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Exploring the Barriers of Net Zero Energy Buildings (NZEBS) Implementation in Malaysia: Perception of Malaysian Construction Practitioners

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Abstract: Malaysia is a country which is undergoing a booming phase of urbanization. However, the rapid development in the construction sector leads to major concerns on sustainability for this sector. The increased volume of carbon dioxide emissions, climate change, depletion of resources as well as excessive of waste generation deteriorates the environment. Besides that, it is beyond doubt that energy invested in building construction has a significant threat towards climate change and sustainability, thus by addressing the issues on energy in building sector, the net zero energy buildings (NZEBs) has emerged to be an important concept to confront with these issues. However, previous studies found that the Malaysian construction industry is still unfamiliar with the concept of NZEBs. Therefore, the purpose of this paper is to investigate the barriers of NZEBs implementation in Malaysia based on a review of the existing literature and by utilising semi-structured interviews with 5 experienced practitioners. The result of this paper indicates that there are three barrier areas that need to be considered which consist of cost barriers, technical and technologies barriers, and government policies barriers. This study provides an exciting opportunity to advance our knowledge of barriers that will exists in the Malaysian construction industry context.

Keywords: net zero energy buildings, barriers, Malaysian practitioners

1. Introduction

In general, energy consumed in the buildings sector consists of residential and commercial end users accounts for 20.1% of the total delivered energy consumed worldwide, and much of this consumption is attributed directly to electricity demand and construction [1]. Therefore, a wide range of measures has been adopted and implemented which actively promoting a better energy performance of buildings, including the NZEBs concept, which can be seen as a realistic solution for the mitigation of carbon dioxide (CO^2) emissions.

Additionally, NZEBs concept is getting more attention after European Union Parliament is actively promoting the improvement of energy efficiency and reduction in energy consumption by setting a regulation through the recast of the EU Directive on Energy Performance of Buildings (EPBD) in which all new buildings to be “nearly Zero-Energy” Buildings by 2020 [2]. Therefore, researchers and other influential community of industry leaders have committed to address the growing energy consumption in the commercial and residential building sector by pushing the boundaries of building performance to develop NZEBs [3].

In the context of Malaysia’s construction industry, the Malaysian government has already moved progressively towards environmental sustainability by considering the various sustainability issues arises from energy in building sector in Malaysia. The government efforts can be seen through Construction Industry Transformation Programme (CITP) 2016-2020, where the two of the three specific issues identified to be addressed under environmental sustainability are lack of sustainability-rated construction for buildings and infrastructure and high carbon emissions and energy usage of buildings [4].

Other than that, the prime minister of Malaysia in his statement on the budget speech of 2016 stated that the government targets a reduction in greenhouse gas emissions intensity up to 40 percent of gross domestic product (GDP) in 2020 through the implementation of Electric Mobility Action Plan involving energy audit process with the provision of RM 45 million. Furthermore, Sustainable Energy Development Authority (SEDA) has also implement Clean Energy Metering Scheme, with a quota of 100 MW per annum in order to promote the use of solar photovoltaic and the government will extend the period of implementation of the Green Technology Financing Scheme up December 31, 2017 with a fund of RM 1.2 billion [5].

As highlighted above, the Malaysian government has put a lot of efforts in promoting energy sustainability in building sector in Malaysia. Thus, it is important to

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understand that it is significant to promote actively on NZEBs concept in Malaysia in order to support the government's targets. In response, the aim of this paper is to present findings based on conducting an exploratory study of Malaysian construction practitioners in terms of NZEBs implementation barriers in Malaysia as well as reviewing extensive of literature.

2. NZEBs Concept Overview

Initially, there are a variety of NZEBs definitions showed in the literature. However, the earliest definition and classification of NZEBs can be found in the study by Torcellini *et al*., [6] that the authors addressed four main primary definitions of NZEBs which are net zero site energy, net-zero source energy, net-zero energy costs, and net-zero emissions.

However, in 2009, about 70 leaders under The Massachusetts Zero Net Energy Buildings Taskforce has been attempting to set up NZEBs definition for the widespread implementation of NZEBs concept, and the taskforce had recognized that there are several terms that require additional specification which is [7]:

i. The minimum practical by different types of buildings should be addressed and additional definition is required when addressing renewable energy since the exiting NZEBs definition and practical give a significant emphasis on efficiency before consideration of renewable energy production opportunities.
ii. The additional definition is required when addressing renewable energy.

