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Chapter

Impact of Zero Energy Building: Sustainability Perspective

Wesam Salah Alaloul and Muhammad Ali Musarat

Abstract

In an era with major developments in the energy sector, along with many benefits of energy consumption, it is also showing adverse effects on the end-users and the environment due to emission of various harmful gases mainly carbon dioxide (CO_2). To deal with these issues, the zero energy building emerges to bring constructive developments through the construction industry. The concept of zero energy building is to develop a structural building which can generate its own required energy and have zero negative effects. The energy will be enough to fulfill all the requirements of the building operations and can save natural quarries. By increasing the numbers of zero energy buildings, major reforms can be brought in the construction industry and thus stabilizing the economy and the climate.

Keywords: energy consumption, harmful gases, CO_2, zero energy building, economy, climate

1. Introduction

The energy sector is going through numerous challenges which will get worse with time. Various concerns have been reported related to the environment, economic instability, and energy security, mainly due to the present behaviour of the energy sector and carbon emissions [1]. In today business world, energy becomes a major source of economic growth. A smooth service for residential and commercial buildings involves extensive energy consumption. In this sector, energy consumption is escalating progressively which results in the emission of greenhouse gases. That is why saving energy with a suitable alternative in providing a better lifestyle gets essential. In this regard, the zero energy building is a very useful solution [2]. By integrating energy efficiency in buildings, sustainable development can be brought into the building sector. For achieving the goal of zero energy building, the design should be such that it can optimize maximum outdoor weather conditions [3].

Major reforms are brought into the construction industry for the betterment of the end-users in which zero energy building is one of them. Still, many are unaware of the concept of zero energy building as it is newly emerged area. Zero energy building is a structural element embraced for residential and commercial purposes which fulfilled the energy requirements by their own energy generation. It is very helpful in meeting the comfort requirements of the end-users, fulfilling the growing energy demand and beneficial to reduce the threat to climate changes due to global warming. Moreover, by adapting zero energy building, natural quarries can be saved from getting vanished. Therefore, this chapter discusses why there is a need for zero energy building and how it can bring reforms to real-world problems.

2. Energy demand

In the current decade, the demand of energy boosts up worldwide to 2.3% compared to the year 2018, making exceptional performance led by a vigorous global economy and high demand of heating and cooling systems in various regions. The highest consumption in the energy sector was made by natural gas due to high demand, posting 45% of the rise. With time, the demand for all the fuels getting increased where fossil fuels have a growth rate of 70%. A double pace was observed in solar energy generations which got increased by 31%, still not enough to meet the higher electricity demand. The increasing energy demand results in high carbon dioxide (CO_2) emissions escalated by 1.7% which is 33 Gigatons in the year 2018. Electricity demand increases by 4% in the year 2018 and remains to spot as the fuel of the future. In the total energy consumption, electricity contributes up to 20% [4]. **Figure 1** shows the historic and predicted data of world energy consumption.

Gradually, the energy demand getting increase, due to the global population increase, and the resources get lesser, requires an approach to overcome these phenomena. As a result, zero energy building is the most appropriate to accommodate the increased population and minimize the adverse effects of the energy shortage. In zero energy building, the energy loads are reduced up to a greater extent so that the renewable energy can meet the remaining requirements of the building, thus fulfilling the demand of end-user.

