Zero Net Energy Buildings

Hossein Mirenayat
Texas Tech University
Hossein.mirenayat@ttu.edu

Dr. Mukaddes Darwish
Texas Tech University
Mukaddes.darwish@ttu.edu

Abstract

Sustainability is one of the most important challenges that the construction industry is facing. As time passes by, the urge to move toward a sustainable world becomes bolder. In the construction sector, the aim is to have buildings that offset their need for energy by utilizing renewable resources and special design considerations to reduce consumption. According to Zainul-Abidin & Pasquire, "Sustainability aspects would contribute to improving project value such as improved quality of output, increase productivity, profitability, reduction to life cost and business enhancement" (2007).

Zero net energy building (ZNEB) is a building that consumes almost the same amount of energy as it generates from renewables on the site. This paper explains the benefits of ZNEBs as well as their development across the US, compared to the EU. The results reveal that there is a huge potential advancement and benefits to gain by investing in zero energy buildings.

Introduction

In recent years, energy saving and sustainable design have become more significant. To reduce greenhouse gas (GHG) emissions and prevent climate change, energy consumption of different sectors needs to be managed. The building industry accounts for almost 40% of energy use in the world, and this needs to be rectified (Groezinger, Boermans, John, Seehusen, Wehringer, & Scherberich, 2014). Goals have been set to reduce the amount of GHG, and building codes have been changed to support those goals. To attain such objectives, important factors should be determined to accelerate reaching the target. These factors can be the progression of technology, cost of buildings, the occupants' lifestyle, and the project manager's willingness to build a sustainable project. This paper assesses the effects of these parameters.

Despite the fact that zero energy building advancements in Europe are more progressive than in the US, there is more room for improvement. By comparing the number of buildings—more than 25,000 in the EU to less than a hundred in the US —we can see that the US needs to dramatically modify its current stance on building development to compete with the EU (2016 List, 2016). Using strategies that the EU has already implemented, US zero energy construction can be improved at a quick but steady rate. The popularity of moving towards green buildings in the EU is very socially acceptable. As a result, the European people

benefit more from green construction. A lack of education and legislation among people and investors in the United States has resulted in limited attitudes and incentives for green building. The key role of project managers also enables them to influence different aspects of the project. Their decisions are mostly influenced by constraints of time, cost, and quality.

Progression of ZNEBs in the US and the EU

There are 53 verified ZNEBs in the United States, Figure 1, with an additional 279 emerging buildings in various stages of planning, design, construction, and with some being fully operational in less than a year. California profits from the central of 18 verified and 119 emerging buildings (2016 List, 2016). According to Daley, Ahdieh, and Bentley,

> Executive Order 13514 mandates that at least 15 percent of existing federal buildings and leases meet Energy Efficiency Guiding Principles by 2015, and that annual progress be made toward 100 percent conformance of all federal buildings, with a goal of 100% of all new federal buildings achieving zero-net-energy by 2030. (2014)

There are more than 500,000 governmental buildings in the USA, and because most of these buildings are organized ineffectively, the US government is the largest energy consumer. About a $5.8 billion investment was completed on energy efficiency by federal agencies in the past year (Obama, 2011).

By contrast, Directive 2010/31/EU, Article 9, requires that "the Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero-energy buildings." Member states shall furthermore "draw up national plans for increasing the number of nearly zero-energy buildings" and "following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings" (Directive, 2010).

By applying extensive green building practices in line with the EU's plans, the Buildings Performance Institute of Europe estimates net energy cost savings of €1.3 billion by 2050. From the entire Europe 2020 program, there will be an annual financial saving of up to €1,000 per household and a decrease of 740 million tons of greenhouse gasses per year (Building, 2014).

In Europe, the definition of ZNEB is already established and implemented in 15 countries. Three more countries have been defined, but legislation has not yet implemented these building standards. Nine more countries are in the process of developing an official definition for future implementation of ZNEB. In terms of existing buildings, only eight countries have set regulations for renovation. Five of these have set the same regulations for new and existing buildings. The remaining three have more lenient regulations for existing buildings. For example, in Brussels, regulations for new non-residential buildings is 90 ($kWh/m^{2}\cdot year$) while for existing building it is 108 ($kWh/m^{2}\cdot year$). To monitor success and sustainability of

zero net buildings, the European Commission has established an assessment plan to reevaluate ZNEBs every three years (BPIE, 2015). Doing this allows the EC to improve strategies to increase the countries progress toward creating ZNEB, whereas in the United States, 31.36 % of the buildings have 50-75 kBtu/sqft/year (Building, n.d.).