Nevertheless, Sartori *et al*., [8] have been developed a consistent framework for setting NZEB definitions in 2012, in which the authors have used the assessment of the criteria in the definition framework and selection of the related options as a methodology to provide NZEB definitions in a structured way. Based on the study, the authors had distinguished the terms between net-zero energy buildings (NZEBs) and zero energy buildings (ZEBs) where ZEBs is a term that is more general than NZEBs since ZEBs may include autonomous buildings. However, the word 'Net' in NZEBs specifies that the energy generation of buildings and energy consumption of the buildings are a balance over a period of time, nominally a year [8].

To conclude, the study consequently described that the core concept of NZEBs is where there is a balance between weighted supply and weighted demand. In other words, the sum of all generated energy is equal to the sum of all delivered energy.

2.1 Relationships of NZEBs and Energy Grid

The connection and interaction between buildings and energy grids are important to be addressed in NZEBs [8][9]. According to Sartori *et al*., [8] in order to fully characterize the NZEBs, energy grids is also requiring to be addressed besides an annual balance in the buildings.

Furthermore, one of the key tasks that play an important role in achieving the goal of NZEBs is the optimal control of energy systems [10]. However, the integration of NZEBs with different types of energy systems makes it a complex task for the NZEBs design as it requires a well-managed and controlled of the energy systems in a building in order to achieve a high building performance [10]. The sketch of connection between buildings and energy grids is illustrated as in Fig. 1 [8].

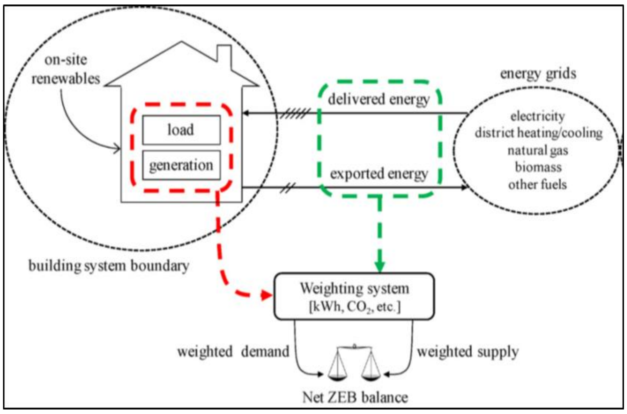

Fig. 1 Sketch of connection between buildings and energy grids.

Based on Fig. 1, Sartori, *et al*., [8] highlighted that the calculation of NZEB balance is where the total of weighted supply is equally balanced with the total weighted demand over a period of time, nominally a year. The weighted supply means the sum of all exported energy (or generation), obtained summing all energy carriers each multiplied by its respective weighting factor, while weighted demand means the sum of all delivered energy (or load), obtained summing all energy carriers each multiplied by its respective weighting factor.

Therefore, previous studies indicate that by addressing the relationships between energy grids and NZEBs, the net-zero energy balance for a building can be identified whether the energy generation through the renewable technologies meets or exceeds the energy consumption over a year as well as important to identify whether buildings achieving the NZEBs goal.

2.2 NZEBs Designs and Practices

Generally, there are three key areas which are passive design strategies, the application of energy efficiency system, and renewable energy system that are significant and need to consider in the implementation of NZEBs concept [10].

Additionally, over the last decades, a number of demonstration buildings exist in order to demonstrate the progress to achieve NZEBs. In general, NZEBs concept can be viewed as a continuation of the concept of 'solar' or 'zero energy' buildings which had been introduced since the 1950's. Historically, the beginning attempts at energy consumption reduction in buildings in the United States of America (USA) began with the projects of Massachusetts Institute of Technology on solar heated structures and this lead to the construction of

Massachusetts Institute of Technology (MIT) Solar IV in the late 1950s [11]. This demonstration building was designed by a team of engineers known as the Space Heating Committee of the Solar Energy Conversion Project, which was founded in 1938 [11].

