero energy balance have been understood everywhere throughout the world. The quantity of completed structures every year has risen persistently. With the expansion in accessibility of productive specialized arrangements, greater and more energy concentrated structure typologies have been worked as Net ZEBs since 1998. Private structure proprietor unions and house building social orders have executed Net ZEB condos and little settlements. Their center has been undermining asset deficiency, atmosphere security just as the evasion of rising energy costs. Furthermore, modelers utilized the idea of zero energy structures to situate themselves in the previous specialty and now current blast part of "superior structures", "green structures" and even "zero energy structures". Medium-sized ventures and land organizations took up the expanding publicity in the segment of "green" structures. To improve the picture of the organization or to offer land more appealing than its restriction, they have constructed Net ZEB industrial facilities, places of business and flats. Regularly these structures are certificated and outfitted with supportable advances or materials. Almost every tenth Net ZEB is additionally recognized with a LEED-, DGNB-, Minergie-P, BREEAM-or a comparative authentication. This shows the advertising systems of these organizations. The primary enormous scope undertakings to get included (Burger King, WalMart) are not realized fundamentally for feasible structures yet trust in upper hands from a "green" picture improvement. [5]

V. DISCUSSION

A. Benefits

1. Compared with an afterthought retrofit, additional costs for new construction are minimized.
2. Reduced energy - auditing requirement.
3. Greater scalability and flexibility of the procurement and development cycle leads to less project time period. Thus the cost of financing is lower.

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4. The use of carbon, waste and water management technologies will lead to monetary benefits other than the intangible benefits over the project's life cycle.
5. Taxes / sanctions can require costly retrofits to obsolete buildings for potential legislative restrictions and carbon emissions.
6. It can be very affordable to build these buildings using standardized building technique and energy cost modelling.

B. Barriers and Challenges

1. Technical- Innovative approaches and innovations.
2. Finance-l Incentives and programs, balance between expense and solution.
3. Social engagement, understanding, behaviour, architectural and cultural heritage of all stakeholders;
4. Environmental and safety- Viewpoint of the life cycle in design; nature of the interior.
5. Corporate / Legal- Law, Governance and Policy; Project Management; Stakeholder / Ownership Structure.

VI. CONCLUSION

- The concept of zero energy buildings is understood by every country, but till an internationally agreed definition is lacking. It is recognized that different definitions are possible, in order to be consistent with the purposes and political targets that lay behind the promotion of Net ZEBs. In this paper, some definitions of NEB are explained briefly.
- Various instances of energy creation strategies for on- site and off site supply is compared. Use of proper materials in an existing environment is a very important task, various materials used for the NZEB are explored, which helps to the New commercial construction and major renovation projects to achieve a high level of energy efficiency and save the nation from the energy crisis.

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