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Survey the Role of Zero Energy Building in Future Architecture

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Abstract
The purpose of study is to assessment of relationship between zero energy with architecture especially with sustainable approach. Research methodology in this research with regard to the topic of discussion is descriptive and area study. With increasing in use of non-renewable resource on world, it can be felt that in the close time we will encounter with a disaster in which influence our life rapidly. One of the field related to energy is architecture that can handle consumption of resource in all phase of building (Pre-building Phase: Manufacture, Building Phase: Use, Post-building Phase: Disposal). Nevertheless, Building Phase is the most use of energy in building due to take a lot of time. The concept of Zero Energy Building (ZEB) has gained wide international attention during last few years and is now seen as the future target for the design of buildings. In zero energy buildings with intelligent use of renewable technologies, the balance between production and consumption of energy is established. A zero energy building is a building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies. The result that comes from this investigation offer that any building with zero energy system obtain your energy from non-renewable source also emphasize energy efficiency and greenhouse gas reduction, therefore, we will be capable to reach sustainable architecture.

Keywords: Zero energy, Sustainable Architecture, Future Zero energy building

Introduction

It is difficult to find a building, which can be named the first Zero Energy/Emission Building (ZEB). One of the reasons could be that maybe ZEB is not a new concept for a building, it is just a modern name for buildings, from times before district heating and electricity, heated with wood or straw and lighted with candles and domestic animals? Nevertheless, in the late seventies and early eighties appeared few articles, in which phrases ‘a zero energy house’, ‘a neutral energy autonomous house’ or ‘an energy-independent house’ were used. It was the time when the consequences of the oil crisis became noticeable and the issue of the fossil fuels sources and the energy use started to be discussed. However, those papers were mainly focused on the energy efficient technologies and passive solutions implemented in the building. Furthermore, only energy demand for space heating, domestic hot water and cooling were accounted in the ‘zero’, hence were they in fact buildings with zero energy use? (Marszal & Heiselberg, 2009)

Table 1: Heating Needs of Building in kWh/m2/year. (Hui, 2008)

No	Types of building	Heating needs
1	Existing buildings (depending on insulation) Heating needs	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

Buildings have a significant impact on energy use and the environment. Commercial and residential buildings use almost 40% of the primary energy and approximately 70% of the electricity in the United States (EIA 2005). The energy used by the building sector continues to increase, primarily because new buildings are constructed faster than old ones are retired. Electricity consumption in the commercial building sector doubled between 1980 and 2000, and is expected to increase another 50% by 2025 (EIA 2005). 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, the U.S. Department of Energy (DOE) has established an aggressive goal to create the technology and knowledge base for cost-effective zero-energy commercial buildings (ZEBs) by 2025. (Torcellini, Pless, & Deru, 2006)

Despite the clear international goals and the international attention given to the ZEBs two major challenges need to be met before full integration of the ZEB concept into national building codes and/or international standards. This includes, in particular, the adaptation of a common and unambiguous definition and the development of a supporting methodology for computing the energy balance. In the existing literature, the Zero Energy Building concept is described with a wide range of terms and expressions and a number of distinct approaches towards ZEB definitions can be distinguished. The lack of a commonly agreed ZEB definition is already widely discussed on the international level. The need for a robust calculation methodology has gained attention with the growing number of ZEB projects and thus the interest in how the ‘zero’ balance is computed. Some countries are on their way to embrace the ZEBs in their national building codes, however no standardized calculation procedure yet exists and most of the calculations are just voluntary proposals developed for a particular ZEB case. (Marszal et al., 2011)

Today a number of buildings exist where the design principle has been to construct a Net Zero Energy Building, Net ZEB (IEA, 2012). The definition of a Net ZEB may differ, usually it is referred to as a building that provides as much energy as itself uses but interacts with an energy supply system and can export energy when the building’s system generates a surplus and import energy when the building’s system not supply the quantities of energy required. To design and build a well-functioning Net ZEB that interacts with an existing grid, it is important to consider the interaction with the grid in the design phase.

