FEASIBILITY OF ZERO ENERGY BUILDING IN THE TROPICS: CASE STUDY MALAYSIA

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ABSTRACT

Being responsible for one-third of greenhouse gases emissions, the building sector is required to develop suitable solutions to overcome this global issue. Therefore, many developed countries have implemented the Net Zero Energy Building (NZEB) as the recommended model to reduce carbon dioxide footprint. This took place in spite of the high cost of super insulation and limited exposure to adequate sunshine in many parts of these countries. On the other hand, the tropics naturally have an advantage in this aspect where the availability of sunlight is all year round. Furthermore, there is no change in climate through seasons or significant fluctuations in temperatures between day and night. Some tropical countries such as Malaysia have taken a big step in green building construction. Nowadays, there is the Green Building Index organization that rates these types of buildings. Moreover, the Feed-In -Tariff program facilitates the selling process of excess generated energy to the utility company. This study aims to investigate the potential opportunities and challenges that might face the adoption of Net Zero Energy Building as a typical archetype in Malaysia. The study has been conducted through analyzing the metrological data provided by the Climate Consultant software. Furthermore, a comparison between high energy efficient buildings in Malaysia and some (NZEB) examples in the tropics has been accomplished and a questionnaire has been conducted on occupants of the pilot project of (NZEB) in Malaysia. The study shows that the geographic location of Malaysia justifies this approach. Besides this, the government supports efforts in reducing greenhouse gases emissions. However, there is not enough studies or a valid bioclimatic framework to adopt (NZEB) as a common affordable prototype in the face of all prospective advantages.

Key words: Tropics, Net Zero Energy Building, energy consumption, cooling system, lighting system.

1.0 INTRODUCTION

1.1 Background

Both geographic location and national policies can enrich or limit the potential opportunities for any country. This research investigates the role of these two factors. Malaysia is located in the tropical zone. This strategic location provides the country with many noteworthy advantages in constructing (NZEBs). Moreover, the state has declared an international commitment to reduce greenhouse gases emissions. According to the COP 21 in Paris "… Malaysia intends to reduce its greenhouse gas (GHG) emissions intensity of GDP by 45% by 2030 relative to the emissions intensity of GDP in 2005." (Lojuntin, 2018) . Therefore, the country has stepped forward in green building construction. However, green buildings are not the only approach to construct energy-efficient buildings. In some other countries, Net Zero Energy Buildings or Nearly Zero Energy Building have been adopted as a typical approach. For example, in the European Union, all new buildings should be Nearly Zero Energy by 2020(2010/31/Eu, 2010). Nevertheless, in Malaysia, this practice is still limited. In 2007, a pilot project of a Net Zero Energy Building (NZEB) was introduced in the form of an office building for the Green Energy Technology Corporation (GEO). Unfortunately, the Net Building Energy Index (BEI) achieved 30 kWh/m²/yr. with a reduction in consumption of 86% only(Lojuntin, 2018).

1.2 Problem Statement

There are many examples of NZEBs in the tropics. For instance, Singapore has launched a second NZEB in 2019. There are also many NZEBs in the island of la Reunion. This indicates that the tropics has the potential to build this NZEB. Hence, what are the opportunities and challenges that face constructing this type of buildings in Malaysia?

1.3 Research Scope

This paper discusses the feasibility of NZEB in Malaysia form two dimensions: Geographic location and policies.