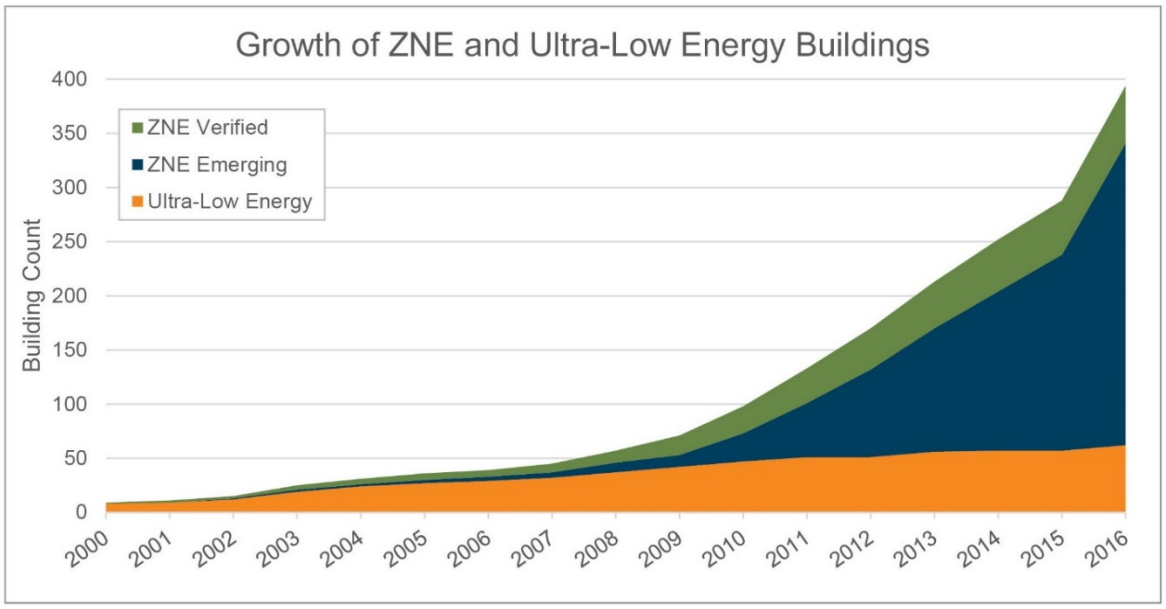

Figure 1. The growth of zero net energy (ZNE) buildings in the USA (2016 List, 2016). Reprinted with permission.

Cost of ZNEB

Despite the fact that ZNEBs are more expensive to build, they are still affordable and more beneficial. Federal tax incentives make it possible for a builder to invest 10% more in order to build a ZNEB rather than a standard one. Besides federal incentives, rebates also help to reduce the remainder to just 5% of a house built to standard building code (Building, n.d.).

ZNEBs can provide more useful, livable spaces and, they are more beneficial in the perspective of some owners. They also find them more attractive because of their wise design and selection of attractive finishes (Building, n.d.). Case studies show that ZNEBs pay back the extra cost in almost 15 years (Adhikari, Aste, Del Pero, & Manfren, 2012). As a result, they are considered more of an investment rather than an expense. The total cost of ownership of a zero energy home can be considerably less than the cost of ownership of a comparable standard home. Even after the additional 5-10% increase in cost to build the home is factored in, a zero energy home may still cost less to own. That is because the monthly savings on energy bills are often greater than the additional monthly cost of the mortgage that results from the zero energy upgrades. For example, if the higher cost of building a zero energy home adds an additional $100 a month on the mortgage but the energy

savings are $200 a month, then the owner saves an additional $100 a month by living in a zero energy home (Zero, n.d.).

Renewable Energy Supply

In the EU-28, the consumption of renewable resources increased almost 7% in 2008-2013. The EU reached the 15% consumption of renewable resources that can be a good example of the hard work being done toward the 2020 goal of supplying from renewable sources up to 20% (see Figure 2).