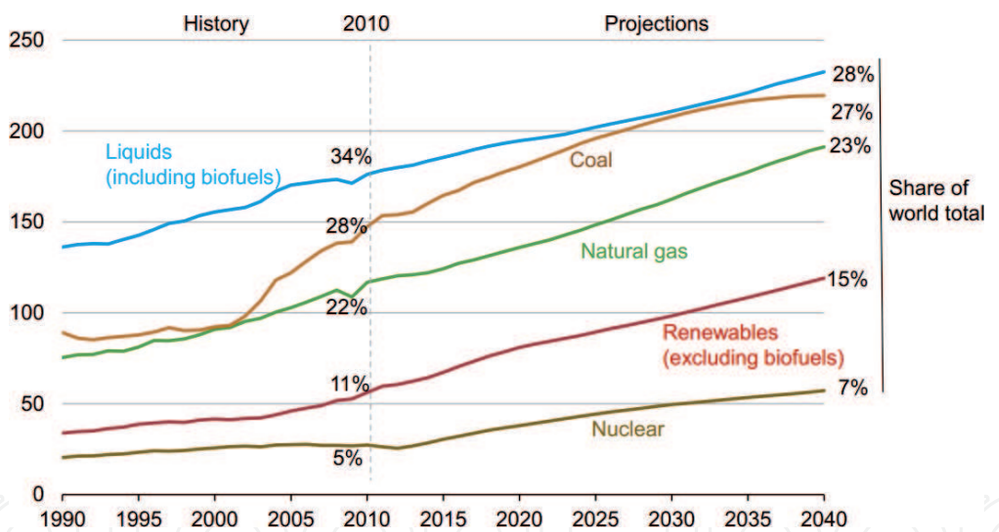

Figure 1.
World energy consumption, 1990–2040 [5].

3. Threat to climate

It is of the high interest for construction stakeholders, end-users, and the government that the construction and commissioning process should be energy-efficient and eco-efficient. Due to high energy consumption, the impact on the environment is greater, however, has been overlooked for years [6]. Sun is the energy source from ages for both humans and the other species where greenhouse gases kept the climate mild for living. But with time, these gases are threatening the living, and severe changes have occurred in the atmosphere. **Figure 2** shows the intensive amount of harmful gases erupted from a single industrial unit.

CO_2 is one of the most harmful and widespread gases in the greenhouse. The highest level of CO_2 is reported in the atmosphere mainly due to the burning of

fossil fuels by humans. These gases absorb the solar energy keeping the heat over the earth surroundings instead of allowing it to evade. This phenomenon is known as the greenhouse effect. Climate change not only refers to the rise in the temperature but also to severe weather conditions which directly impacts the population and has other serious consequences as well. CO_2 itself responsible for three-quarters of the gas emissions as it remains in the atmosphere for a thousand years [8]. The greenhouse effect is explained in **Figure 3**.

The impact of greenhouse gas emissions is directly on the country's economy, civilization, and the atmosphere. The emission of CO_2 to the atmosphere breaks all the record with 410 parts per million thresholds in the world. The cause of this constant expansion is mainly due to human actions that are undermining the climate [10]. It is due to industrial revolution, which is adding CO_2 abruptly to the climate. As a result, around 1°C temperature has been increased, and the sea levels are getting higher. The impact of these changes can be seen worldwide. Beside these consequences, high heat waves, heavy rainfall, and the large wildlife distinction are

Figure 2.
Harmful gases emission from industrial unit [7].

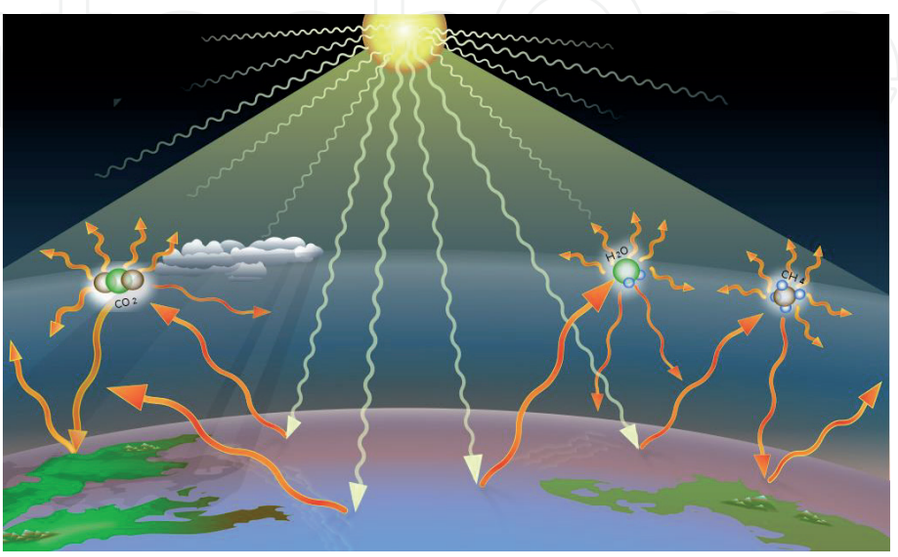

Figure 3.
Green house effect [9].

also disrupting the climate, all due to increasing temperature [11]. To portray a true picture of these effects is the current fire issue in the Australia, which occurs due to climate changes and results in assassination the life of many species, humans, and a big burden to the economy.