One reason for this is that self-consumption of on-site generation is generally more economically favorable than selling the surplus, in the absence of generous feed-in tariffs. Lower overproduction also lowers the load on the grid and increases the so-called hosting capacity of the grid. (Berggren, Widen, Karlsson, & Wall1, 2012)

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. Therefore, by the concept of ZEB (Zero Energy Buildings) 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. (Kashiyani, Pitroda, & Shah, 2013)

Low energy building (LEB)

A Low Energy Building (LEB) could be commonly described as a construction built according to particular design principles that aim to minimize its energy use and achieve a very high level of energy efficiency (compared with 'typical' buildings). (Hui, 2000). Definitions for LEBs have changed over time. A low energy house could refer to a building that uses 50-70% less energy than a code compliant building. (Torcellini, Hayter, & Judkoff, 1999). Some authors specifically define a low energy building in terms of end-use energy and primary energy consumption. As an instance, in their analysis of 60 case studies of operating and embodied energy of low energy buildings, Sartori and Hestnes (2007) adopted the following definition: a low energy building has an annual operational end-use energy ≤121kWh/m2, or primary energy ≤ 202kWh/m2 per year.

The term "low energy" differs from country to country, firstly because of differences in building standards, construction practices and climates (and therefore the heating and cooling demands). Second, the difference of the alteration coefficient between end-use and primary energy differs, depending on the type of energy generation and distribution systems used in different countries. (Nazari, 2014)

Definitions of Zero Energy Buildings

Approaching a NZE building goal based on current definitions is flawed for the following reasons:

(A) NZE definitions only deal with operating energy quantities and related emissions. NZE definitions deal with operating energy quantities and related emissions and do not include all other energy inflows required for the particular building to exist, e.g., the energy required for building manufacturing, maintenance, etc., In current NZE practice, this vast quantity of energy is unaccounted for and ignored for simplification purposes and perhaps also because up to this time there has not been a way to efficiently and accurately quantify these requirements in a uniform manner. In addition, current definitions and calculations for NZE do not include the energy flows from the sun, wind, rain, geological cycles and so-forth from the beginning and by including them using the emergy methodology, we demonstrate how a complete energy and material balance for buildings can be quantified.

(B) NZE definitions do not establish an "energy threshold" which ensures that buildings are optimized for reduced consumption of resources before renewable systems are integrated to obtain an energy balance. Current NZE definitions are at a level that is particularly generic and does not provide information on the desired "energy threshold" to optimize building energy consumption prior to renewable system integration. For example, a building can attain NZE status by way of surplus renewable energy generation without optimizing its building energy consumption as can be noted in several of the current NZE projects. Such an approach defeats the goal of NZE and may not fulfill the larger objective of energy efficiency. (Srinivasan, Braham, Campbell, & Curcija, 2011)

With so many ways to look at zero energy buildings there are indispensably many different definitions available. In the International Energy Agency (IEA) report written by Jens Laustsen in 2008, the issue of different explanation the ZEB definition is further discussed. When concentrate on the issue of what zero refers to Lausten, (2008) and Mertz, et al. (2007), we gain two definition:

- Zero Net Energy Buildings are buildings that over a year are neutral, meaning that they deliver as much energy to the supply grids as they use from the grids. Seen in these terms they do not need any fossil fuel for heating, cooling, lighting, or other energy uses although they sometimes draw energy from the grid.
- Zero Carbon Buildings are buildings that over a year do not use energy that entails carbon dioxide emission. Over the year, these buildings are carbon neutral or positive in the term that they produce enough CO2free energy to supply themselves with energy. Zero Carbon Buildings differ from Zero Energy Building in the way that they can use for instance electricity produced by CO2 free sources, such as large windmills, nuclear power, and PV solar systems, which are not integrated in the buildings or at the construction site. (Asl, Sattarzadeh, & Gane, 2012)

The energy performance of an NZEB can be accounted for or defined in several ways, depending on the boundary and the metric. Different definitions may be appropriate, depending on the project goals and the values of the design team and building owner. As documented and discussed by Torcellini et al. (2006), four commonly used accounting methods are :

- Net-Zero Source Energy Building
- Net-Zero Energy Costs Building
- Net-Zero Site Energy Building
- Net-Zero Energy Emissions Building

Each definition uses the grid for net use accounting and has different applicable RE[1] sources. (Pless Shanti, 2010)

Net Zero Source Energy Building

A net zero source energy building produces as much energy as it uses compared to the energy content at the energy source. The system boundary is drawn around the building, the transmission system, the power plant, and the energy required getting the fuel source to the power plant. It tends to be a better representation of the total energy impact. However, it is challenged by difficulties in acquiring site-to-source conversions and by the limitations of these conversions. Fixed conversion factors do not account for dispatch of energy with time of day, and the changes in dispatch as new buildings and the new power plants to supply them come on-line. This definition can depend on how the utility is buying or producing the power, rather than on the energy performance of the building. Therefore, if someone wants to construct a building in an area with a large percentage of hydroelectric energy, it may have a low source energy impact. However, placing the building in that location may necessitate new fossil fuel generation plants and the building may actually use the new generation capacity, which is coal. This analysis is very difficult. (Torcellini & Crawley, 2006)

Net Zero Energy Cost Building

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.