1.4 Research Questions

1.4.1 What is the effect of the geographic locations of Malaysia on constructing NZEB?

1.4.2 How do the policies limit or encourage this typology in Malaysia?

1.5 Research Objectives

1.5.1 Investigate the potential of geographic location in constructing NZEB in Malaysia.
1.5.2 Identify the role of policies in controlling the quality of NZEB

1.6 Research Methodology

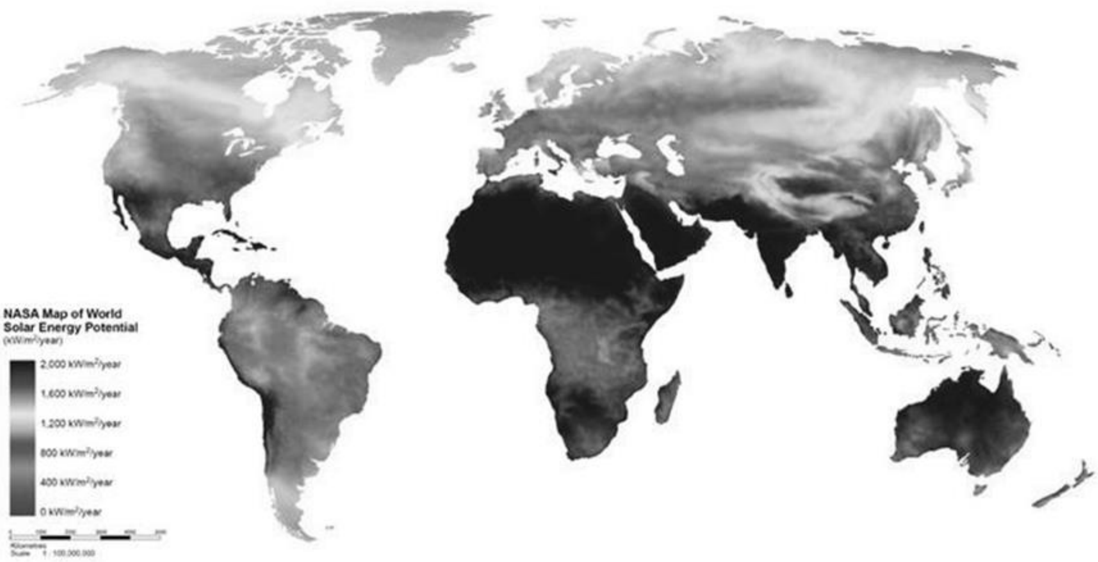
In order to answer the first research question, a combination of different methods has been used. In the beginning, the software of Climate Consultant was used to provide the metrological data about Malaysia. This was analyzed to investigate the impact of the climate on constructing NZEB in Malaysia. Then, the validation of the results has been conducted through two methods by conducting a comparison between 3 case studies. These case studies are Green Energy Technology Corporation (GEO), Enerpos, in the University of la Reunion, and BCA Academy in Singapore. Secondly, conducting a questionnaire survey among the occupants in (GEO). Finally, the literature review from different sources has been done to answer the second question.

2.0 FINDINGS AND DISCUSSION

2.1 Geographic Location

Metrological Data
The meteorological data shows that the climate condition can reduce the construction cost for NZEB and increase the benefits of solar energy. Firstly, the country receives a natural source of energy all year round. This fact maximizes the potential solar energy in the state as shown in figure 1.

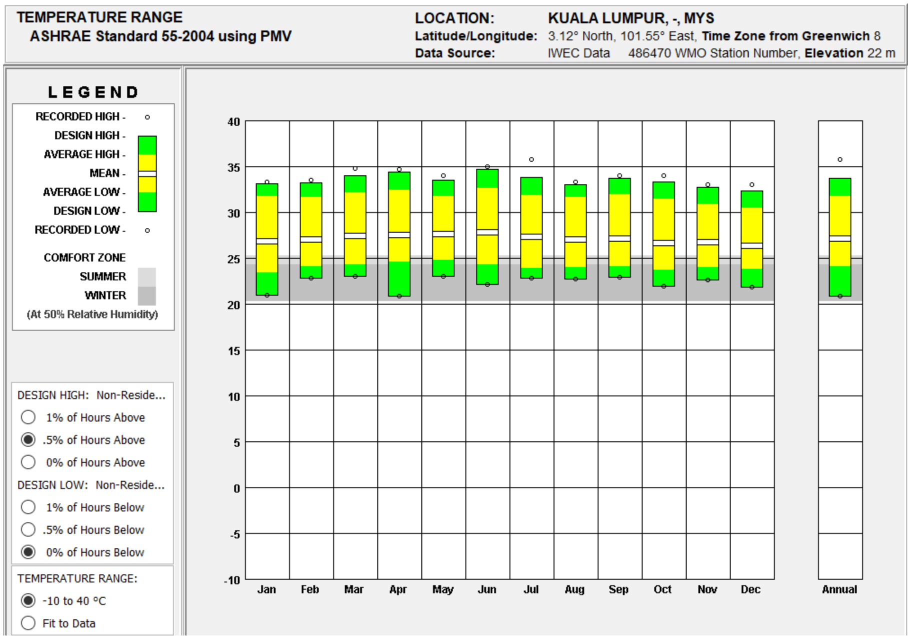
Figure 1. The greatest potential solar energy in the world