4. Concept of zero energy building

Reviewing the method of construction in the construction industry, the innovation is lesser compared to other industries. Previously decisions were made to get a construction performed on the lowest initial cost without giving any attention to the limitation of the resources, especially during the operation stage. Progressively, the advancement came in the industry, and the focus was to improve the properties of the available materials for better utilization and cost-efficient. The change in the philosophy of construction industry materializes to build and construct living societies with improved health and environmental conditions [12]. The construction industry has been criticized for being the major contributor to the carbon emission and global warming. Around 10% of worldwide energy is consumed while manufacturing building materials and also generates 40% of the solid waste [13]. The rising energy demand and environmental concerns lead to sustainability by providing the living facilities which minimize the harmful effects and can easily be implemented [14].

The concept of achieving zero net energy consumption and zero carbon emissions of a building is known as zero energy building, also called as a net-zero energy building. Zero energy building generates its energy resources without relying on energy grid supply. The net-zero design principle provides the ease to the building users even in the extreme conditions, the more extreme exposure to the elements the higher energy requires for the comfort [15]. This principle is getting significant attention as developed renewable energy eliminates greenhouse gas emissions [16, 17].

The growth in zero energy building mainly occurs due to advancement in construction technologies and due to the input of academic researchers by collecting and analyzing the accurate energy performance information. Though zero energy building is still not common yet gaining value in developed countries. In the current

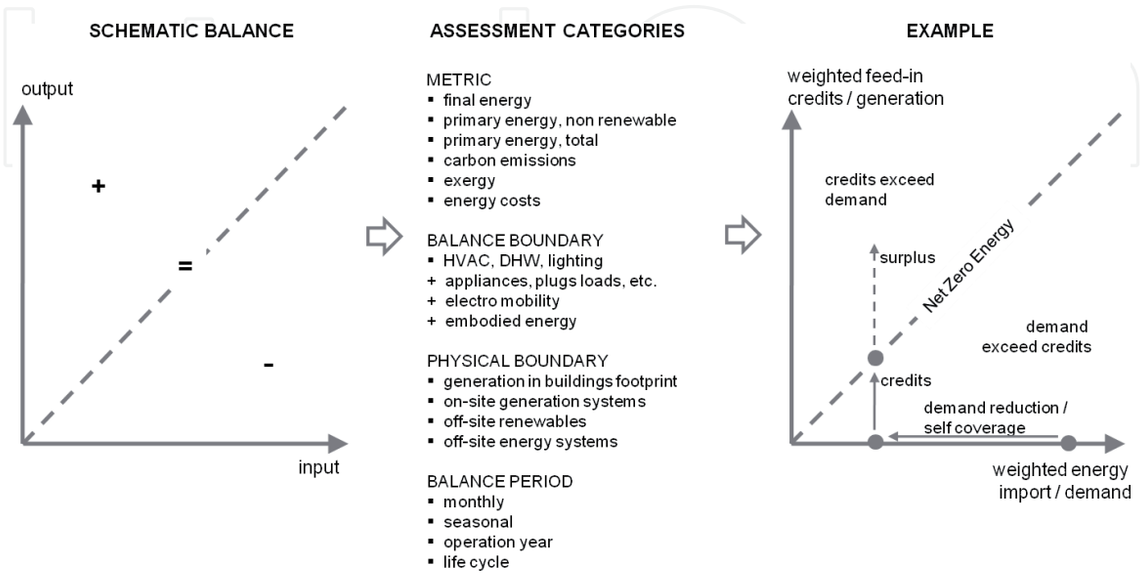

Figure 4.
Zero energy building balance concept [18].

era, computer models can detect how efficient is the engineering design decisions. With the concept of zero energy building, carbon emissions and fossil fuels dependency can be reduced [15]. The first consideration for zero energy building was made by the US Department of Energy; whereas, the European Union was the first region to mandate zero energy building use [19]. The zero energy building balance concept is described in **Figure 4**.

In real-world industrial estate, the zero energy building is the next revolution and contest. The construction industry is under pressure to provide efficient, cost-effective, and low energy consumption buildings in lesser time. In energy efficient approaches, zero energy building plays a vital role. A total of 30–40% of energy is utilized by the building sector, and reform in this area is the key step towards the future of sustainability. But this reform cannot be possible without the support of the stakeholders and should have familiarization about such kind of projects [11].