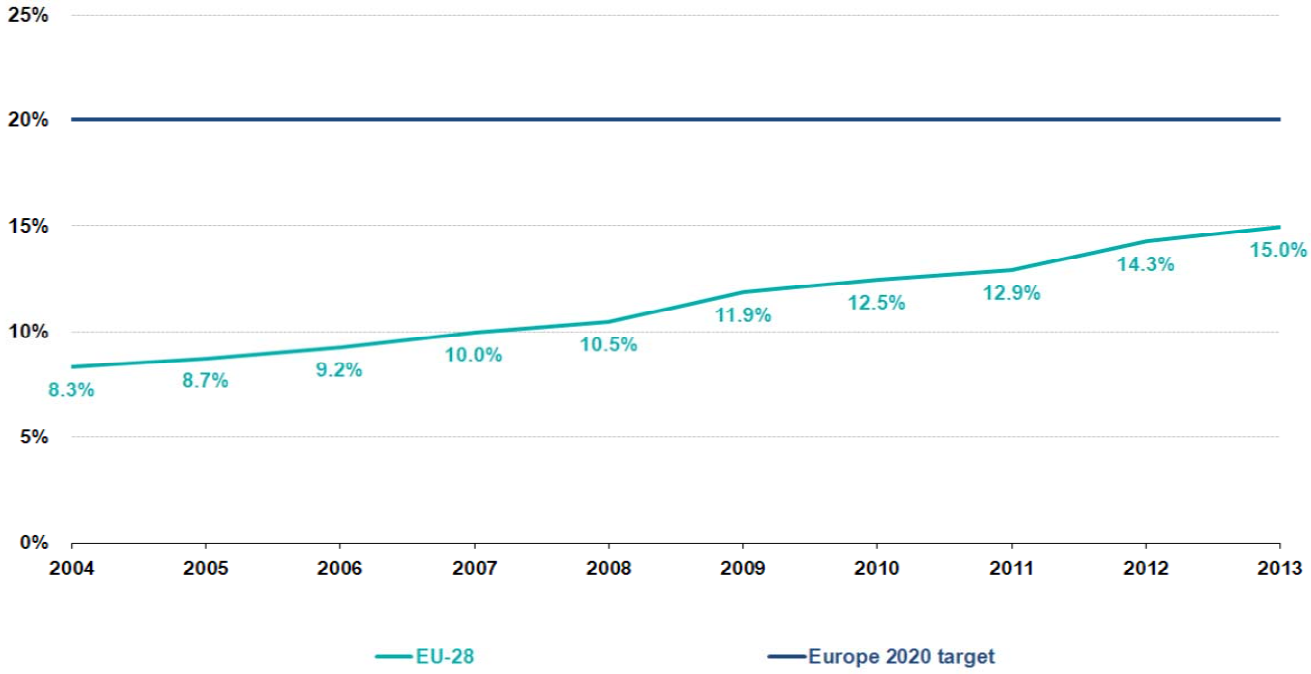

Figure 2. Share of energy from renewable sources in gross final consumption of energy (Eurostat, 2013). Reprinted with permission.

Renewable resources supplied 25.4% of total Eu-28 electricity needs in 2013. Austria took the lead in with 68.1%, while the level for some countries, such as Malta, is lower than 2%. This shows a great difference and a great potential for improvement (Renewable, 2017).

The United States' renewable energy sources account for 13% of electricity generation. It is produced by hydropower (6%), wind power (4%), biomass (2%), geothermal power less than 1%, and solar panels less than 1% (US, 2016). The usage of solar panels must be taken into consideration, as it is possible through ZNEB, since they are environmentally friendly and have less impact on the environment.

Social Acceptance

One of the debated issues in constructing environmentally friendly buildings is the cost. Some factors, such as photovoltaics, new appliances, and modern technologies need more funding. A premium cost of <2% was evaluated for most of the green buildings but yield 10 times as much over the entire life of the building (Kats & Alevantis, 2003). Surveys included on the ThinkProgress website suggest, "Over 20 years, the financial payback typically exceeds the additional cost of greening by a factor of 4-6 times the predicted benefits gained from green building." There are also more benefits, "such as reduction in GHGs and other pollutants [that] have huge, positive impacts on surrounding communities and on the planet" (Costs, 2010).

