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A Study on Conceptual Approach to Zero Energy Building in Modern Era

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ABSTRACT

The main objective of this paper is to give an overview of existing Zero Energy Building (ZEB) definitions in modern era. The 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. Buildings consume approximately 40% of the world's primary energy use. Considering the total energy consumption throughout the whole life cycle of a building, the energy performance and supply is an important issue in the context of climate change, scarcity of energy resources and reduction of global energy consumption. An energy consuming as well as producing building, labeled as the Zero Energy Building (ZEB) concept, is seen as one of the solutions that could change the picture of energy consumption in the building sector, and thus contribute to the reduction of the global energy use. However, before being fully implemented in the national building codes and international standards, the ZEB concept requires a clear understanding and a uniform definition.

KEYWORDS: Zero Energy Building, renewable source, energy, construction sector

INTRODUCTION

It is difficult to find a building, which can be named the first Zero Energy/Emission Building (ZEB).in simple language zero energy building is which consume the renewable energy from the sources like solar, wind, geothermal etcetera. Zero energy building can be used for the Reduce energy consumption and costs, Reduce carbon emissions and Reduce dependence on fossil fuels.

The development of modern zero-energy buildings became possible not only through the progress made in new energy and construction technologies and techniques, but it has also been significantly improved by academic research, which collects precise energy performance data on traditional and experimental buildings and provides performance parameters for advanced computer models to predict the efficacy of engineering designs.

When looking at the general practice for calculating the energy use of a building, the most commonly used unit is the primary energy. This unit allows taking into consideration the difference in the generation and distribution of 1 kW of electricity and 1kW of heat or natural gas and thus express better the actual building energy use. Since the energy prices not only change in time but also differ worldwide, using the energy costs, as unit could make it almost impossible to design a building, which would be a ZEB through its entire lifetime. Thus a building could be ZEB only at the time when it is design. The final energy is the easiest unit to implement and understand, but on the other hand quality of the different kinds of energy if fully neglected. CO2 emission could be a unit, however for a second separate definition of Zero Emission Building.

The question regarding the energy demands should not be difficult to answer, because if a building is named zero energy building, then total energy use should be included. In order to evaluate total building environmental impact embodied energy should be taken into account in the balance. However, it can be difficult, since in early design phase many data, values needed for including embodied energy in the calculations are yet unknown.

TABLE 1
HEATING NEEDS OF BUILDING IN kWh/m2/year

No	Types of building	Heating needs
1	Existing buildings (depending on insulation)	80 – 300 kWh/m2/year
2	Low-energy building	40 – 79 kWh/m2/year
3	Three-liter-building	16 – 39 kWh/m2/year
4	Passive energy building	Max. 15 kWh/m2/year
5	Zero-energy building	0 kWh/m2/year
6	Energy-producing building or energy surplus	(-ve) kWh/m2/year

Source: Dr. Sam C M Hui, "Zero Energy Building: What Does It Mean?" ASHRAE Hong Kong Chapter Annual General Meeting, 2008

RELATED DEFINITION TO ZEB

Net Zero Site Energy: A site ZEB produces at least as much energy as it uses in a year, when accounted for at the site.

Net Zero Source Energy: A source ZEB produces at least as much energy as it uses in year, when accounted for at the source. Source energy refers to the primary energy used to generate and deliver the energy to the site. To calculate a building's total source energy, imported and exported energy is multiplied by the appropriate site-to-source conversion multipliers.

Net Zero Energy Costs: In a cost ZEB, the amount of money the utility pays the building owner for the energy the building exports to the grid is at least equal to the amount the owner pays the utility for the energy services and energy used over the year.

Net Zero Energy Emissions: A net-zero emissions building produces at least as much emissions-free renewable energy as it uses from emissions-producing energy sources.

ENERGY CONSUMPTION

Buildings are the Largest Energy Consumer in the world.

- 40% of primary energy, 72% of electricity, 55% of natural gas

We are using all the non-renewable sources of energy. So, by the concept of ZEB we can use the renewable sources like sun, wind, geothermal etc. to reduce the use of non-renewable sources. From the commercial sector trends graph, Energy use increasing 1.6% per year – faster that energy efficiency improvements.