5. Construction of zero energy building

The aim is to construct a zero energy building that utilizes natural resources, lessen the waste, and fully optimize the producible energy. The construction team usually consists of engineers, architects, developers, owners, builders, and the occupants. The approach to constructing a zero energy building is to consider the building as one energy system in which every part should be energy efficient. Only those construction materials, developing systems and assemblies are taken into the account which decreases the energy use and utilizes all the built renewable energy. The building is furnished with the robust thermal envelope, providing a continuous air and moisture barrier, enhancing the effectiveness, and providing a relaxing indoor atmosphere. Site orientation is a critical factor for zero energy building as the moto is to take full benefit of the energy produced by the sun. Preferably, the orientation should be north-south in the Northern

Figure 5.
Zero energy building [20].

Hemisphere, as it lowers the direct sunlight in the summer which reduce the cooling demand and higher the sunlight in the winter to reduce heating demand. The windows should be able to utilize the maximum natural light, control the heat variations, and automatically get darken when hit by the sunlight. Moreover, southern facing windows can prevent the heat in summer and warming up in the winter using shades and louvers. The roof of zero energy building holds the building cool by preventing the heat gained by the solar panels. Thicker and light colour materials are good to keep the roof cool as they oppose the sunlight and improve the indoor conditions. As zero energy building is air tightened, a proper energy recovery ventilation system is provided which keeps the air fresh and reduces the energy losses. It is recommended to keep the connection of zero energy building with the conventional energy source as well just in case of renewable energy cannot fulfill the requirements of the end-user. Also, if the energy generated is in surplus, it can be transferred to the grid so the energy inside the zero energy building should be steady [21]. **Figure 5** shows a model of a zero energy building.

6. Pros and cons of zero energy building

There are many advantages of the zero energy building, yet everything comes with a downside. The pros and cons of the zero energy building are discussed below:

6.1 Pros

1. Due to improved energy efficiency, the cost to the end-user get reduced.

2. The comfort of zero energy building is more as compared to the conventional building due to the uniform inside atmosphere.

3. No impact of the external energy crisis to the end-user.

4. Reduction in monthly living expenses.

5. Environmentally friendly and reduce the carbon emission.

6. Higher resale value compared to conventional building.

6.2 Cons

1. Less availability of experienced designers to build zero energy building.

2. The initial cost of zero energy building is higher compared to the conventional building.

3. Not suitable in the region with cold temperature due to less exposure to the climate.

4. Limit future ability to respond to global warming due to specific temperature design.

7. Ecological restoration by zero energy building

Eventually, every industry contributes to the emission of CO_2, and construction industry is not exempted. The best way to reduce CO_2 emissions is to avoid the burning of fossil fuels. Just avoiding the burning is not enough as energy is required in all the sectors to perform day to day operation. Here, the importance of the zero energy building emerges as it is the most suitable way to avoid the emission of CO_2 and also fulfill the requirements of the end-users by generating their energy. Zero energy building is also known as the zero-carbon building as the emissions of carbon from fossil fuels get balanced with the amount of produced renewable energy [22].

Under crucial circumstances of climate change, the construction industry requires to construct high performance buildings where zero energy buildings are the robust solution as it provides healthy and energy efficient buildings which generates their own energy for usage. With the help of zero energy building, country's economy will also boost [11]. Climate change and shortage of natural resources is a global issue where adapting zero energy buildings can be restored and lemmatize the hazards.

8. Zero energy building as cost efficient

Cost efficiency of the zero energy building implies the energy cost that is utilized by the building, which is the main concern of most of the end-users. Infrastructural components and high demand costing by utility suppliers often included in energy cost. That is why cost does not only portray the energy consumed vs. energy generated by the building [18]. The main hurdle in endorsing the zero energy building is the initial construction cost which is paid by the investors. Direct and indirect costs are involved in the construction of the zero energy building. Direct cost includes materials cost, labour cost, machinery cost, and other costs which are directly related to construction activities. Indirect cost includes documentation fees, design cost, commission, and other official fees; whereas, the post-construction cost includes operational costs of building utilized in energy development [23–25].

