Benefits For Public Healthcare Buildings towards Net Zero Energy Buildings (NZEBs): Initial Reviews

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Abstract. NZEBs concept has received incrementing attention especially since European Union Parliament are progressively moving towards regulation in which all new buildings to be “nearly Zero-Energy” Buildings by 2020. Even though this concept delivers promising benefits, previous studies found that the benefit of NZEB is still in vague to the Malaysian construction industry, mostly for healthcare buildings. The NZEBs concept implementation is critical in healthcare building as it seen as a key part of the needed transition towards sustainable development. This paper aims to define benefits of NZEBs practices through initial investigation among architects. Several existing energies works of literature and pilot studies by using semi-structured interviews were conducted. The findings divulge that, although the term ‘NZEBs design strategies’ is not being used largely across construction industry in Malaysia, some sustainable practices related to the design stage of construction has been implemented. The findings are also promising in growing awareness, practices and implementation of NZEBs design strategies by the practitioner in Malaysia. It is foreseen that the paper will provide a straightforward knowledge for future research in NZEBs design strategies practices for healthcare buildings construction in Malaysia.

1. Introduction
Net-zero energy buildings (NZEBs) is a concept that uses renewable energy technology to produce a mix of renewable electricity and other renewable heat resources like biomass and solar to generate as much energy as they consume [1]. Similarly, [2] emphasized that NZEBs is conceptually a building with a lower of energy demand and are balanced by the on-site generation of electricity, or other energy carriers, from renewable sources. Moreover, [3] and [4] highlighted that net-zero energy buildings (NZEBs) are typically a grid-connected building with very high energy performance. On the other hand, NZEBs are buildings with the concept of cost-optimal in which ensuring the minimum cost of the estimated economic life cycle of the building, by taking the package of efficiency measures.

Despite today’s buildings energy consumption demand increasing significantly, NZEBs concept practices enable to develop a network of clean domestic energy assets. The timeline for the implementation of NZEBs according to the Energy Performance of Buildings Directive (EPBD) recast is illustrated in Figure 1.
As highlighted in Figure 1, NZEBs has gained much attention in 2010 through EPBD recast. Based on the recast, European Union Parliament had agreed to set the targets for all members of Parliament to regulate a regulation in their counties that all new buildings are NZEBs in 2020. According to [6], the healthcare buildings have high electricity consumption as the result of the extensive use of various medical equipment, mechanical ventilation of building, lightings, and sterilization. Besides that, some of the countries have shown that healthcare buildings are considered as one of the most energy-intensive commercial-sector buildings. For instance, healthcare buildings in the United States are considered as one of the most intensive users of total energy among the building types where the high electricity consumptions are due to the continuity of services and the utilisations variety of complex applications in energy-intensive equipment such as medical imaging equipment [7].

In the context of Malaysia’s construction industry, there is an upward trend of demand in energy consumption in building sector as the energy consumption in the commercial and residential building had an increase of 2.7% and accounts for up to 14.4% in 2013 as compared to 11.7% in 1993 [8]. Additionally, [9], analysed the energy use, energy savings and corresponding emission reductions for the energy using equipment in a public hospital in Malaysia. The authors reported that around 19,311 MWh of energy consumption for the hospital in 2008. Besides that, for the end-use energy breakdown for the hospital, the authors found that lighting uses a major fraction of total energy consumption comprises of 36% and followed by medical equipment which accounts for 34%. The findings also showed that the energy intensity of the hospital is 234 kWh/m.

2. Malaysia Healthcare Project Developments
In general, the total health expenditure for Malaysia’s national spending shows an increasing trend from RM8,303 million in 1997 to RM44,748 million in 2013 [10]. From this trend, it is indicating that the Malaysia’s health expenditure is growing exponentially over sixteen years. Even though there is a breakdown of several types of expenditure, but most of this expenditure is spent for gross and total output in which services provided by hospitals of the total expenditure as illustrated in Figure 2.

