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Investigation On Carbon Emission from Energy Usage at Universiti Tun Hussein Onn Malaysia

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Abstract: Carbon emissions are the main contributor to global warming, and it is well known that emissions must be significantly reduced to avoid the worst effects of climate change. The objective of this study is to investigate the carbon emissions from energy use in Universiti Tun Hussein Onn Malaysia campus. The main data collection approach for this study is the analysis of technical reports on energy consumption from 2015 to 2021 collected from the Development and Maintenance Center (PPP) and Sustainable Campus Office (SCO). The data collected was analyzed and compared over seven years of data presentation and analysis. The results show that the highest energy consumption has a significant impact on increasing carbon emissions on campus, with the highest emissions in 2015 at 1955.38 tCO_2e and the lowest in 2021 at 965.70 tCO_2e. On the other hand, based on the collected data, depending on the building, from 2018 to 2020, the highest carbon emission was demonstrated by the Faculty of Technical and Vocational Education (FPTV) with 2,875 tCO_2e. As a result, lower energy consumption will lead to less carbon emissions that could create a better environment with less pollution and significantly lower costs.

Keywords: Carbon emission, energy usage, global warming, carbon reduction

1. Introduction

Carbon emissions are the primary contributors to global warming. It is widely accepted that the world must reduce emissions as quickly as possible to avert the worst effects of climate change [1]. Carbon dioxide emissions are caused by everyone's clothing, food, housing, and daily transportation [2]. GHG emissions from all activities within the organization, including energy used in buildings, industrial processes, and company cars, are measured in an

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organizational carbon footprint [3]. More than 70 countries, including some of the world's largest GHG emitters, have committed to achieving net-zero emissions and carbon neutrality by 2050 or earlier by 2020. As a result, more effective policies and regulations can be put in place to accelerate the transition to net-zero carbon emissions [4].

Previously, in the study by Abdul Latif et al. [5], several studies examined the energy scenario and the development of energy policies in Malaysia at different points in time over the past two decades and further discussed the associated challenges in implementing these technologies [5]. In short, it seems that the full implementation of sustainable energy sources in Malaysia will still take a long time [6].

2. Overview of Carbon Emission by Energy Usage

The amount of carbon emitted from our planet into the atmosphere has recently been a cause for concern. To achieve low carbon emissions, we need to know the source, type, and amount of energy used, as well as the level of emissions from these sources [7]. The problem of carbon dioxide emissions is particularly acute in universities because teaching, learning, residential, and administrative activities have high energy demands for lighting, air conditioning, and electricity, resulting in carbon dioxide emissions [8]. The need and potential for universities to become "carbon neutral" is a hot topic among researchers [9]. The emissions and documentation performance of about half of these institutions are assessed [10]. Overall, this study focused on the carbon emissions of Universiti Tun Hussein Onn Malaysia. Table 1 shows the summary of carbon emissions by energy consumption from previous researchers.

Table 1 - Overview table of carbon emission by energy usage

Researcher and Institute	Title	Carbon Emission $MtCO_2$	Findings
Gaurangi Sen, Hing-Wah Chau, Muhammad Atiq Ur Rehman Tariq (College of Engineering and Science, Victoria University, Australia) [11]	Achieving sustainability and carbon neutrality in higher education institutions: A review	20,000	Higher education institutions seek to priorities the efficient use of natural resources throughout the educational process
Arnis Asmat, Ramlan Zailani, Siti Noor Hajjar Md Latip, Azlin Mohd (UiTM Campus Shah Alam) [12]	Campus operational carbon assessment based on low carbon city framework (LCCF)	1168.56	The products of direct and indirect activities such as classroom, laboratories, offices and consumptions of food and drinks generate negative environmental impacts
Sustainability Team, University Park, Nottingham (University of Nottingham) [13]	Carbon and energy	39,216	Majority of carbon emissions are from electricity and transport sectors
Abdul-Azeez (Universiti Teknologi Malaysia) [14]	Measuring and monitoring carbon emission to promote low carbon development in Johor Bahru	46,000	The major sources of carbon emission releases was electricity, transportation

In achieving sustainability and carbon neutrality in higher education institutions study conducted by Sen et al. [11], it is found that the amount of carbon emissions ($MtCO_2$) released on campus is about 11,658 $MtCO_2$ and the energy sources contributing to carbon emissions on campus are fossil fuels and electricity [12].

