Energy Performance Index and Its Carbon Impact: Malaysia Commercial Green Buildings.

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Abstract. Green building is the spine of the Sustainable Development Goals. It is supported by their rating tools that cover energy efficiency as a part of the indicator. The aim of this paper is to assess the electricity consumption relationship with carbon emission for commercial green building. The objectives are to calculate the Building Energy Index of the commercial green building. Secondly is to calculate the carbon emission in metric tonnes of CO_2. The finding shows that the most energy efficient building is a museum in Johor, at 46.50 kWh/year/m^2. The highest energy consumption is a shopping complex in Kuala Lumpur at 299.00 kWh/year/m^2. All buildings which were analysed are under the average standard of by MS1525:2019. In contradiction with the electricity consumption, the CO_2 emitted found highest at a shopping complex in Kuala Lumpur amounting 2,123,027.85 $MtCO_2$. The lowest CO_2 emission was found at a museum located in Johor at 744.80 $MtCO_2$. These results of energy and CO_2 emission indicate the highly positive relationship between this two for the case study covering commercial work place of green building at 0.71.

1.Introduction

Acute short-term impacts from the toxicity of carbon dioxide among the major concern of the United Nation (UN). This is underpinned under SDG 13, to combat CO_2 emissions. This goal works aligns with SDG 3 where the UN highlighted on the reducing number of deaths and illness from hazardous air pollution. The evolving building technologies establish a doubtful thought on how green is the operation of our green building especially on the emission of carbon dioxide.

Viewing this perspective in Malaysia also has introduced 2030 Sustainability Goal that aim reduction of 25% from the gross electricity usage by building sector. Malaysia also aims in decreasing 45% of the CO_2 emissions per GDP by the year 2030.

2. Electricity Consumption and Carbon Dioxide Impact

The building system developed rapidly and simultaneously changing the coordination of the installation and operation of the system. Pandey [1] highlighted that 30 to 40 percent of total energy consumption were from building operations. He also claimed that 70 percent was by electricity consumption. These signify the relationship between the green building and environmental burden. It is believed that through the adoption of energy efficiency concept in green building, this burden can be reduced.

This paper aims at assessing the electricity consumption relationship with carbon emission for commercial green building. The objectives of this paper are to calculate the Building Energy Index of the commercial green building. Secondly is to calculate the carbon emission in metric tonnes of CO_2. As a result, this paper explains on the context of commercial buildings that focus mainly on green

commercial building, particularly on carbon emission. Moreover, this paper analyses seven buildings. The scope of calculated type of energy is limited to the building electricity consumption only.

2.1. Green building energy performance index

The concept of green building involves the reduction of energy consumption, adverse environmental and occupant health impact, increase usage of green materials and improve productivity for the whole life cycle of a building [1; 2; 3; 4; 5; 6; 7; 8; 9; 10]. Primary sustainability theme in the Malaysian green building rating tools includes indoor environmental quality (IEQ) and energy efficiency. The IEQ takes into account carbon dioxide monitoring and control.

Nowadays, the non-residential green building established rapidly in both developed and developing countries to meet sustainable planning for built environment [4; 7; 11; 12; 13]. The hike of interest among investor in building green building simultaneously contributes to the economic growth of a country [12; 14]. Thus, this highlighted that green building provides benefits to the social, economic and environmental aspects of life.

A commercial building is "*a building that is used for business activities*". Therefore, for the purpose of this paper, data were collected from both workplace and shopping malls with the size 55,000 m^2 to 126,793 m^2 net floor area. In comparison with conventional buildings in Malaysia, the ranges of BEI found are between 100 to 450 kWh/m^2/year. About thirty per cent (30%) of the building's consumption are below the benchmark of an energy efficient building standard [15]. The level of energy consumption among green energy buildings in Malaysia is still unknown until today. Thus, this paper's findings are to fill this gap.

2.2 Carbon dioxide in green building

The global level of carbon dioxide (CO_2) increases since the beginning of industrial revolution. Construction Industrial Development Board (CIDB) 2018 [16] highlighted that the built environment contributes to twenty per cent (20%) of CO_2 emissions through energy consumption. Out of this percentage, seventy one percent (71%) are believed from the electricity consumption in buildings.

The visual, central, auditory, respiratory, skin heart and muscular body systems can be affected with certain exposure towards CO_2 emission [17]. There are symptoms that can be face by a person with different level of percentage of CO_2 in a volume of air. At one per cent (1%), a person can face drowsiness symptom. At 3%, it can reduce hearing, increase heart rate and blood pressure and cause mild narcosis. At 5% a person face shortness of breath, dizziness, confusion and headache. At 8% a person can face dimmed sight, unconsciousness, sweating and tremor at muscular.