Figure 1. Timeline for NZEBs implementation according to the EPBD recast [5]
Figure 2. Expenditure by functions of health services, 2014[10]

Besides, based on the Tenth Malaysia Plan (10MP – 2011-2015), there are four strategies that need to be implemented in order to support one of the trust in 10MP which is to achieve the quality of life of an advanced nation. The four strategies involved are: 1. Establish a comprehensive healthcare system & recreational infrastructure, 2. Encourage health awareness & healthy lifestyle activities, 3. Empower the community to plan or implement individual wellness programme (responsible for own health), 4. Transform the health sector to increase the efficiency and effectiveness of the delivery system to ensure universal access. Based on those strategies, three key result areas (KRA) were identified which comprising health sector transformation towards a more efficient and effective health system in ensuring universal access to healthcare, health awareness and healthy lifestyle and empowerment of individual and community to be responsible for their health [11]. Therefore, The Country Health Plan: 10th Malaysia Plan 2011-2015 has highlights several physical healthcare development projects that will need to be implemented in order to achieve KRA [11].

As a matter of facts, since 2007 until 2014, the development progress of healthcare buildings projects in Malaysia is consistent every year although, for the past four years, the allocation budget for the healthcare project development is decreasing in 2014 as compared to 2011. However, as compared to 2010, there is an increase of 2 new hospitals in 2014. Moreover, up to 2014, there are 133 government hospitals and 9 special medical institutions which comprise of 35,318 beds and 4,942 beds respectively [12]. Overall Bed Occupancy Rate (BOR) for MoH hospitals and Institutions in 2014 was 71.79%. Besides that, in the Tenth Malaysia Plan (10MP – 2011-2015), the government has approved an allocation of RM 21.98 billion in 2014 to be allocated for MoH which consists of RM 20.49 billion for the Operating Budget and RM1.49 billion for the Development Budget.

The initial allocation for the development budget that has been approved by the government for MoH in 2014 was RM 1.662 billion which includes constructing new hospitals, upgrading existing hospitals, facilities and others [12]. Based on 71 new MoH programs, it is involved in 67 physical projects and 4 non-physical projects [12]. Moreover, for the physical projects, Public Works Department (JKR) will handle 53 projects while JKR Sabah and JKR Sarawak will handle 4 projects and 3 projects respectively. The remaining 4 projects will be handled by the Engineering Services Division (ESD) of MoH [12]. Therefore, it is important to consider the healthcare buildings sustainability in the long term. Some of the challenges including low building performance and high energy consumption for Malaysian healthcare buildings need to be addressed in order to ensure the sustainability of healthcare buildings.
3. Net Zero Energy Buildings (ZEBs)

Study by [13], stated that four main primary definitions of NZEBs which are net zero site energy, net zero source energy, net zero energy costs, and net zero emissions as illustrated in Figure 3. According to the four definitions, it pointed out that the NZEBs is a grid connected building where the annual energy generation from a renewable source is equally with energy consumption during the term of one year. Similarly, [2] emphasized that NZEBs is conceptually a building with a lower of energy demand and are balanced by the on-site generation of electricity, or other energy carriers, from renewable sources. Moreover, the authors also mentioned that the term NZEBs refer to buildings that are connected to the energy infrastructure. Furthermore, another study by Kurnitzki et al.,[3] and Karsten et al.[4] highlighted that NZEBs are typically a grid-connected building with a very high energy performance.

![Figure 3. Four main definitions of NZEBs][9]

However in 2009, The Massachusetts Zero Net Energy Buildings Taskforce which comprised of more than 70 leaders has worked together to establish key solutions that will guide to the worldwide adoption of NZEBs and deep energy reduction retrofits throughout the Commonwealth by 2030. The taskforce defined NZEBs as a building that is capable to generate energy onsite with a quantity that is equal to or greater than the total quantity of energy consumed onsite within a period of a year, and the building uses clean renewable resources [14]. The continuous improvement on the NZEBs definition can be seen through the study of [2] which introduces a harmonised framework for describing the important elements of NZEBs in a series of criteria. Based on their study, the authors have listed several criteria that should be questioned and addressed in order to strengthen the overall NZEB “goodness of design” as well as to give a sound NZEB definitions in a formal, systematic and comprehensive way [2]. In 2012, a consistent framework for setting NZEB definitions has been developed through the study of [15] in which evaluation of the criteria in the definition framework and selection of the related options becomes a methodology to set NZEB definitions in a systematic way. According to the study, the authors stated that there is the difference between the terms of net-zero energy buildings (NZEBs) and zero energy buildings (ZEBs) as the terms of ZEBs is broader and it could include autonomous buildings. The wording ‘Net’ in NZEBs indicates that the energy obtained from and provided back to the energy grids nominally within a period of a year is a balance[15]. Moreover, the study showed 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.