A review of carbon and energy in UK universities and the results show that UK universities will consume about 40,000 tons of gas and electricity per year between 2010 and 2020. The main energy sources contributing to carbon emissions in UK universities are natural gas and thermal insulation, both of which result in 39,216 carbon emissions [13]. Numerous previous studies have been conducted to investigate the reduction of carbon emissions from energy use on campus and globally [14].

3. Materials and Methods

This study investigates the carbon emissions from energy consumption in Universiti Tun Hussein Onn Malaysia campus. The research flow of the study is shown in Fig. 1. Data were collected from technical reports of energy consumption from 2015 to 2021 in the Office of Maintenance and Planning (PPP) and the Sustainable Campus Office (SCO). Energy consumption was determined and later converted to carbon emissions. In addition, the carbon emissions data were used to determine the hot spot area in the main UTHM campus building [16].

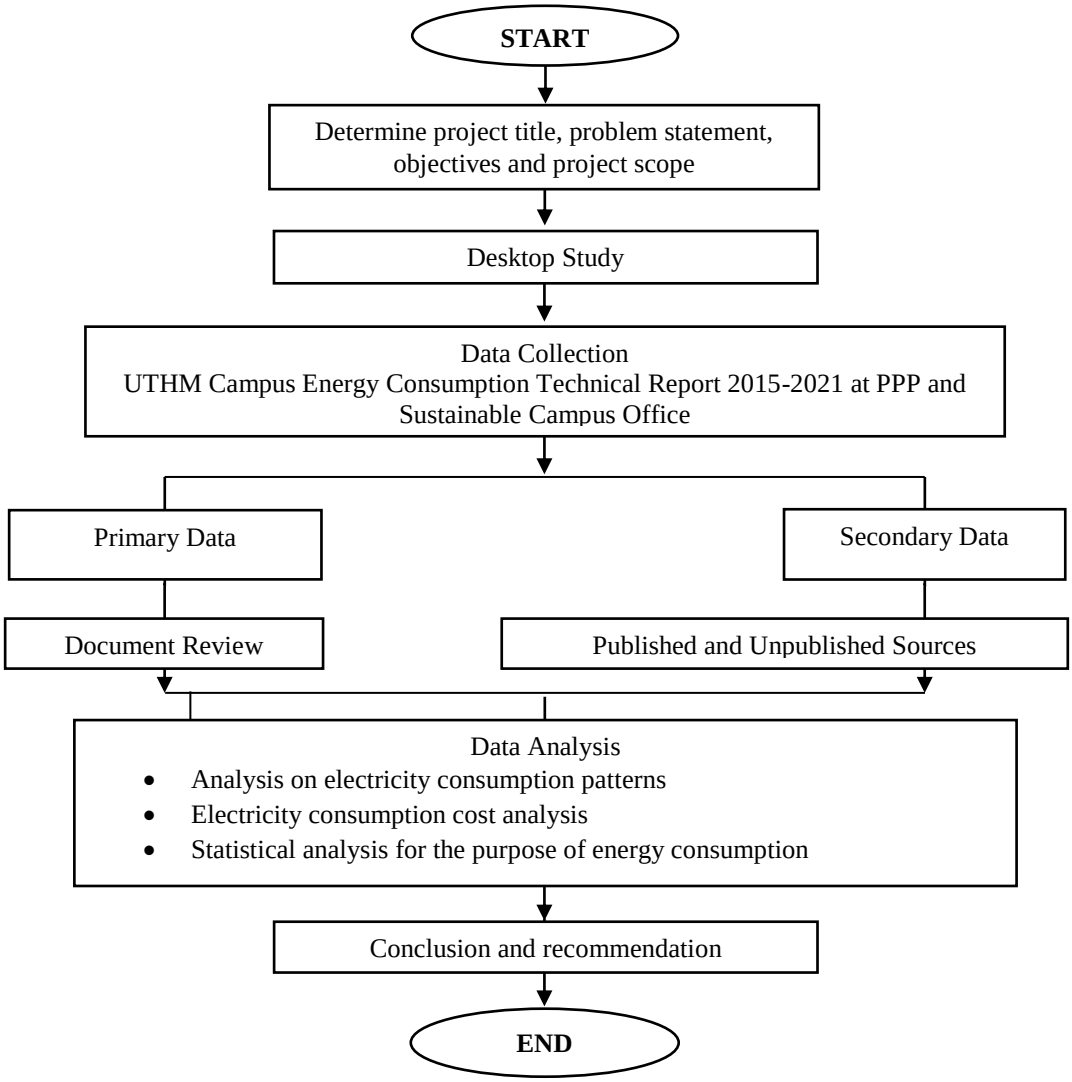

Fig. 1 - Methodology framework of the study

3.1 Data Collection

As shown in Fig. 2, the study site was located on the main campus of Universiti Tun Hussein Onn Malaysia (UTHM). This university is a public university affiliated with the Malaysian Technical University Network (MTUN). The university received a 4-star overall rating from QS Stars University Ratings, with 5-star ratings for teaching, inclusiveness, employability, facilities, and social responsibility, resulting in a 1-star rating for the Energy Management Gold Standard (EMGS) [16].

3.2 Data Analysis