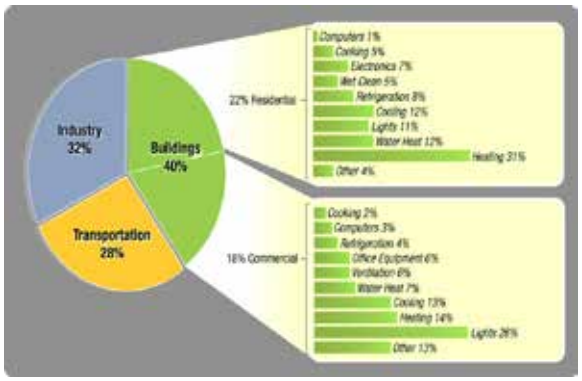

Figure 1: Energy consumption chart

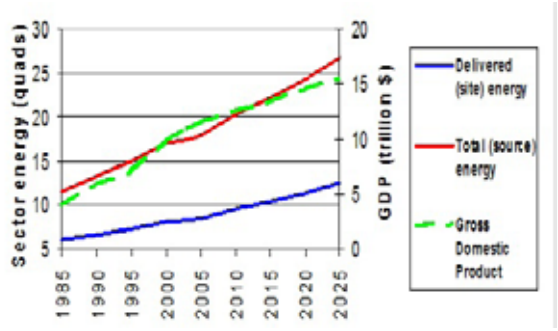

Figure 2: Commercial sector trends
Source: Gregory B. Stark, P.E., "Pathway to Net-Zero Energy Commercial Buildings", Research.unl.edu/events/nzgbworkshop/ppt/Stark_Presentation.ppt

CONSTRUCTION

Zero-energy buildings are built with significant energy-saving features. The heating and cooling loads are lowered by using high-efficiency equipment, added insulation, high-efficiency windows, natural ventilation, and other techniques. These features vary depending on climate zones in which the construction occurs. Water heating loads can be lowered by using water conservation fixtures, heat recovery units on waste water and by using solar water heating, and high-efficiency water heating equipment. In addition, day lighting with skylights or solar tubes can provide 100% of daytime illumination within the home.

ZEBs harvest available energy to meet their electricity and heating or cooling needs. In the case of individual houses, various micro generation technologies may be used to provide heat and electricity to the building, using solar cells or wind turbines for electricity, and biofuels or solar thermal collectors linked to seasonal thermal stores for space heating. To cope with fluctuations in demand, zero energy buildings are frequently connected to the electricity grid, export electricity to the grid when there is a surplus, and drawing electricity when not enough electricity is being produced. Other buildings may be fully autonomous.

Because of the design challenges and sensitivity to a site that are required to efficiently meet the energy needs of a building and occupants with renewable energy (solar, wind, geothermal, etc.), designers must apply holistic design principles, and take advantage of the free naturally occurring assets available, such as passive solar orientation, natural ventilation, day lighting, thermal mass, and night time cooling.

TABLE 2
ZEB RENEWABLE ENERGY SUPPLY OPTION HIERARCHY

Option Number	ZEB Supply-Side Options	Examples
0	Reduce site energy use through low-energy building technologies	Day lighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, etc.
On-Site Supply Options		
1	Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located on the building.
2	Use renewable energy sources available at the site	PV, solar hot water, low-imp act hydro, and wind located on-site, but not on the building.
Off-Site Supply Options		
3	Use renewable energy sources available off site to generate energy on site	Biomass, wood pellets, etlianol 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.
4	Purchase off-site renewable energy sources	Utility-based wind. PV, emissions credits, or other "green' purchasing options, Hydroelectric is sometimes considered.

Source: P. Torcellini, S. Pless, M. Deru, "Zero Energy Building: A critical look at the definition", ACEEE summer study Pacific Grove, California, 2006 Conversion of natural sources of energy

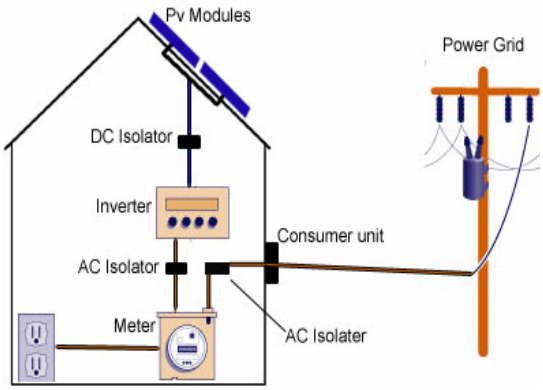

Figure 3: Grid connected PV systems

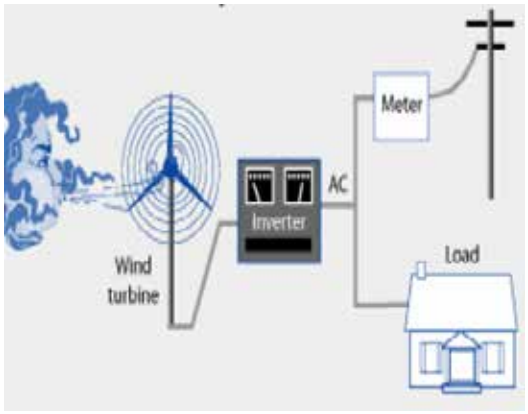

Figure 4: Grid connected wind energy systems
Source: Dr. Sam C M Hui, "Zero Energy Building: What Does It Mean?" ASHRAE Hong Kong Chapter Annual General Meeting, 2008