4. Research methodology

The method discussed here is based on the perspectives of the knowledge of experienced architects that involved in the sustainable related project and it is appropriately could be used for this study onwards. Hence, the objective of this section is to explain the methods that were used for this paper comprised of research design and interview data collection procedures. This paper reviewed an existing literature relating to NZEBs in order to gain an understanding as well as insight into previous studies. To ensure the quality of this paper, a literature review is important to provide insight into ways in which the researcher can limit the scope to a needed area of inquiry [16]. Besides that, the
semi-structured interviews were conducted with architects in order to explore their understanding on NZEBs as well as to explore the sustainable practices in the context of Malaysian construction industry particularly on the healthcare building subject. Authors used the concept of saturation in order to determine the suitable sample size for the interviews. This decision was based upon recommendations by [17] to avoid ending up with repetitive and unessential information which does not contribute to the research. Besides that, the amounts of information obtainable from interviews do not necessarily increase just because more data was obtained [17] and the authors further claimed that researchers generally use saturation as a guiding principle during their data collection towards determining appropriate sample sizes. Therefore, the authors decided to choose 3 interviewees to be interviewed for this paper. The interviewees were assigned codes as R1, R2, and R3. Besides that, to ensure the quality of the interviews, all respondents required to be active in Malaysian construction industry and had direct involvement in the buildings projects located within Malaysia. The key profiles for the interviewees are shown in Table 1.

Table 1. Key profiles for interviewees

| Item        | R1                          | R2                               | R3               |
|-------------|------------------------------|----------------------------------|------------------|
| Position    | Architect                    | Architect                        | Architect        |
| Organization| Consultant                   | Consultant                      | Developer / Client|
| Experience  | More than 5 years working on sustainability aspects | More than 5 years working on green building | More than 5 years working on sustainable development agenda |

As for the interviews, the objective of this paper involved the architect’s opinions on design and practices of NZEBs based on the Malaysian construction industry context as well as to identify the benefits of NZEBs.

5. Findings and discussion
In order to identify the benefits of NZEBs, the practices that support this concept are crucial to being identified. Based on [18] there is a growing interest in NZEBs as many NZEBs demonstration projects showed that the goal of this concept is achievable. However, the need to identify NZEBs approaches is crucial in order to enable broad replication of NZEBs, especially in a healthcare building. Furthermore, all interviewees indicate that there are various of ways to achieve sustainability in construction since construction sustainability is too wide and different architect will have its own different of sustainable practices, but then all practices will be based on the same principles which are to increase the dependent on renewable sources as well as to protect the environment (R1, R2, R3). Similarly, according to [19] in the study on close inspection of the relevant design strategies and relative performance indicators of the eight case studies, the authors stated that there is no standard approach for designing NZEBs. Nevertheless, [20] highlighted that it is important for architects or engineers to have specific design guidelines and strategies in order to popularize NZEBs.

Even though there are still no specific design strategies in achieving NZEBs design, but based on [21] there are several common design elements and some consensus in designing NZEBs. The design elements that support NZEBs is important to be identified since the adaptation of NZEBs in buildings will ensuring the high performance in buildings can be achieved as well as to support the use of renewable energy for buildings. Generally, according to [22] and [21], there are three main steps of a design approach that can be applied in designing NZEBs which are the first design approach is a passive approach that focused on reducing energy demand. The second design approach is the use energy efficiency system, and the third design approach is renewable energy system which is needed to generate renewable energy as well as to offset in large measure the energy demand. The combination of this three-design approach is also crucial to be taken in designing healthcare buildings since these approaches able to succeed in reaching the desired energy performance as well as NZEBs target.