Energy consumption data for 2015 to 2021 was obtained from the Office of Maintenance and Planning (PPP) and the Sustainable Campus Office (SCO). Documents from the previous report were evaluated. Reports from many studies were collected and compared in this study. In order to evaluate the energy consumption and carbon emissions, the formula of Sustainable Energy Development Authority (SEDA) Malaysia [17] was used to calculate the carbon emission value. The carbon emission value for the years 2015 to 2021 was calculated using the formula shown in Eq. (1). The value of 0.694 tCO2/MWh was adopted from SEDA, which is applicable to Malaysia Peninsular for the year 2014.

$$\text{Carbon emission} = \frac{\text{energy usage } (\text{kwh})}{1000} \times 0.694 (\text{tCO2/MWh}) \quad (1)$$

Fig. 2 - Universiti Tun Hussein Onn Malaysia maps in Google Maps

4. Results and Discussion

The results and discussion section presents data obtained from energy usage and carbon emissions at UTHM. The analysed data were compared level of carbon emissions at UTHM's main campus were evaluated. In addition, in order to identify the hot spot area for carbon emission the energy usage by each office at UTHM was also determined.

4.1 Energy Usage at UTHM's Main Campus

The information in Table 2 demonstrated the energy usage at UTHM main campus that was derived using the monthly power bills by Tenaga Nasional Berhad Malaysia between 2015 and 2021 from January to December.

Table 2 - Energy usage at UTHM's main campus

Item	Year	Total Energy Usage (kWh)
1	2015	33,970,750.00
2	2016	30,421,351.00
3	2017	28,511,548.00
4	2018	26,958,566.00
5	2019	26,243,490.00
6	2020	18,820,435.00
7	2021	15,349,328.00

In Fig. 3, the bar chart illustrates the total energy consumption of UTHM's main campus from 2015 until 2021. The total energy consumption has decreased every year where the lowest energy usage being 15,349,328 kWh in 2021 while the highest was in 2015 with 33,970,750 kWh. In overall, a clear decreasing trend is observed in total energy usage from 2015 until 2021.