Source: Nasa

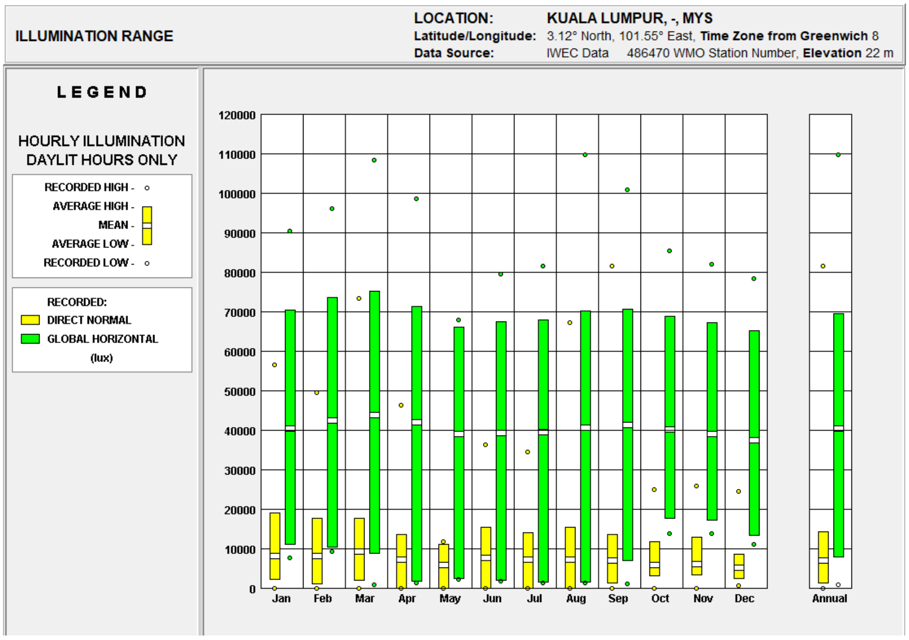
Secondly, according to the meteorological data figure 2, the mean temperature is not far from the standard thermal comfort range, which is from 23℃ to 26℃ (Standards Malaysia, 2014). Thus, the moderate mean temperature can reduce the need for a high degree of insulation on all facades. It also shows that thermal comfort can be achieved by implementing passive techniques in design to use natural ventilation. Thirdly, there are no extreme fluctuations in temperatures. Accordingly, the need for thermal mass to hold the coolness from the night is intensely minimized and the required cooling load to cool down the building directly during the day is not huge. Fourthly, the mean of the direct normal illumination is 6516 lux as shown in figure 3. According to Malaysian Standards the required illumination level in office buildings, like the pilot project, is only 300-400 lux (Standards Malaysia, 2014). This illustrates that using natural lighting can contribute significantly in reducing the energy consumption in the lighting system. However, the mean sky cover is considerably high, about 88% as can be seen in figure 4. In this case, the need for artificial lighting cannot be eliminated. As a result, there should be good coordination between both natural and artificial light in the lighting system. All these factors can reduce the cost of construction and increase the application of NZEB in the country.