A result of a survey querying consumers about extra charges for green products found that if the premium is not more than 5%, in US and Europe, 70% of consumers buy a green product that performed similarly to its conventional counterpart. But, note the authors, the willingness disappears when the premium increases (Miremadi, Musso, & Weihe, 2012). In such cases, high-tech manufacturers should offer specific deals, so products would be more affordable to the customers. Experts and green publicity can play a significant role in marketing more sustainable-related products.

Project Manager's Decisions Impact

Sustainability Concept and Principles

If it is the belief that the capacity of our planet is limited in renewing natural resources, and with the current exponential speed of population growth, encountering a critical point seems very probable. Sustainability implies that "the natural capital remains intact. This means that the source and sink functions of the environment should not be degraded. Therefore, the extraction of renewable resources should not exceed the rate at which they are renewed, and the absorptive capacity of the environment to assimilate waste should not be exceeded" (Gilbert, Stevenson, Girardet, & Stren, 1996). There are two major solutions to keep the equilibrium. One is by decreasing the production and consumption level, which is impossible to implement with the projected level of population growth. The other is to minimize natural resources usage by taking advantage of green energies and recycling the residual waste materials.

Project Manager's Decision Impact

Of significance is realizing how project managers consider sustainability dimensions in the pre-construction phase, since their decisions direct the project and play a crucial role in contributing to sustainable management practices. On the other hand, the criteria that can influence managers toward sustainable construction should be studied. One important factor to consider is how the construction managers make decisions for a sustainable project, according to the "triple constraint of time, cost, and quality."

According to the Silvius et al. 2017 study, considering "sustainability principles is underrepresented, compared to the triple constraint criteria." For this study, the considerations in decisions were representing three categories of sustainability consideration, "iron triangle [of] time, cost and quality," with an additional category of risk consideration. The authors also distinguish four particular viewpoints of how project managers rank these considerations: "people and quality," "people and risk," "time and cost," and "quality, time and risk." The result of this investigation shows that project managers consider only a limited number of criteria. Short-term benefits, as well as strict legislation, should be contemplated to encourage project managers to build more sustainably (Silvius, Kampinga, Paniagua, & Mooi, 2017).

Conclusion

Clearly, the concept of zero net energy buildings is more accredited in the EU rather than the US. The generation of electricity from renewable sources in the EU is more than what it is in the US. The EU generates 23% of its energy through renewables compared to the US generation of 13%. The more the publicity and renewable technologies increase, and the cost decrease, the more zero net energy buildings become feasible.

There is a huge potential in growing zero net energy buildings in the United States and, as a result of that, there will be many job opportunities. Those can be related to the technologies of harvesting renewables, advertising, and social media that can play a significant role in educating people about the advantages of zero energy buildings. Also, according to the climate-change problems that the people in the 21st century are encountering, ZNEBs can be considered as the option in the construction sector, benefiting not only the residents but also the environment and future generations.

As a result of this study, it is finally understood that although the EU is doing much better than the United States in developing passive houses and zero energy buildings, the need for a unique definition can still be sensed, even in Europe, as there is a big difference in different parts of Europe. Some members are excelling in harvesting renewables but some others are falling behind because of a lack of technology. On the other hand, the reduction of GHG emissions is not possible with just reducing them in the EU and the US, but in the planet as a whole. The concept should be implemented worldwide and followed as a rule. As Silvius et al. observe, "Sustainability is about balancing or harmonizing social, environmental and economic interests" (2017).

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Biographies

HOSSEIN MIRENAYAT is currently a first-year PhD student at Texas Tech University pursuing a doctorate in Civil Engineering with a focus on construction engineering. He is working under the mentorship of Dr. Mukaddes Darwish. He has earned his MS at TTU and is the president of the TTU chapter of US Green Building Council. He may be reached at Hossein.mirenayat@ttu.edu.

MUKADDES DARWISH is a respected and decorated professor at TTU. Her research focuses on construction enginnering, with current research interests in construction safety and health, risk management, green building materials and techniques, and sustainable development and construction. Contact Dr. Darwish at Mukaddes.darwish@ttu.edu.