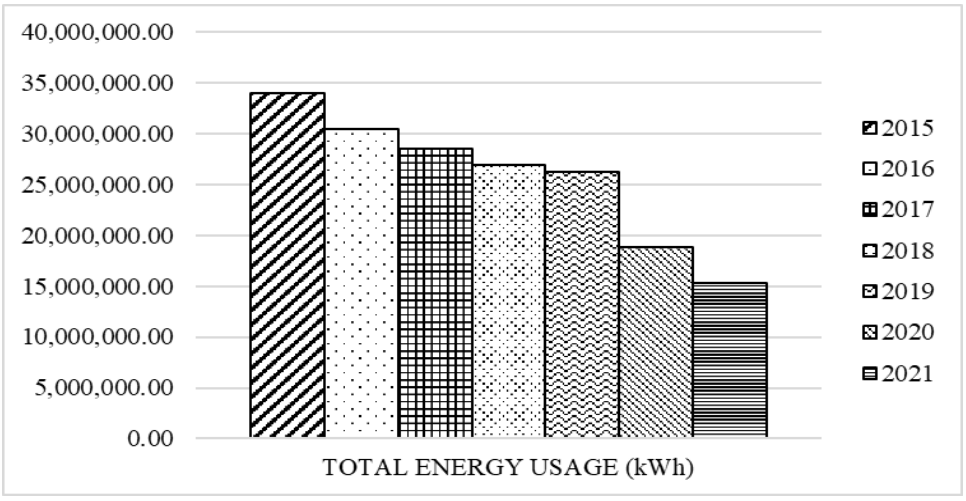

Fig. 3 - Energy usage by UTHM's main campus for 2015 until 2021

4.2 Carbon Emissions (tCO_2e) at UTHM's Main Campus

Based on the research of this study, energy usage by UTHM's main campus for the year and monthly was collected. The carbon emission value was evaluated yearly and monthly from 2015 to 2021 using calculations with the carbon footprint formula, and the result is shown in Table 3 below.

Table 3 - Carbon emission yearly at UTHM's main campus 2015 to 2021

Item	Year	Carbon Emission (tCO_2e)	Percentage of Carbon Emission (%)
1	2015	23,575.70	19
2	2016	21,112.42	17
3	2017	19,787.01	16
4	2018	18,709.24	15
5	2019	18,212.98	15
6	2020	13,061.38	10
7	2021	10,652.43	8

From Table 3, the highest peak data was recorded at 23,575.69 tCO_2e in 2016. On the other hands, the lowest recorded value was 10,652.43 tCO_2e of carbon emissions in 2021. From 2016 to 2021, the carbon emissions on the campus had shown a tendency to substantially decline. Through observations the value decreases with 19,787.03 tCO_2e in 2017, 18,709.24 tCO_2e in 2018, and 10,652.43 tCO_2e in 2021.

According to Fig. 4, the trend of carbon emission release was detected on campus throughout the data collection in February. The highest monthly carbon emissions were recorded in February 2015, at 1590.32 tCO2e, while the lowest was in February 2021, with 899.38 tCO2e. In March, the trend of carbon emission in this month shows a drastic downward trend in the carbon emission of carbon dioxide, where the highest emission was in 2015 also with 2240.60 tCO2e, the emission level sharply changed and dropped each year in March where the lowest amount of carbon emission was also in 2021 with 1120.47 tCO2e.