Figure 1. The temperature range in Kuala Lumpur throughout the year



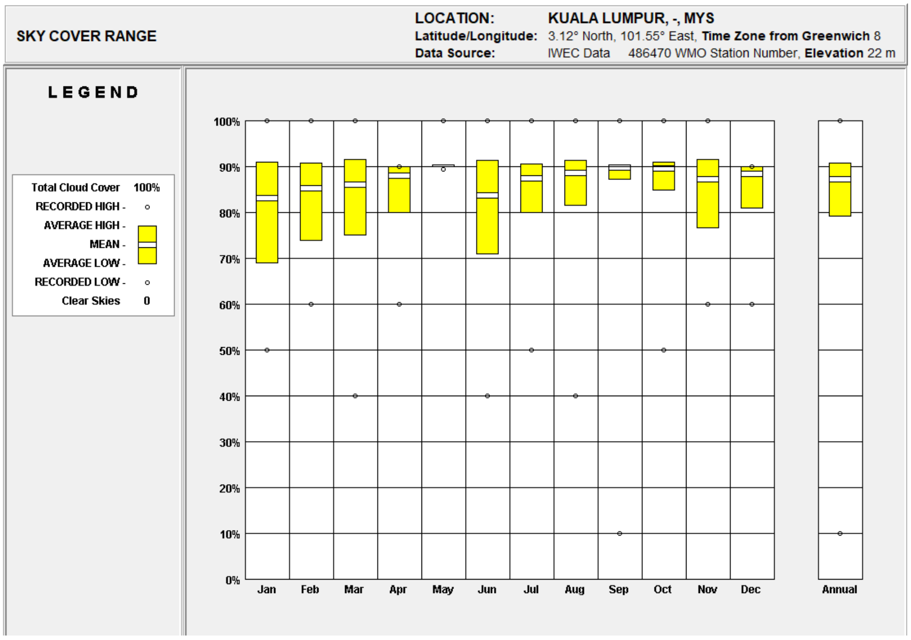
Source: Climate Consultant Software

Figure 2. Illumination range in Kuala Lumpur throughout the year



Source: Climate Consultant Software

Figure 3. Sky cover range in Kuala Lumpur throughout the year

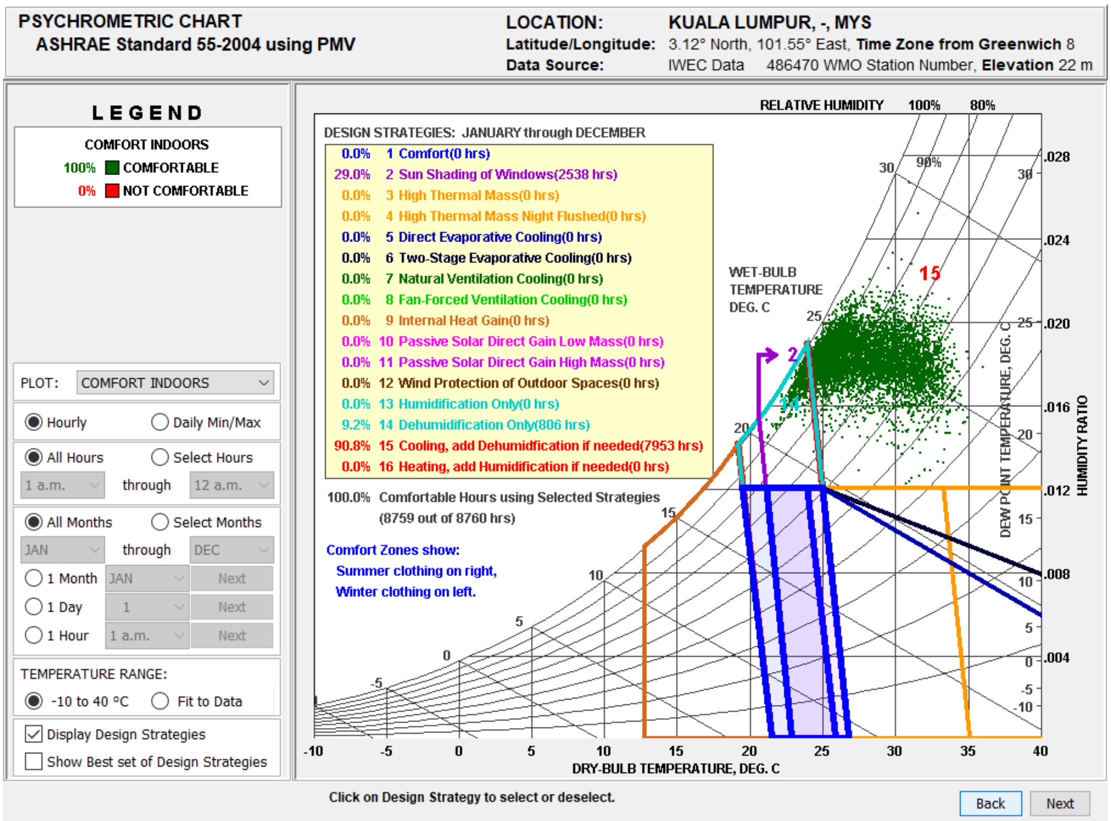


Source: Climate Consultant Software

CASE STUDIES

It is useful to clarify that the largest energy consumption in a building in the tropics is for cooling and lighting. Therefore, the study focuses on the strategies that have been used to reduce consumption in these two major fields. The (GEO) building, the pilot project for (NZEB), is an office building of 4000m^2. It was constructed in Bangi, Selangor. The cooling system in this building depends on creating an airtight super-insulated envelope to avoid losing the coolness provided by mechanical AHUs and supported by a radiant cooling system (Seyedehzahra Mirrahimi, Mohd Farid Mohamed, Nik Lukman Nik Ibrahim, 2017)(Shafii & Othman, 2007). In fact, within the Malaysian context, there is no need for this super-insulated envelope to reduce heat gain since the mean temperature is not far from the thermal comfort range. In the BCA Academy, an NZEB building in Singapore, the radiant cooling system is integrated with natural ventilation to minimize energy consumption (Wittkopf, 2015) while Enerpos, an NZEB building in La Reunion island, relies totally on natural ventilation and ceiling fans (Ashrae, 2012). In point of fact, even the radiant cooling system is not recommended for the tropics in order to avoid condensation issues. Besides this, there are difficulties in construction and maintenance for the system since it is integrated with the structural system (BY T.L. CHEN, P.E., C.ENG., FELLOW ASHRAE; AND AHMAD IZDIHAR, 2013). Neither, super insulation nor extra low e-glazing are necessary for Malaysia. According to the Psychometric Chart, as shown in figure 5, about 29% of the thermal comfort during the day can be achieved by using effective sun shading only on windows. The accompanying recommendations in the software highlight the possibility of substituting the mechanical cooling system with stack effect or natural cross ventilation to reach thermal comfort. The possibility of using natural ventilation to achieve thermal comfort eliminates the need for Super insulated envelope with lo e-glazing windows.

Figure 4. Psychometric Chart of Kuala Lumpur



Source: Climate Consultant Software

The second huge energy consumer is lighting. Since the country receives sunlight all year round, it is advantageous to use natural light during working hours. The GEO building was designed to use 100 % natural lighting. This increases the energy efficiency of the building. It is recorded that if the building did not use 100% daylight during the daytime, but had to rely on electric lighting (energy efficient), then the energy index would increase by 35% according to the computer modeling software has been used during design stage (Kristensen, 2005).