Passive approaches are one of the key element when designing NZEBs as this approach will affect directly to the energy needs for the buildings mechanical and electrical systems, and also indirectly
affect the renewable energy generation [19]. Similarly, [23] also highlighted that the passive approach plays a significant part in the NZEBs design. Besides that, the improvement of energy consumption of a building can be achieved through passive design strategies as buildings are constructed that react to the environment, hence it is possible for a building to achieve high environmental quality [24]. Additionally, [20] stated that architects have an important role in controlling aspects of a passive design when designing NZEBs. Similarly, some of the interviewees have highlighted that an architect is responsible to ensure some elements of passive approach should be carried out in order to support the sustainability of construction.

One of the most important aspects of passive design strategies is maximizing the amount of natural daylight into a building and reduce the amount of energy requires for artificial lighting in a building [25]. This strategy is important for designing buildings, especially healthcare buildings since these types of buildings is operating continuously 24 hours a day and required a huge amount of artificial light to provide services to patients. Besides that, it is important to control passive design strategies in a building as this approach will influence the energy performance of a building such as natural lighting, heat gain, shading, and envelope conduction. [20][26]. In addition, Aleinei et al., [19] stated that the passive design strategies in buildings should be appropriately orientating building towards solar heating maximization when buildings are dealing with heating challenges.

Furthermore, according to [27] when designing NZEBs, façades have a strong impact on heating, cooling and artificial light in the building needs as well as on daylight. Thus, it is important to realise that the passive heating solutions are essential to be studied along with passive cooling solutions in order to prevent overheating in a building [19]. Therefore, it is important to consider passive approach while designing NZEBs as it will enable maximisation of natural daylight and the amount need of artificial light in the building needs will be reduced, hence it will create a pleasant environment. In regards to second design approaches which is the utilizations of energy efficiency system, it is important to realise that the pathway towards NZEBs is reducing energy demand by means of energy efficiency measures [2]. Besides that, energy efficiency has a significant part to act as a parameter that indicates the reduction level of energy consumption in carrying out a related task [28]. Generally, energy efficiency can be improved by several design strategies including airtightness to avoid infiltration and mechanical ventilation systems with heat recovery to provide air conditioning and indoor air quality (IAQ) [29]. However, the selection of high-efficiency technologies is also crucial in the improvement of energy efficiency in a building. One of the interviewees has indicated the importance of energy efficiency system in healthcare buildings.

As an architect, we have emphasized the importance of energy efficiency measure for this healthcare building since this measure is much easier to be applied rather than the passive approaches and these measures do not relates to any hygienic condition requirements. (R1)

There are numerous energy efficiency technologies that can be applied in buildings. For instance, the use of low power lighting, energy efficient electrical equipment such as washing machines and dishwashers with a warm water connection are strategies in planning an equated energy balance [30]. Similarly, established by [31], healthcare building’s energy demand can be significantly reduced by considering energy efficiency as a factor in buying medical equipment, besides the proper use of electricity. Moreover, in relation to the availability of energy efficiency technologies in Malaysia, there are no problems to obtain the technologies since Malaysia is one of developing countries (R2, R3). However, the cost of this technologies is quite high and for that reason, most of the developers are not fully utilised the application of energy efficiency technologies in buildings (R3). Similarly, based on Vogel et al., [32] which investigated barriers that prevent energy efficiency adoption in multifamily buildings in Sweden and authors proposed a novel categorization framework for barriers to energy efficiency in buildings. The results showed that barriers related to contextual level are the most significant to prevent energy efficiency adoption. The contextual level is characterized by the rules and regulations that influence technological design and market development. In addition, as stated by interviewees R2,
The local authorities will reject the proposal of purchasing some energy efficiency technologies form the architect if the cost is too high. (R2)

Thus, based on the findings and the arguments, energy efficiency measure in a building is vital towards designing a healthcare that achieved NZEBs since energy reduction, as well as energy savings in buildings, can be achieved. Moreover, by improving the energy efficiency of the various incorporated building systems, it will help to reduce building’s energy demand [15]. It shows that NZEBs can provide a reduction in both primary energy as well as CO² emissions.