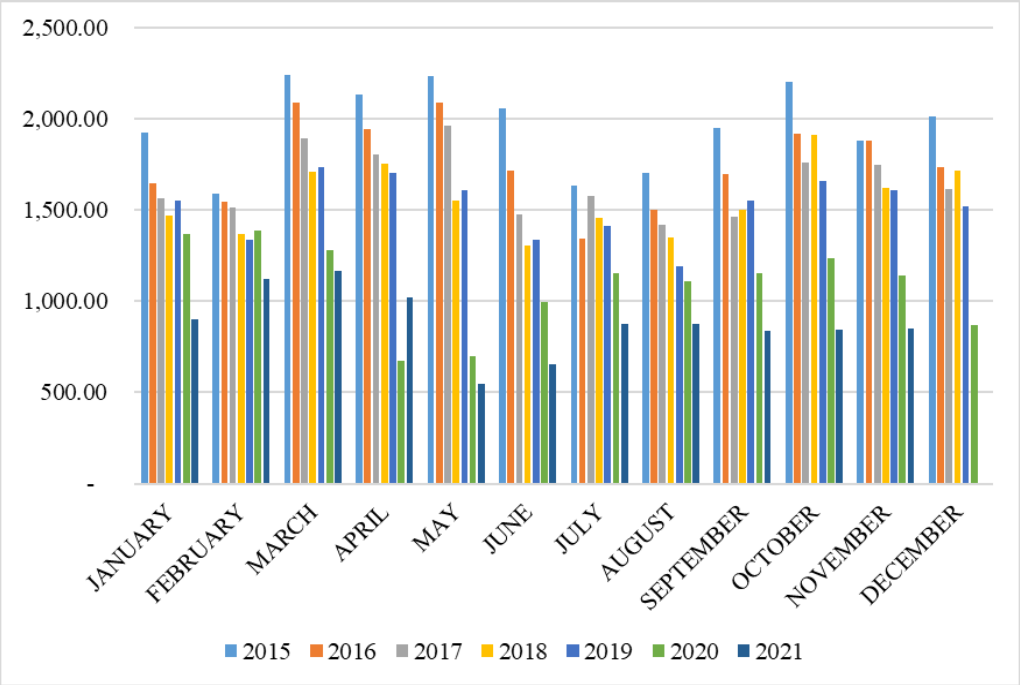

Fig. 4 - Carbon emission monthly from 2015 to 2021 by UTHM's main campus

4.3 Energy Performance in UTHM's Main Building Area

The energy performance of UTHM's main building was determined from 2018 to 2020. Energy performance was evaluated based on eight main buildings used for teaching and learning purposes, including labs, classrooms, offices, and others. Due to the Covid 19 pandemic, drastic changes were evident in building energy performance and operations

during the pandemic and endemic impacts on energy use of buildings on the UTHM campus. Table 4 lists eight of the major buildings on UTHM's main campus that were characterized to examine carbon energy performance.

Table 4 - Information of UTHM's main building

Information	Building							
	FKAAB	FPTV	FSKTM	FPTP	FKEE	FKMP	G3	PTTA
Operating Hours	12 hr/day, 84 hr/week, 372 hr/month							
Building Function	Teaching and Learning Activity							

Note: FKAAB = Faculty of Civil Engineering and Built Environment, FPTV = Faculty of Technical and Vocational Education, FSKTM = Faculty of Science and Information Technology, FPTP = Faculty of Technology Management and Business, FKEE = Faculty of Electrical and Electronic Engineering, FKMP = Faculty of Mechanical Engineering, PTTA = Tunku Tun Aminah Library

4.4 Energy Usage and Carbon Emission (Tco_2e) By UTHM's Main Building from 2018 To 2020

The energy performance of the UTHM Main Building from 2018 to 2020 ranges from 341,448.16 kWh to 4,143,203.52 kWh. In addition, the carbon emissions of the UTHM Main Building from 2018 to 2020 range from 170.89 tCO_2e to 2,875.38 tCO_2e. The iSCADA Data Center System was used to collect energy consumption data for this building from 2018 to 2020, and Microsoft Excel was used to analyse all data. From 2018 to 2020, energy consumption and carbon emissions were evaluated by assigning them to selected PTJ buildings on the main UTHM campus.

The energy consumption and carbon emissions of the main UTHM building from Fig. 5 show that the Faculty of Technical and Vocational Education (FPTV) had the largest carbon emissions compared to the other buildings in 2018, with a value of 2,875.38 tCO_2e. FPTV was the largest contributor to carbon emissions with energy consumption of 4,143,203.52 kWh in 2018. However, the Faculty of Technical and Vocational Education's carbon emission value of 2,772.49 tCO_2e was only 102.89 tCO_2e lower than that of Tunku Tun Aminah Library (PTTA), UTHM. In addition, the G3 building on the main campus PTJ of UTHM had the lowest carbon emissions in 2018 with 236.97 tCO_2e, while it consumed 341,448.16 kWh of energy.

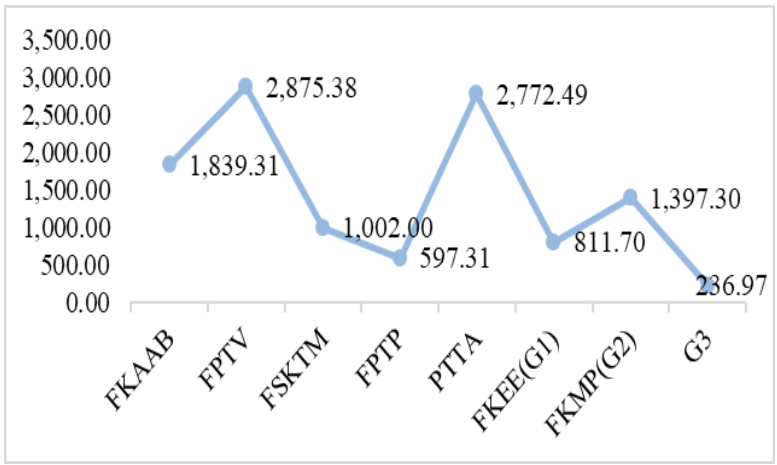

Fig. 5 - Carbon emission by UTHM's main campus PTJ in 2018 (tCO_2e)

Observation has shown that energy consumption and carbon emissions are caused by some factors, including air conditioning, teaching, and learning activities, machinery, and workshop. In addition, a welding store, a machine store, and other advanced technology facilities occupy half of the area of this faculty. According to FPTV students, classes were held in lecture halls and seminar rooms that were fully air-conditioned and equipped with the latest high-voltage technology equipment. In addition, courses and educational activities were held at night. Fig. 6 shows the PTJ carbon emission hot spot in 2019.