One of a recent NZEBs residential building is Net-Zero Energy Residential Test Facility in USA that has been constructed at the National Institute of Standards and Technology to demonstrate that a home similar in size, aesthetics, and amenities to those in the surrounding communities can achieve net-zero while meeting the needs of a four-member family [12]. The home incorporates a vast array of renewable energy and energy-efficient technologies, a subset of which was used during the first year of operation, including an air-to-air heat pump system, a solar photovoltaic system, a solar thermal hot water system, and a heat recovery ventilation system (HRV). The results showed that the solar photovoltaic system generated for this NZEBs residential building was 13523 kWh of energy, exceeding the home's annual energy consumption by 484 kWh during the twelve-month test interval.

By considering NZEBs demonstration projects in developing countries, Krarti & Ihm [13] has investigated the approach and the cost-effectiveness potential for designing net-zero 14 energy residential buildings in the Middle East and North Africa (MENA) region. The results showed that energy consumption can be reduced up to 32-60% cost-effectively through optimal designs compared to current design practices of residential buildings throughout the MENA region. Moreover, it is found that the specific selection of optimal design features varies significantly with the utility costs and implementation costs of energy efficient features.

Based on the studies as highlighted above, it shows that NZEBs is achievable and this concept can be successfully implemented in both developed as well as in developing countries.

3. NZEBs Implementation Barriers

While many of the researchers have investigated and proved that there are many benefits that can be achieved through the implementation of NZEBs, but there are still exist several NZEBs implementation barriers that need to be addressed to ensure that this concept can be implemented thoroughly. In general, there are three main areas that impeded the implementation of this concept which are cost, technical and technology, and government policy.

3.1 Cost

One of the largest barriers to the implementation of NZEBs in the marketplace is the refusal of the client to comply the necessary up-front investments [14]. Besides that, many other researchers were agreed that the cost to implement NZEBs is quite high. For instance, Leckner & Zmeureanu [15] had studied on life-cycle cost of Net Zero Energy House (NZEH) and their findings showed that it is unlikely that Montreal homeowner would accept the extra expenditures for the construction of a NZEH based on the current solar technology and electricity prices. Similarly, Ferreira *et al*., [16] presented the results of a study regarding cost-effective renovation in residential buildings with a nearly-zero energy target. The author investigated comparison of the cost-optimal renovation packages with the ones that lead to near the zero energy levels, with the lowest costs by analysing the Portuguese building stock, reference buildings representative of the residential building stock.

The authors concluded that to achieve the NZEB target it is necessary to use technical systems based on renewable energy sources or make use of systems that locally produce renewable energy. However, there is in many cases a considerable increase, of up to 20%, in the global costs when renewable energy sources are included in renovation packages.

Additionally, in order to implement NZEBs, a building is required to install renewable energy technologies. However, these technologies are not necessarily cost-effective. Based on Marszal & Heiselberg [17] in their study on life cycle cost analysis of a multi-storey residential NZEBs in Denmark, the analysis has shown that with the current price level and photovoltaic (PV) installation for generating electricity, it is more cost effective to invest in energy efficiency as compared to renewable energy technologies.

Besides that, the cost for operation and maintenance of these systems is quite high and thus unattractive from the private economy perspective [17].

3.2 Technical and Technologies

One of the significant barriers that need to be considered is the technical and technologies barriers. As mentioned in the previous section, there are a lot of technical and technologies that can be used to achieved NZEBs. Based on Berggren, Hall & Wall [18], technical systems such as solar thermal collectors, PV panels and heat pumps if properly designed could reduce the operating energy use.

However, designers need to have the knowledge and have to consider on which technologies are having advantages over the others. For instance, Pyloudi, Papantoniou, & Kolokotsa [19] in their studies on the potential of retrofitting an office building at Technical University of Crete to achieve NZEB by using TRNSYS and HOMER software. Their analysis showed that by concerning the renewable energy technologies, it can be inferred that the PV panels produce more energy (24,000 kWh/year) than the wind turbines (20,000 kWh/year), contributing to a greater extent in achieving NZEB. Thus, this study is indirectly had showed that a designer should have technical expertise in considering the renewable energy technologies options before designing NZEBs. Without the technical knowledge and expertise, it will be a barrier to implement NZEBs and the objectives of NZEBs are not able to achieve.