For the third design approaches which are renewable energy system, the necessity of renewable energy systems is vital towards NZEBs since these systems are required to reduce and as well as to offset the thermal energy need in buildings. Moreover, designing NZEBs is not only achieved by reducing the energy consumption of the building with passive design methods or the application of energy efficient system in buildings, but NZEBs should also be designed with the balances energy requirements between active energy production techniques and renewable technologies in order to achieve the NZEBs objective [33]. Besides that, the utilization of renewable energy systems in buildings can be an important solutions against global warming and greenhouse gasses [34]. Furthermore, most of the countries have already promoted the application of renewable energy systems in buildings through enforcement, regulation, target, incentive, and fund provided in the countries [35]. However, in the context of Malaysia, the interviewees agreed that there is a lack of enforcement and target set by the government even though there is some government efforts to promote renewable energy systems in Malaysia (R1, R2, R3). 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)

Phuangpornpitak and Tia [36] stated that the integration of renewable energy in a smart grid system and they concluded that renewable energy system is one of incomparable option to generate energy since these systems able to provide a clean energy resource. However, they suggested that some issues such as the design, sizing, and the suitability of the system in terms cost for energy generation need to be addressed in order to ensure that it can be used thoroughly and commercially. The summary of NZEBs practices and benefits are shown in Table 2.

### Table 2. Key profiles for interviewees

| NZEBs practices       | Literature                                                                 | Key points from interviewees                                                                 | NZEBs benefits                              |
|-----------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|---------------------------------------------|
| Passive approaches    | Ferrara et al. [37]; Ascione et al. [38]; Becchio et al. [39];            | “...take into consideration on passive elements before prepare architecture plan.” (R1)       | Reducing energy demand                      |
|                       | Rodriguez-Ubinas et al. [40]; Barbolini et al. [29]                        | “...undeniably passive design elements plays significant part in architecture.” (R3)         | Reducing primary energy and CO² emissions   |
| Energy efficiency     | Gaitani et al. [41]; Dalla et al. [42]; Buonomano et al. [43]; Ascione et | “As an architect, we can propose to developer some energy efficiency system for buildings.” (R1) | Reducing primary energy and CO² emissions   |
| technologies          | [44]                                                                       | “If we don’t have any cost constraints, we can widely use energy efficiency in buildings to save electricity.” (R2) |                                             |
| Renewable energy      | Kurnitski et al. [3]; Becchio et al. [45]; Ajla Aksamija [25]               | “…even though the movement is still slow, but we are still put our efforts to increase the utilisation of renewable energy technologies in buildings” (R2) | Increase renewable energy share             |
| systems               |                                                                           |                                                                                             | Reducing primary energy and CO² emissions   |
6. Conclusion

The NZEBs concept is achieve significantly since it is a realistic solution for the easing of CO₂ emissions. The acceptance of this concept into Malaysian healthcare buildings is vital because of the energy consumption for this buildings is high and this concept able to support the government initiative in Construction Industry Transformation Programme (CITP) 2016-2020 which one of strategic thrust that seeks to transform the industry is environmental sustainability. However, NZEBs concept in Malaysian construction industry is still needs to be explored and understood. But, the previous studies on NZEBs able to give an understanding into design and practice of this concept and thus, it gives the understanding to be explored based on Malaysia context. The findings showed that by the adaptation of NZEBs concept in Malaysia healthcare buildings, benefits that can be gained through this concept are it helps to reduce energy demand for healthcare buildings, reduce primary energy and CO₂ emissions for healthcare buildings, and increase the renewable energy share for healthcare buildings. However, the authors recommend that by increasing the number of sample size, it will produce any significantly different findings. Besides that, it is also recommended that this paper need to further investigate in order to get more comprehensive findings as well as reflect more on the Malaysia context. Extra note, this paper could provides some sustainable design and practices insight as basis for further investigation for public healthcare building.

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Acknowledgement
The author would like to thank Universiti Tun Hussein Onn Malaysia, Research Grant TIER 1, VOT H104, Research Management Centre Office UTHM, Department of Construction Management, Faculty of Technology Management and Business for supporting this research