Meanwhile, Fig. 7 shows the carbon emissions results for the main UTHM campus building in 2019, using the line graph above to show the energy consumption results. The highest percentage of energy consumption in UTHM buildings is in Tunku Tun Aminah Library (PTTA) with 2,652.72 tCO_2e, while the lowest energy consumption in 2019 is in Faculty of Technology Management and Business (FPTP), which consumes 541.75 tCO_2e, followed by Faculty of

Electrical and Electronic Engineering in G1 with 688.40 tCO_2e. Hours of operation, services provided, and facilities were some of the factors that had the greatest impact on PTTA's energy consumption and contributed to the increase in carbon emissions. The highest electricity consumption was recorded in March at 417,980 kWh.

Fig. 6 - PTJ carbon emission hot spot area in 2019

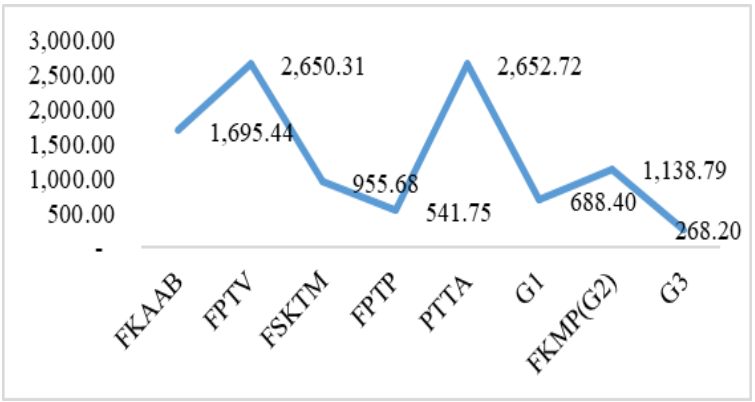

Fig. 7 - Carbon emission by UTHM's main campus PTJ in 2019 (tCO2e)

4.5 Energy Usage and Carbon Footprint of PTJ According to EAC

In an effort to develop a sustainable, green campus, a strategic plan was established for a college with fewer carbon emissions. UTHM organized all campus energy use and developed the Energy Accounting Center in 2021. The aim of the development is to monitor the energy management strategy and the efficiency of implementation, which also acts as a committee for all activities related to the college's energy management. Fig. 8 shows the Energy Accounting Center (EAC) building area on UTHM's main campus.

According to Fig. 9 on the energy usage by responsibility centre (PTj) According to EAC on UTHM's main campus in 2021, the highest PTJ consumed energy usage was EAC-01 with 7,527,773 kWh where in this category. Most of the building that mainly focuses on teaching and learning, laboratories and offices. This building category involved eight PTJs which are Faculty of Technology Management and Business (FPTP), Faculty of Technical and Vocational (FPTV), Faculty of Civil Engineering and Built Environment (FKAAB), Tunku Tun Aminah Library(PTTA), Faculty of Science Computer and Information Technology (FSKTM), Faculty of Electric and Electronic Engineering(FKEE) and Student Affairs Office. Overall, based on Fig. 8, the energy usage for EAC-04 shows the lowest among the other EAC building with amount only 124,642 kWh in 2021.

Fig. 10 illustrates a graph on the carbon emission by PTJs According to EAC in 2021 showing the highest amount of carbon emission released was 4,038.13 tCO2e by EAC-01. In 2021, UTHM's primary campus will have carbon emissions ranging from 4,038.13 to 86.50. As a result, EAC-04 produced the lowest amount of carbon emissions in 2021, with a total of just 86.50 tCO2e.