A building that receives at least as much annual revenue from the utility for on-site energy exported to the grid as the amount paid to the utility (or utilities) for energy used over the year. (Kallushi, Harris, Miller, Johnston, & Ream, 2012)

Net-zero site energy Building

A building that produces at least as much renewable energy in a year as it uses in non-renewable energy, when accounted for at the site. Example: A building uses 2,000 kWh of utility electricity during winter for heating to supplement its renewable energy. But in summer it produces a surplus of renewable energy and exports 2,000 kWh back the grid – the solar energy exported cancels out the utility power purchased. (Nesler & Palmer, 2009)

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[1] Energy Rating

Net Zero Energy Emissions Building

A net zero emissions building produces (or purchases) enough emissions-free renewable energy to offset emissions from all energy used in the building annually. (Williams, 2012). Nitrogen oxides, and sulfur oxides are common emissions that ZEBs offset. To calculate a building's total emissions, the appropriate emission multipliers based on the utility's emissions and on-site generation emissions (if there are any) multiply imported and exported energy.

These materials are utilized in three different ways, either through on-site supply, side-supply, or off-site supply. (Crawley, Pless, & Torcellini, 2009).

On-site supply is the availability of renewable resources within the design of the building, as well as available at the site. These types of resources include technologies like PV, solar hot water heaters, and wind technologies (S. Pless, P. Torcellini and D. Crawley 2009, D. Crawley 2014. These types of resources are in the building to assist in not only the decreased consumption of energy but the production of energy as well. Side-supply resources are techniques such as enhanced natural daylight, HVAC equipment, natural ventilation etc. that allows the site to reduce its energy through using these practices. Off-site supplies are renewable energy sources that can be transferred or imported to the site. These materials are things such as biomass, wood pellets, ethanol, biodiesel etc. and are ultimately used to create off-site renewable energy sources as well as energy production (P. Torcellini, S. Pless, M. Deru, and D. Crawley 2006). The best way to incorporate these technologies into design is through careful consideration of climate, environment, occupants, and most importantly the initial energy efficiency capacity of the building. The most cost-effective and efficient way to choose technologies for the building is to first optimize energy efficiency as much as possible and then to introduce other sustainable technologies that can counteract energy uses as well as produce renewable energy. Examples of these technologies could be split between night and day uses. During the night when the building is unoccupied designers can use low impact hydro, wind technologies, biofuels, active thermal storage i.e. ice storage and chilled water storage, passive thermal storage i.e. building mass and phase-change materials, and different district energy systems to comply with night time energy peaks. Daytime options include solar photovoltaic, solar hot water, and wind technologies.

Table 2: ZEB supply options strategy. (Hirsch, 2010)

ZEB Classifications	Option Number	**ZEB Supply-Side Options**	Examples
	0	Reduce site energy use through low-energy building technologies	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, ground source heat pumps, etc.
Option	**On-Site Supply Options**		
ZEB: A	1	Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located on the building.
ZEB: B	2	Use renewable energy sources available at the building site and connected to the building electrical or hot water distribution system	PV, solar hot water, low-impact hydro, and wind located on parking lots, adjacent open space, etc, but not on the building. RE output directly connected to building systems.
	Off-Site Supply Options		
ZEB: C	3	Use renewable energy sources available off site 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.
ZEB: D	4	Purchase certified off-site renewable energy sources	Utility-based wind, PV, emissions credits, or other "green" purchasing options, as certified by programs such as Green-E. Hydroelectric is

			sometimes considered.