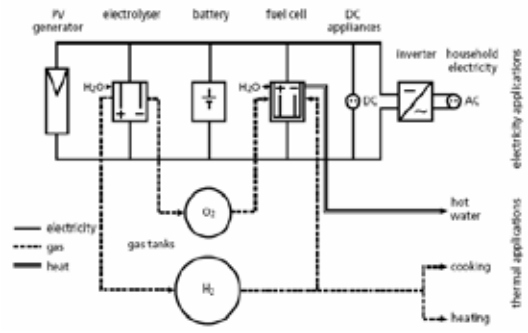

Figure 5: Generation of electricity and thermal energy from natural sources
Source: www.ise.fhg.de

ADVANTAGES

- Isolation for building owners from future energy price increases.
- Increased comfort due to more-uniform interior temperatures
- Reduced requirement for energy austerity.
- Reduced total cost of ownership due to improved energy efficiency.
- Reduced total net monthly cost of living.
- Extra cost is minimized for new construction compared to an afterthought retrofit.
- 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.
- Future legislative restrictions and carbon emission taxes/penalties may force expensive retrofits to inefficient buildings.

DISADVANTAGES

- Initial costs can be higher - effort required to understand, apply, and qualify for ZEB subsidies.
- 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.
- Challenge to recover higher initial costs on resale of building - appraisers are uninformed - their models do not consider energy.
- Without an optimized thermal envelope the embodied energy, heating and cooling energy and resource usage is higher than needed.
- Solar energy capture using the house envelope only works in locations unobstructed from the South. The solar energy capture cannot be optimized in South (for northern hemisphere, or North for southern Hemisphere) facing shade or wooded surroundings.

HOW ZEB IS DIFFER FROM THE GREEN BUILDING

The goal of green building and sustainable architecture is to use resources more efficiently and reduce a building's negative impact on the environment. Zero energy buildings achieve one key green-building goal of completely or very significantly reducing energy use and greenhouse gas emissions for the life of the building. Zero energy buildings may or may not be considered "green" in all areas, such as reducing waste, using recycled building materials, etc. However, zero energy, or net-zero buildings do tend to have a much lower ecological impact over the life of the building compared with other "green" buildings that require imported energy and/or fossil fuel to be habitable and meet the needs of occupants.

CASE STUDY

Here case study is taken of A Net-Zero Energy Home in Urbana, Illinois in USA.

Figure 6: The Equinox House, Urbana, Illinois in USA

Sources: © 2012 Equinox Built Environment Engineering; a division of Newell Instruments Inc. and http://cnx.org/content/m44455/latest/?collection=col11325/latest

According to owner Ty and Deb Newell, their house "The Equinox House" required about 12,000 kilowatt-hours of electricity to operate from December 2010 through November 2011. That total includes electricity for heating and air conditioning, hot water heat, clothes washing and drying, and all other appliances. No natural gas is used in the house.

During the first year, the solar panels that power the Equinox House produced approximately 11,000 kilowatt-hours of electricity. Thanks to the more efficient heating system now in place, the Equinox House will produce surplus electricity in 2012 and in the future. In conjunction with its solar panels, the Equinox House achieves net-zero energy use because it requires far less energy than even a well-built conventional home about one-fifth as much. It does so through the use of design and technology that did not add a significant burden to the cost of construction.

When he talks about the Equinox House, Ty Newell emphasizes how well it works from an economic perspective, since the couple's average daily cost for energy is a mere $3.00. That's based on a twenty-year life for the solar array, which cost a net of $20,000 installed.

In addition, Newell enjoys the fact that a significant part of their upfront expenditure supported job creation, the labor that went into the manufacture and installation of their solar panels. That's in contrast to money they might have otherwise spent on fossil fuel.

The Newells must be sacrificing comfort for the sake of energy savings, but that's not the case. Their house boasts 2,100 square feet of living space and all of the amenities you would expect in a contemporary suburban residence.

CONCLUSION

We conclude that in modern era, zero energy building is important mainly for the increase in the energy price. We can save the non-renewable sources of energy like electricity, fuel gas etc. ZEB is also beneficial for the owner because freedom from the energy consumption bills. Zero energy building is totally environment friendly. For the zero energy building initial cost is high but overall it is most suitable for the safe future. Utilization of natural resources more efficiently reduces a building's negative impact on the environment. By constructing zero energy building to reduced national energy consumption and also reduced global warming effect.

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