Furthermore, availability of the renewable energy technologies is also contributing to the implementation barriers of NZEBs since these technologies are important to achieve NZEBs. This is based on the study by Morelli *et al*., [20] which investigated possible retrofit to "nearly-zero" energy building based on a case study of an old Danish multi-family building built in 1896. The findings of this investigation indicate that it is difficult to attain a "nearly-zero" energy building without using renewable energy sources. Besides the renewable energy technologies, the concern on energy efficiency system is also significant in achieving NZEBs. Based on Mohamed, Hasan, & Sirén [21], they concluded that increasing the thermal energy efficiency by using efficient thermal insulation or by installing solar thermal collectors (STC) is a step towards fulfilling all of the NZEB balances.

3.3 Government Policies

A large and growing body of literature has investigated the government has a significant role to ensure that the goal of NZEBs can be successfully achieved. Based on Praene *et al*., [22] which presents the current policies status, major achievements as well as the future objectives in the placement of renewable energy programme. They concluded that Reunion Island offers key advantages to set the example of being a net zero energy island by acting as a real-scale testing ground of renewable energy technologies (RETs). Thus, the study has offers some important insights into the major government role in achieving NZEBs. However, if the government policies are lacking to promote a sustainable approach, then NZEBs concept becomes increasingly difficult to be implemented.

Moreover, it is important that the government provide the financing to cover any incremental costs due to the implementation of this concept [14]. In a study which set out to assesses the potential of renewable resources and significant barriers to utilization of RETs based on the national energy for Oman, Al-Badi, Malik, & Gastli [23] found that government has put their efforts to explore the possibility of using solar thermal power. Thus, they suggested that the government should provide more incentive to encourage people to produce energy in their houses by utilising the solar or wind energy.

Besides that, it is important to realize that the lack of coordination between authorities leads to unstructured of administrative procedures, where it can lead to constitute an obstacle course for the project-owner [22].

4. Methodology

A semi-structured interview was chosen for this study with the purpose to explore deeply on barriers that will arise on the NZEBs implementation in Malaysia. Besides that, the selection of this method is also due to the limited literature on the NZEBs practices in the context of Malaysian construction industry. In addition, apart from simply relying on the previous studies in which their scenarios, culture, policies differ than Malaysia, the interview sessions are significant to ensure that all NZEBs implementation barriers in Malaysia are captured. Hence, by directly interviewing the Malaysian construction practitioners, NZEBs implementation barriers that may only apply to Malaysia context can be explored. However, to ensure the quality of this paper, a literature review is also being reviewed since it's important to provide insight into areas of inquiry.

Moreover, the selection of places for interviews was decided by interviewees, and each of the interviews took approximately 30 to 60 minutes to complete. All sessions are recorded for the purpose of transcription as well to ensure that the data is accurate. The authors decided to choose 5 interviewees to be interviewed for this paper. The interviewees were assigned codes as R1, R2, R3, R4 and R5. The key profiles for the interviewees are shown in Table 1.

Table 1. Key profiles for interviewees

Respondents	Position	Organization	Experience
R1	Architect	Consultant	> 10 years
R2	Architect	Consultant	< 10 years
R3	Architect	Consultant	< 10 years
R4	Engineer	Consultant	> 10 years
R5	Engineer	Contractor	< 10 years

5. Discussion

This section of this paper will examine and discuss the key findings that emerged from the literature review and semi-structured interview on NZEBs implementation barriers.

As mentioned in the literature earlier, a number of studies have found that the high initial investment cost to implement NZEBs has caused it to be one of the main barriers to NZEBs implementation. The majority of respondents also have responded that the technologies that are required for the implementation of this concept are quite high. As stated by interviewees R1 and R5,

> …some of renewable energy technologies are available in Malaysia such as PV system, but it is very costly and these technologies do not yet to be our main priority to be utilised in building construction project. (R1)

> As a contractor, we are admitting that the price of this technologies is quite high in Malaysia and due to this reason, we can see that most of the developers do not include these technologies in their requirement for the projects. (R5)

Thus, these findings further support the idea from previous researchers that most of the construction practitioners reluctant to comply the necessary up-front investments [14]. Besides that, in accordance with the present findings, it indicates that cost barriers exist in the Malaysia context.