Net-Zero Energy Homes Overview

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. (Torcellini, Pless, Deru, & Crawley, 2006) The net-zero energy concept is that buildings could generate enough on-site energy to balance-out or exceed their annual energy consumption. The "net" portion means the building may use energy from the utility grid (electricity/natural gas) during some times of the day but supplies renewable energy back to the grid during other times, in a balance that equals out over the course of a year. (Figure 1). (Najafi, 2011)

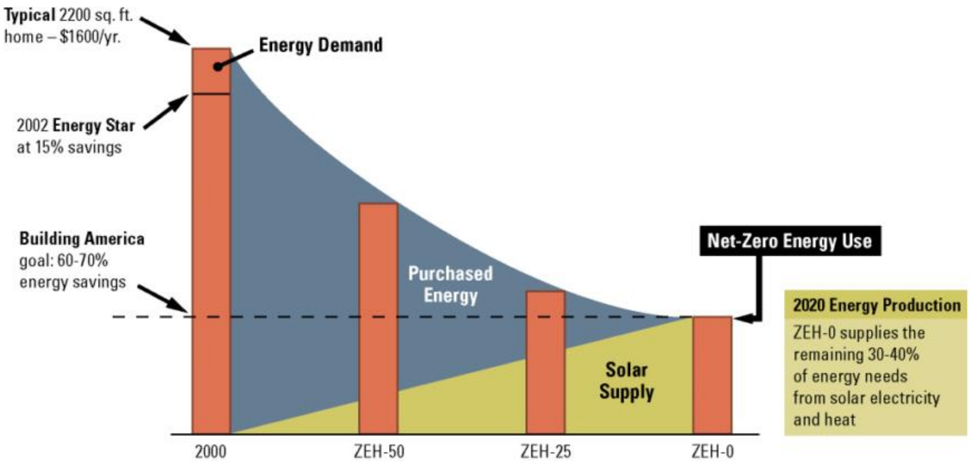

Figure 1: The pathway envisaged by building America towards a zero energy home.

A building approaching zero energy is called:

• Near-zero energy building

Nearly-ZEBs are a new frontier which represents an ambitious goal and which raises a few causes for concern. However, the design choices that underlie the performance of these buildings, which strive to reach energy self-sufficiency, stem from a pre-existing trend that had already initiated the development of a new approach. The key elements of this new paradigm can be summarized as follows:

- The energy performance of building envelopes improves considerably thanks to the more widespread use of insulation materials, plants, and shielding systems, all of which reduce thermal loads during both the winter and the summer;
- Mainstream architecture has embraced the principles of bioclimatic architecture, which has gained increasing popularity (exploitation of the passive potential of buildings, greenhouses, etc.); direct gains, solar
- Renewable energy sources (solar thermal, solar photovoltaic, biomass, wind, etc.) become the primary sources, and are used to their full potential;
- Conventional energy sources are used merely to integrate building energy balances, and/or as a back-up;
- Instead of a single generation system, more systems are installed and employed depending upon their convenience (e.g., solar thermal, biomass, heat pump, condensing boiler, inertial accumulation systems, etc.);
- Exploiting the building’s thermal inertia allows planners to install lower power-capacity systems: the thermal inertia of the whole system can be increased by, for example, installing inertial storage tanks;

- Buildings are no longer isolated in terms of systems, but instead become elements of a distributed, regional energy network: this approach allows the use of technologies (such as solar thermal or cogeneration systems) that can supply excess energy to the heating network (or excess electricity to the grid), contributing to the shift from centralized generation to distributed generation (which requires the implementation of smart energy infrastructures, such as smart grids);
- Home automation becomes the most important tool to manage energy services in the best possible way. (Dall'O, Belli, Brolis, Mozzi, & Fasano, 2013)

Advantages and disadvantages of ZEBs

Table 3: Consideration of the different definitions of ZEBs. (Thomas Boermans, 2011)

Definition	Advantages	Disadvantages	Other Issues
Site ZEB	• Easy to implement. • Verifiable through on-site measurements. • Conservative approach to achieving ZEB. • No externalities affect performance, can track success over time. • Easy for the building community to understand and communicate. • Encourages energy-efficient building designs.	• Requires more renewable energy export to offset the consumption of fossil fuel generated energy. • Does not consider all utility costs (can have a low load factor). • Not able to equate fuel types. • Does not account for non-energy differences between fuel types (supply availability, pollution).	
Source ZEB	• Able to equate energy value of fuel types used at the site. • Better model for impact on national energy system. • Easier ZEB to reach.	• Does not account for non-energy differences between fuel types (supply availability, pollution). • Source calculations too broad (do not account for regional or daily variations in electricity generation heat rates). • Source energy use accounting and fuel switching; this can have a larger impact than efficiency technologies. • Does not consider all energy costs (can have a low load factor).	• Need to develop site-to-source conversion factors, which require significant amounts of information to define
Cost ZEB	• Easy to implement and measure. • Market forces result in a good balance between fuel types. • Allows for demand-responsive control. • Verifiable from utility bills.	• May not reflect impact to national grid for demand, as extra PV generation can be more valuable for reducing demand with on-site storage than exporting to the grid. • Requires net-metering agreements such that exported electricity can offset energy and non-energy charges. • Highly volatile energy rates make for difficult tracking over time.	• Offsetting monthly service and infrastructure charges require going beyond ZEB. • Net metering is not well established, often with capacity limits

			and at buyback rates lower than retail rates.
Emission ZEB	• Better model for green power. • Accounts for non-energy differences between fuel types (pollution, greenhouse gases). • Easier ZEB to reach.\		• Need appropriate emission factors.