Furthermore, it is believed that the development of the workplace will indirectly affect the environment for the personnel in completing their task [18]. Therefore, green building development meets this need. This is for, the green building with the control of CO_2 level can helps to improve the employee productivity [2; 3; 9; and 10].

3. Research Methodology

Data were gathered from eighteen (18) nos. of green buildings. The commercial green building information is as listed in the following Table 1 as follows:-

Table 1. Green Building Information

No.	Building Type	Location	Gross Floor Area (m^2) excluding car park	Green Rating
Building 01	Office Building	Selangor	14,087.67	GBI
Building 02	Office Building	Kuala Lumpur	52,271.75	MyCrest/GBI

Building 03	Office Building	Putrajaya	55,300.00	MyCrest
Building 04	Office Building	Putrajaya	73,123.00	MyCrest
Building 05	Retail	Kuala Lumpur	126,793.35	GBI
Building 06	Retail	Selangor	107,072.00	GBI
Building 07	Office Building	Kedah	822.10	GreenRe
Building 08	Office Building	Kedah	2,449.50	GreenRe
Building 09	Industrial	Malacca	20,316.00	GreenRe
Building 10	Shopping Complex	Selangor	19,980.94	GreenRe
Building 11	Institution	Johor	286.00	GreenRe
Building 12	Industrial	Selangor	5,101.00	GreenRe
Building 13	Office Building	Kuala Lumpur	41,389	GBI/BCA Greenmark
Building 14	Retail	Johore	5747.00	GreenRe
Building 15	Office Building	Johore	3,210.00	GreenRe
Building 16	Office Building	Kuala Lumpur	17,004.00	GreenRe
Building 17	Office Building	Kuala Lumpur	98,348.00	GreenRe
Building 18	Office Building	Selangor	2,896.16	GreenRe/GBI

Specific energy consumption of a building being assessed by using an international standard namely, energy performance index. This determine the building yearly usage of all type of energy with exception of renewable energy generated. The outcome must with the unit of kWh/m^2/year.

The formula is as follows: -

$$\text{Building Energy Index} = \frac{(\text{TBEC-CPEC}) \times (52)(\text{WOH})}{\text{GFA excl carpark})}$$

Where

TBEC denotes Total Energy Building Consumption in kWh/year,

CPEC denotes Car Park Energy Consumption in kWh/year,

GFA denotes Gross Floor Area in m^2 and

WHO denotes weighted weekly operating hours [19]

There is also an establish standard by MS1525:2019 stating that the baseline for energy consumption as 200 kWh/m^2/year (Office), 300 kWh/m^2/year (Retail), 300 kWh/m^2/year (Industrial) and 330 kWh/m^2/year (Shopping Complex) in order to be acknowledged as an energy efficient building (SIRIM,2019) .Fulfillment of objective number two were found from the CO_2 impact

calculation. The baseline for the Peninsular Malaysia emission factor as calculated by GreenTech is 0.672 CO_2/kWh [20]. The adopted formula as shows below: -

Carbon Impact = Average Monthly Electricity Used (kWh/12) x Electricity Baseline Emission Factor 0.672 CO_2 / kWh

There is no typical pattern of reading or standard found for the carbon impact, hence the level of risk cannot be determined. However, comparison still can be made base on per net floor area of a building. As for objectives one and two had been fulfilled by the above two method of calculation, thus, the aim was then found through drawing scattered diagram in order to understand the correlation between BEI and CO_2.

4. Findings

The finding shows that the average building energy index (BEI) is 134.28 kWh/year/m^2. However, the most energy efficient building is Building 11 at 46.5 kWh/year/m^2 where its function is more towards retail. The highest energy consumption is Building 05 at 299.00 kWh/year/m^2. This building is a retail building at 126,793m^2 GFA. All the analysed building under the baseline determined by MS1525:2019.