According to the results of the questionnaire, 82.6% of the sample expressed their satisfaction about using natural light in their workspace while 73.8 % show their satisfaction about the performance of both artificial and natural lighting together. 50% complained about the performance of sensors and 23.1% claimed that there is not enough artificial lighting during rain.

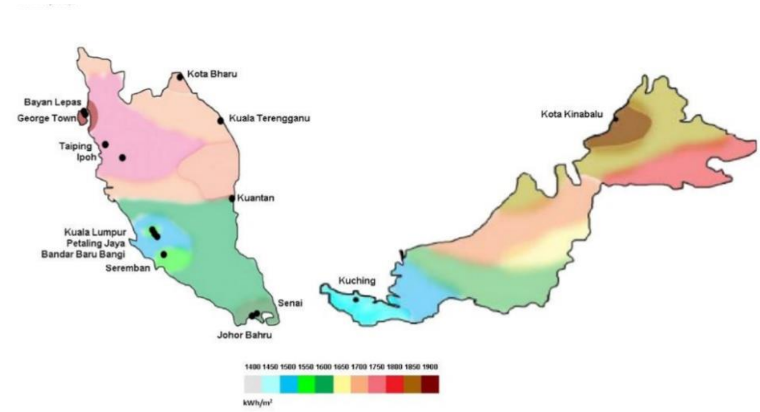
2.2 POLICIES

The government commitment to reduce carbon dioxide emission led to the establishment of the Green Building Index organization. This approach incorporated the idea of energy efficiency. Furthermore, the Feed-In-Tariff program allows electricity that is produced from indigenous resources to be sold to the power utility providers at a fixed premium price and for a specific duration. This facility would make the integration of NZEB with the Power utility easy and fast.

However, the study reveals that in spite of the climate and governmental support, there is a gap in research to establish a bioclimatic framework to construct an NZEB in Malaysia. Until now, there is no specific policy and regulation related to the promotion & development of NZEB (Lojuntin, 2018). This absence of clear guidelines affects the quality of applications for zero energy buildings in Malaysia. For example, even in the CIDB guidelines, the section on air-conditioned spaces does not indicate specific requirements for mechanical ventilation to ensure air quality in mechanically ventilated areas. Furthermore, there are no guidelines to ensure visual comfort when both natural and artificial lighting are combined.

Beside this, there are several factors that should be taken into consideration in selecting the location and building type for constructing NZEB. For instance, the pilot project's scale, location, and type contributed to giving the wrong estimation in evaluating the practice of NZEB in Malaysia. The floor area of the GEO is 4000m^2, which is huge and can magnify the impact of any defect. Furthermore, the location of the building is in Selangor, whereas the best location to get the best potential solar energy is in Penang or Sarawak as can be seen in figure 6. Also, building type plays a role. For example, schools have an advantage as a pilot project because of the reduction in energy consumption during the summer vacation while energy production is still continuing.

Figure 6. The yearly average potential solar energy in Malaysia



Source: https://scialert.net/fulltext/?doi=tb.2016.35.43

3.0 CONCLUSION

Malaysia has a great opportunity for designing and building affordable and efficient NZEBs. Challenges and problems can be overcome by conducting further studies to establish a bioclimatic framework. The study shows that the pilot study gets the advantage of the natural resources in its context. The occupants expressed great satisfaction. As mentioned earlier, in spite of the existence of issues regarding the integration between both natural and artificial light in the lighting system in (GEO), the daylight has a good impact on both the occupants and energy efficiency of the building. Also, adopting natural cooling and dehumidification systems or even a mix between mechanical and natural cooling systems can significantly reduce costs and energy consumption as seen in the BCA academy in Singapore. However, more studies need to be undertaken to develop policies that can ensure visual and thermal comfort in the NZEB. Furthermore, selecting the right building type, location and scale can contribute to achieve an NZEB effortlessly.

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