Sustainable Architecture

Used more in the sense of human sustainability on planet Earth and this has resulted in the most widely quoted definition of sustainability and sustainable development, that of the Brundtland Commission of the United Nations: “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” It is usually noted that this requires the reconciliation of environmental, social and economic demands -the "three pillars" of sustainability. This view has been expressed as an illustration using three overlapping ellipses indicating that the three pillars of sustainability are not mutually exclusive and can be mutually reinforcing. (Motallebzdeh, Rashid, Bagherzadeh, & Shahizare, 2015)

Green buildings make it possible to preserve natural resources for the next generations by reducing pollution and increasing ecosystem self-recovery. Green building is environmentally responsible and resource efficient throughout a building's life-cycle. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. A life cycle assessment (LCA) can help to avoid a narrow outlook on environmental, social and economic concerns by assessing a full range of impacts associated with all the stages of a process from cradle-to-grave (i.e., from extraction of raw materials through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling). Impacts taken into account include (among others) embodied energy, global warming potential, resource use, air pollution, water pollution, and waste. (Motallebzadeh, Vaziri, Bagherzadeh, & Shahizare, 2015)

Around the world, engineers, architects, and policymakers have been exploring ways to deliver highly efficient buildings whose reduced energy demand is satisfied by clean, renewable energy. Building off of the broader concept of a green or sustainable building, the concept of the “net zero building” focuses on the energy dynamics and performance of the building. In addition, as policymakers and leaders align toward the net zero concept, the focus on achieving deep energy efficiency has centered on integrated technologies as well as ways to connect buildings to the natural environment. Lessons learned from early efforts can help to inform the next generation of best practices. (Ghiran & Mayer, 2012)

New Green Principles of building Construction

These new standards are required for all new buildings in the City of Whitehorse.

Minimum Thermal Insulation Values

- Walls including foundations above and below grade R28
- Attics R50
- Floors above unheated spaces R28
- Slabs on ground R10
- Concealed floor space or crawl space from grade R10
- Doors R12
- Windows R4.0 (end up being triple paned low---e argon filled)

- Freeze protection for footings R10 extending 2' from building face. An alternative to these values may use energy modeling to achieve the same energy consumption or build to an EnerGuide Rating System value of 82. (Barrett, 2013)

The Future of Zero Energy Buildings

- The DOE Net-Zero Energy Commercial Building Initiative aims
- to achieve marketable net-zero energy commercial buildings by
- 2025
- Buildings consume 40% of US energy (70% electricity) – electricity
- use predicted to increase 50% by 2025 under BAU
- ASHRAE Vision 2020
- AIA 2030 Challenge
- California Public Utilities Commission ZEB Action Plan
- All new residential ZEB by 2020
- All new commercial ZEB by 2030
- EU ZEB requirement by 2019
- International Energy Agency ZEB Definitions Task
- All Federal Buildings ZEB by 2030
- October 2009 Executive Order
- Beginning in 2020 all new Federal buildings that enter the planning
- process is designed to achieve zero-net-energy by 2030. (Hirsch, 2010)

Conclusion

The certain consideration to the Zero Energy Building concept improved during the last years. In this years many countries have already established ZEBs as their future building energy target. Among different strategies for declining the energy consumption in the building parts, ZEB cut off the promising potential to significantly diminish the energy use and as well to increase the overall share of renewable energy. This framework should allow for a variety of solution sets and not focus only on PV based solution sets, for instance this strategy is mainly addressing small and new buildings.

In the end, it can be indicated that ZEBs are more different than sustainable architecture, sustainable development, or green building. First, zero energy building achieve one key of green-building that use resources more efficiently and decrease a building's harmful influence on the environment. However, ZEBs, or NZEBs have a tendency to take a much lower environmental impact over the life of the building compared with other "green" buildings that need imported energy and/or nonrenewable energy source to be habitable and meet the needs of occupants.

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