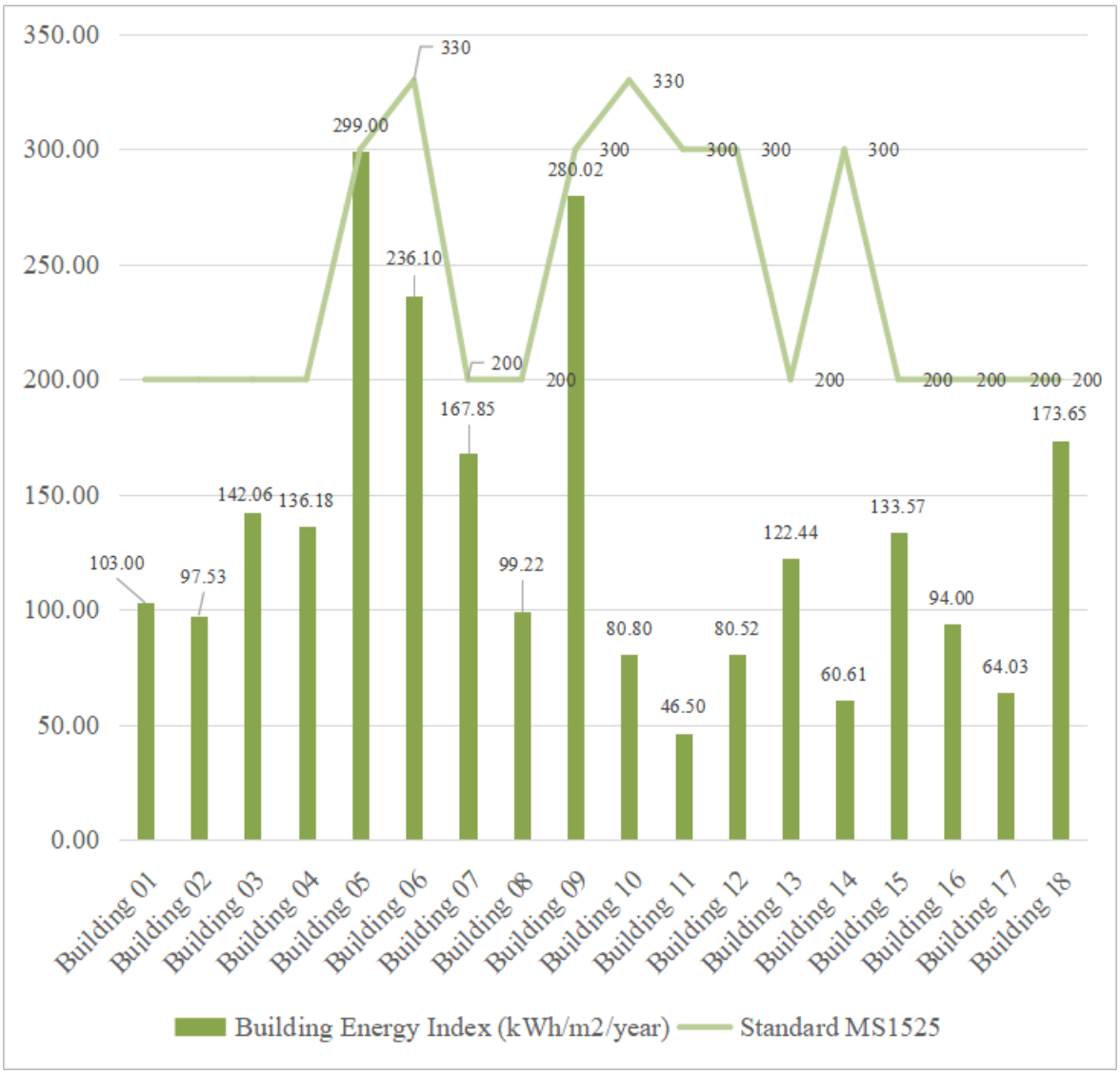

Figure 1. Building energy index for green commercial building in Malaysia.

The following figure 2 shows the correlation chart between the gross floor area with carbon emission. It indicates highly correlated at 0.871 as the size of occupancy increases, the amount of CO_2 emissions also increases. Moreover, the lowest CO_2 emission is found at Building 11 with 744.80 $MtCO_2$. The highest CO_2 emission found at building 05 at 2,123,027.85 $MtCO_2$.

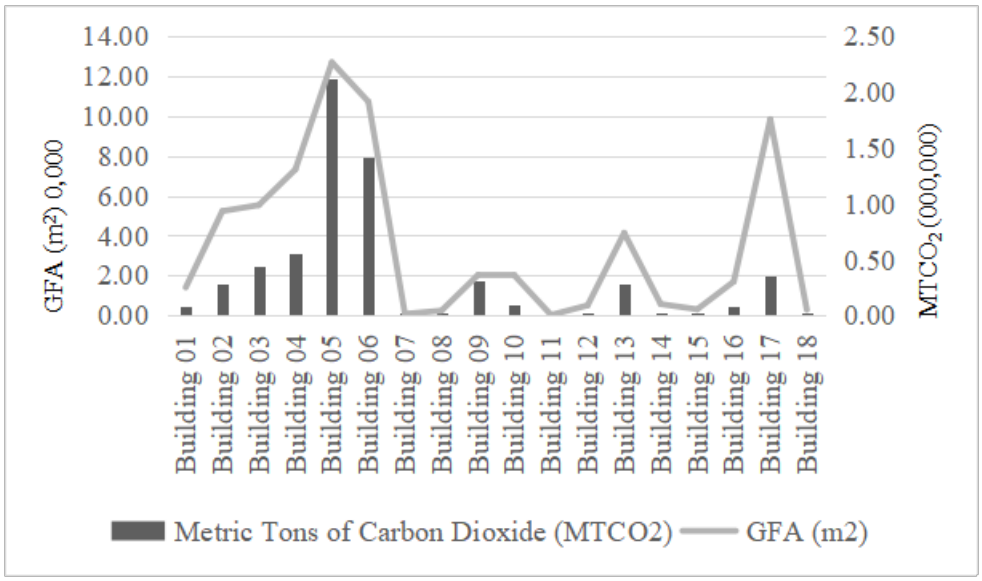

Figure 2. Carbon emission at green commercial building in Malaysia.