Usually, people compare the initial construction cost of the zero energy building with the conventional building, which is higher for zero energy building, but the running expense is much lesser as compared to the conventional building. In zero energy building, all the energy demand is fulfilled by the building itself which is more cost-efficient compared to energy generated by the government, as that includes taxes and other hidden costs. It can be concluded that in the long run, zero energy buildings are way more advanced and cost-efficient, compared to conventional buildings.

9. Impact of zero energy building on economy

Zero energy building implies a significant impact on a country's economy. Every country is struggling to produce a generous amount of energy to meet the requirement of the end-users. But due to limited resources, it is getting difficult and burdened the economy as well. Zero energy building comes as a solution not only to fulfill the energy demand but also stabilize the country's economy.

There could be one perception that instead of supporting the economy, zero energy building will leave a negative impact on the economy as people will not pay taxes for energy usage. This perception arises because taxes are the main source of income for government and country's development. The perception can be refused as the government is utilizing more money for energy generation compared to the money getting in return. Zero energy building mainly operates with solar panels to generate energy. Due to this fact, the demand of the solar panels increases, so as its industry and the country's economy.

10. Social impact of zero energy building

Uncertainty in foreseeing the energy use in the building sector is due to occupant behaviour which is the most critical factor. Variation in energy usage in buildings has been observed even with the same climate conditions. The comfort level of every human being varies which directly affect the building operations and also increases the energy demand [26].

Humans are spending 90% of their lives in indoors premises for various works or living. Hence, to maintain a healthy lifestyle, safe and comfortable environment in buildings is significant. To provide the comfort and enhancing the condition of a building, almost 40% of the world's energy is been consumed which results in one-third greenhouse gas emissions mainly associated with the building sector [27, 28].

Besides environmental and economic benefits, zero energy building shows a positive impact on the society as well. Most of the benefits are related to the health of the end-users involved in working or living in the zero energy building. People associated with zero energy building tend to have an increase in brain functioning, getting better sleep at night, and due to low concentration of CO_2 and other pollutants, the overall performance also gets an increase. Zero energy building not only focuses on the environmental perspective but also aims to provide a comfortable and healthy lifestyle [29].

11. Life cycle cost analysis of zero energy building

In long run, the zero energy building is more cost-efficient compared to conventional building. A life cycle cost analysis (LCC) was performed for 20 years using present worth analysis between conventional building and zero energy building [30]. The comparison is discussed in **Table 1**.

From **Table 1**, it can be observed that although the initial cost of zero energy building is higher compared to conventional building, LCC shows that zero energy building is much more cost-efficient and economic.

12. Conclusion

High energy consumption is a threat to climate, and the changes occurring are adverse for the life on earth as it is causing global warming. Not only the plants and animals but humans are also getting affected. With time, even the sources are getting shorter for mankind and one day will vanish. To deal with this issue, alternative solutions are required which fulfill the energy demand and have no impact on the environment. In this scenario, the zero energy building emerges as the best available solution to control both the major issues. In the long run, zero energy buildings are more cost-efficient and contribute to the country's economy as well. Though understanding of zero energy building is still lesser to many but will get a boost as it is in favour of everyone.

Activity	Conventional building	Zero energy building
Construction cost (USD)		
Construction cost for building	30143.50	39339.04
Cost for home appliances	203,320	2270.04
Cost for gas arrangements	42.06 (natural gas)	42.06 (biogas)
Total initial cost	**33036.15**	**41651.15**
Operation, maintenance and replacement costs (USD)		
Present value of water charge for 20 years	5.54	5.54
Present value of electric charge for 20 years	6820	—
Present value of fuel cost for 20 years	1642.47	96.04
Present value of home appliances for 20 years	3949.64	3652.55
Present value maintenance of building	3068.19	1840.86
Present value of total operating maintenance and replacement cost for conventional building	15485.84	5594.98
LCC for conventional building	**48521.99**	**47246.13**

Table 1.
Comparison of conventional building and zero energy building.

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Conflict of interest

The authors declare no conflict of interest.

Author details

Wesam Salah Alaloul* and Muhammad Ali Musarat
Department of Civil and Environmental Engineering, Universiti Teknologi PETRONAS, Tronoh, Perak, Malaysia

*Address all correspondence to: wesam.alaloul@utp.edu.my

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