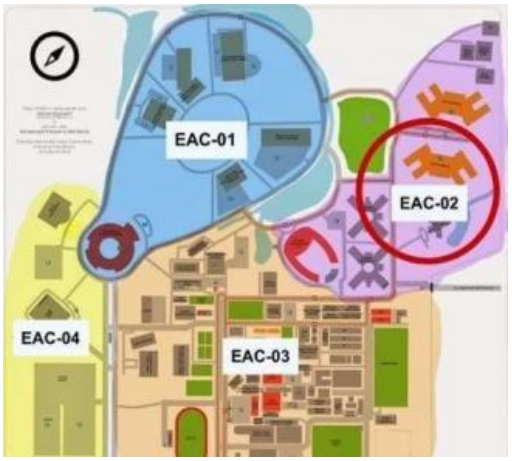

Fig. 8 - Energy Accounting Centre (EAC) building area in UTHM's main campus

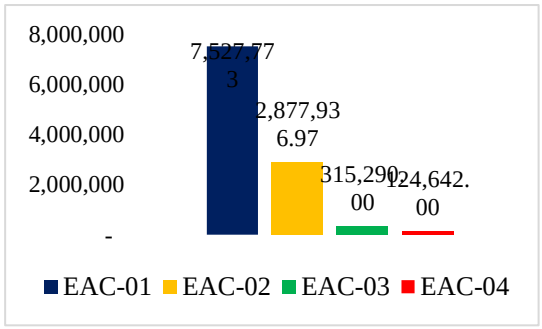

Fig. 9 - Energy usage by PTJ according to EAC UTHM's main campus in 2021

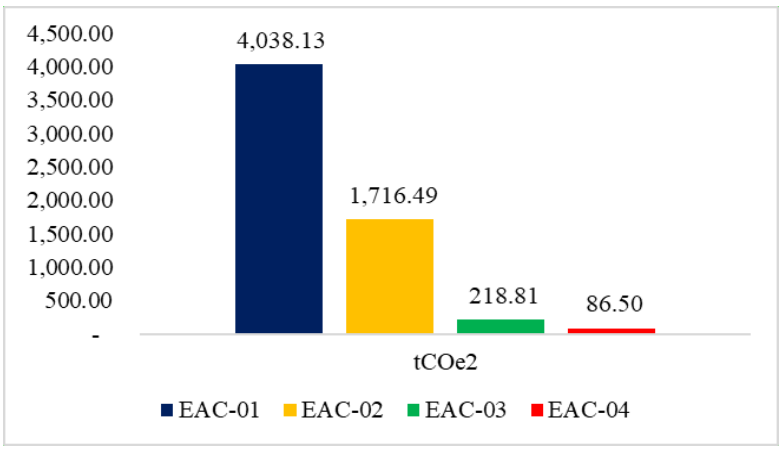

Fig. 10 - Carbon emission by PTJ according to EAC in 2021

5. Conclusion

At the end of this study, it was possible to analyze the energy consumption and carbon emissions on the main campus of UTHM from 2015 to 2021. Raw energy consumption data for the 2018 to 2021 PPP and SCO energy performance report was compiled and analyzed. The analysis showed that UTHM's main campus consumed the most energy in 2015 at 33,970,750 kWh and the least in 2021 at 15,349,328 kWh. The highest energy consumption has a significant impact on the increasing carbon emissions on campus, with the highest emissions occurring in 2015 (1955.38 tCO2e) and the lowest in 2021 (965.70 tCO2e). From 2018 to 2020, the Faculty of Technical and Vocational Education was the building with the highest carbon emissions with 2,875 tCO2e, which changed from year to year, due

to some factors, such as air conditioning, class operating time, large number of workshops and laboratories. In 2021, a systematic and proper data collection on energy consumption was conducted. In this year, the energy consumption data was categorized based on EAC, and it can be found that EAC-01 has the highest carbon emissions compared to other EAC lists:

- Lack of information. The energy usage data could not be compared for certain years because the electricity bills at UTHM are incomplete.
- Changes of system in energy usage according to building applied in UTHM's PTJ building were not standardized that lead to inconsistency data collected on each PTJ building.
- A field visit on the initiative or effort that had been made in reducing carbon emission on the campus is recommended to study how the effort contributes to lowest levels of carbon emission.

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