5. Conclusion

Data were gathered in order to obtain the energy efficiency and carbon oxide emission of all eighteen commercial green buildings. It is found that 0.71 highly correlated between the BEI and CO_2 impact. This is as clearly drawn in a chart in figure 3. Thus, it can be interpreted that the electricity consumption per m^2 area contributed to the emissions of carbon dioxide.

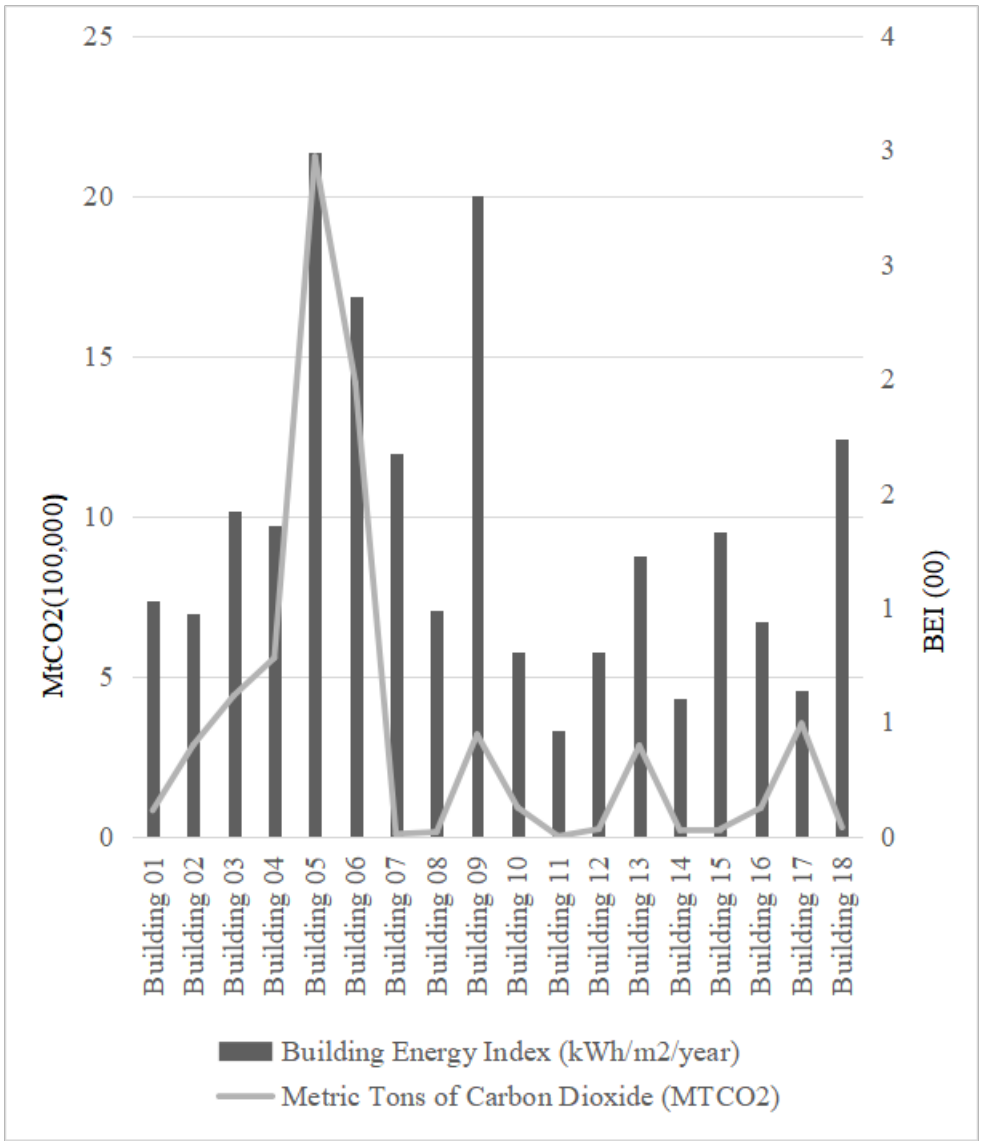

Figure 3. Correlation between building energy index and carbon emission building in Malaysia.

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