Moreover, there is a large volume of published studies describing the role of the technical requirement is important towards achieving NZEBs. For instance, Fong & Lee [24] had proposed design of NZEB village house in Hong Kong, and the authors concluded that in order to design NZEBs, solar energy is required as the main source to heat generation as well as electricity generation, through the Building-integrated photovoltaics (BIPV) on the walls, as well as the PV and solar water heating system (SWHS) on the roof. In the same vein, a study conducted by Deng *et al.*, [25] had shown that the electricity generation of PV can meet the demands of two ZERB models in Shanghai and Madrid. Thus, it indicates that certain technologies are required in achieving NZEBs.

However, in the Malaysia context, the interviewees have responded differently. Some of the interviewees agreed that the availability of some technologies required for NZEBs is limited in Malaysia since, the technologies can only be acquired through importing from another country (R1, R2, R4). However, another interviewee has argued that availability of these technologies is not considered as the main barriers since, some manufacturers of this renewable energy technologies are available in Malaysia (R3, R5). As mentioned by R3:

> Recently, we can see that there are many manufacturers who are involved in producing renewable energy technologies in Malaysia. Thus, it is much easier for us to acquire these technologies in Malaysia as compared in the 90's. (R3)

Therefore, the results of this study show that the technical and technologies barriers exist in the Malaysian construction industry context. However, this finding indicates that this barrier is not as significant as the cost barriers. Besides that, these results match those observed in earlier studies.

Furthermore, Winkel *et al.*, [26] have shown that most of the countries have set their own target, incentive, regulation, and enforcement in promoting the utilisation of renewable energy systems in buildings. However, in the context of Malaysia, the Malaysian government has shown their commitment towards sustainability in construction sector through the eleventh Malaysia Plan (2016-2020), where this recent Malaysia plan has the aim to have a resilient, low carbon, resource efficiency and social inclusion kind of development.

The findings showed that all the interviewees agreed and realized that Malaysia is progressively moving towards sustainability through giving the incentives to the construction practitioners and setting the targets. However, the majority of the interviewees also mentioned that there is a lack of government enforcement on sustainability in construction. Due to lack of government enforcement, NZEBs concept will not able to be successfully implemented in Malaysia. One of the interviewees has highlighted that,

> The government has provided some incentives to promote the green concept in construction such as tax exemption, however, the enforcement is not executed strictly and thus, the utilisation of renewable technologies is not widely used. (R2)

As a result, these findings indicate that although a government can provide some incentives and regulation on sustainability in construction, if there is a lack in terms of the enforcement, this scenario will create a barrier of NZEBs implementation. Thus, table 2 has shown all the implementation barriers that exists in the Malaysian construction industry.

Table 2. Summary of NZEBs Implementation Barriers

NZEBs Implementation Barriers	Key points from interviewees
Cost Barriers	"If we don't have any cost constraints, we can widely use renewable energy technologies in buildings to save electricity." (R2) "…it is undeniable that RETs are very costly in Malaysia due to limited of providers." (R4)
Technical and Technologies Barriers	"The market is still small and there is still lack of suppliers." (R1) "The client will take consideration of technological elements, and we have to design a plan according to the requirements." (R4)
Government Policies Barriers	"…even though the government will provide us some tax incentives, we are still facing some lack of support system from the government especially regarding the enforcement." (R5)

6. Conclusion

As a conclusion, NZEBs concept takes a systematic approach to meet energy needs in a building by using various renewable energy systems that produce enough energy and involve all cost-effective measures to reduce energy usage through energy efficiency. In other words, the building's energy consumption and building's energy production are a balance to the energy grids over a period of time, nominally a year. However, the findings indicate that to implement NZEBs in Malaysia, there are three barrier areas that need to be considered, which consist of cost barriers, technical and technologies barriers, and government policy barriers. This implementation barrier of NZEBs is important to provide a guideline to Malaysian construction practitioners to overcome the barriers in order to successfully implement NZEBs in the future. However, it is suggested that government agencies perspective should be included in order to establish a more comprehensive perspective in Malaysia context.

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