

Performance and Reduction of Carbon Footprint for a Sustainable Campus

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Abstract: This research is to analyze and reduce the emission of carbon footprint around campus in order to build a sustainable campus for future generations. One of the most profound issue faced by the world today is the rise of temperature which is also known as global warming. The emission of GHGs has been an alarming issue in our world today which causes not only the rise of temperature but also disastrous natural disasters such as flood, hurricane, drought and many more. Like other developing countries, Malaysia have given its full support and cooperation in its attempt to achieve a sustainable development. In Malaysia, there are several policies and legislation developed to encourage sustainability in four major areas which are water and waste management, transportation, energy and building. The importance of higher education institutions such as universities should address the diverse needs of local societies and promote sustainability. Universities should also consider including sustainability into student's education and program to promote the environmental issues which have been one of the highest concerns around the world. Therefore, the focus of this research is to analyze and reduce the carbon footprint for a sustainable campus. Hence, the aim of this research is to analyze the emission of carbon footprint throughout the campus such as traveling to class and to suggest alternatives that the student or staff can take in order to reduce the emission of carbon footprint around campus and to build a sustainable campus.

Keywords: Carbon footprint; CO₂ emission; transportation; sustainable campus; green initiatives.

I. INTRODUCTION

One of the most profound issue faced by the world today is the rise of temperature which is also known as global warming. The modernization of technology such as production and consumption of food, generation of electricity, and development of building are some of the factors which leads to climate change and global warming in Malaysia. The emission of GHGs has been an alarming issue in our world today which causes not only the rise of temperature but also disastrous natural disasters such as flood, hurricane, drought and many more. Over the past century, the average global temperature rises by 1.4°F and is expected to rise by 2°F to 11.5°F in another hundred years. Therefore, the change in temperature and climate pattern will cause danger to the lives in Earth due to the extreme weather and temperature shift conditions [1].

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Despite the increase in population in our world today, the most remarkable emission of GHGs would be the emission of CO₂ by society enjoying a better living standard and material wealth [2]. Besides that, the increase rate of CO₂ emission between 1971 and 2004 due to the generation of electricity in buildings has estimated to increase by 1.7% per year for residential buildings and 2.5% per year for commercial buildings [3]. Therefore, it is important to emphasis on the importance in combating global warming to mitigate the increase of CO₂ emission which can be harmful to the lives on Earth.

Like other developing countries, Malaysia have given its full support and cooperation in its attempt to achieve a sustainable development. In Malaysia, there are several policies and legislation develop to encourage sustainability in four major areas which are water and waste management, transportation, energy and building. Due to the increase of GHGs emission, Malaysia has pledge to reduce the GHGs emission up to 40% per capita by year 2020 as compared to year 2005 [4].

The importance of higher education institutions such as universities should address the diverse needs of local societies and promote sustainability. Universities should also consider including sustainability into student's education and program to promote the environmental issue which have been one of the highest concerns around the world. Not to forget, universities is an institution to initiate and participate to archive sustainability development in the country [5]. A sustainable campus can be described as the higher education institutions to improve the campus energy efficiency, converse resources and increase environment quality by educating students on the importance and benefit of a sustainable to create a healthy and better learning environment [6].

The first step in imposition of a sustainable development is to start with the awareness of population towards the importance of sustainability and to have a sustainable practice throughout their daily activities such as recycling and reuse waste materials. Consequently, universities today play an important role towards sustainable development throughout the process of management, education, campus operation, construction of building and many more. Therefore, the understanding, realization and execution of sustainability in higher education institutions cannot be disregard.

II. LITERATURE REVIEW

The natural process which warms the Earth's surface is known as the GHGs effect from the incoming and outgoing energy from the Sun. Some of the Sun energy reaches the



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atmosphere and some will be reemitted back to space in different direction while the remaining energy will be absorbed and re-radiated by the GHGs. The radiation that is reflected downwards will increase the temperature of the Earth's atmosphere which is known as the GHGs effect. Hence, the Earth's atmosphere resemblance the glass of a greenhouse absorbs and traps the heat. Furthermore, the high concentration of GHGs will increase and disturbed the Earth's temperature. GHGs comprises of water vapour, carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone. The concentration of N_2O , CH_4 and CO_2 in the atmospheric have increased since it was last measured around 800,000 years ago.

During the pre-industrial, specifically from fossil fuel combustion, the CO_2 concentration have drastically increased by 40%. Fossil fuels are known as hydrocarbons which are made of hydrogen and carbon. Therefore, when fossil fuels react with oxygen (O_2), combustion occur and will release heat to the atmosphere. If hydrocarbons are burned, it produces water vapour and CO_2 .

The concentration of CO_2 in the atmosphere have increased rapidly from 280ppm up to 408ppm since the start of the industrial transformation [7]. Not just that, due to the population growth, revolution of technology and economy growth, the emission of the anthropogenic GHGs have increased consistently. According to Pachauri, in the middle of 1750 and 2011, the cumulated anthropogenic CO_2 emission increase up to 2,040 gigatons [8]. In 2012, almost 9.6 gigatons of CO_2 due to the emission from cement and fossil fuels while in 2014, the CO_2 increase to 9.8 gigatons.

Among the CO_2 that have been released to the atmosphere, 40% of the CO_2 emission will remain in the atmosphere while the other 60% of the CO_2 will be dispose to the land or the ocean. Therefore, the remaining GHGs that remain in the atmosphere would cause the Earth's temperature and climate due to the heat that is trapped in the atmosphere. Furthermore, "enhanced greenhouse effect" is known from the increase of GHGs due to the rise in Earth temperature and human daily routine [8].

Hence, the role of higher education institution to input green initiatives around the campus was presented with many positive as well as negative feedback by several researchers [9]. This is because higher education institutions are well constructed, long-term thinking to achieve the education goals and research without forgetting to educate the students about the importance of sustainability towards the environment. Year by year, the higher education successfully incorporates ideas and innovation not only from local but also globally. Furthermore, new proposal towards campus green initiatives are from the talented faculty, staffs and students to develop new sustainable creation.

Besides that, educating students towards the importance of producing a sustainable campus can allow them to expand their knowledge, skills and practicality to be involve in decision on their daily activities which will improve the quality of the environment and not damage mother earth for the future generations [10]. Besides that, from Table 1, the Department of Food and Rural Affair 2012 (DEFRA) has provided the emission factor for the vehicle type as a standard factor to measure the emission of carbon footprint for various countries including in Asia.

Table. 1 Emission Factors for Mode of Transportation

Mode of Transportation	GHG emission factors, F (kg CO ₂ e per km)
Traveling by bus	0.136
Traveling by personal car	0.242
Traveling by carpool	0.121
Traveling by motorcycle	0.142
Traveling by bicycle/walking	0.000

III. METHODOLOGY

In this work, the steps that were taken to achieve the objectives of the study are elaborated as below. The focus of this study is to analyze and reduce the carbon footprint for a sustainable campus. The research methodology for this study is arrange and shown in the flow chart below, as shown in Fig. 1.

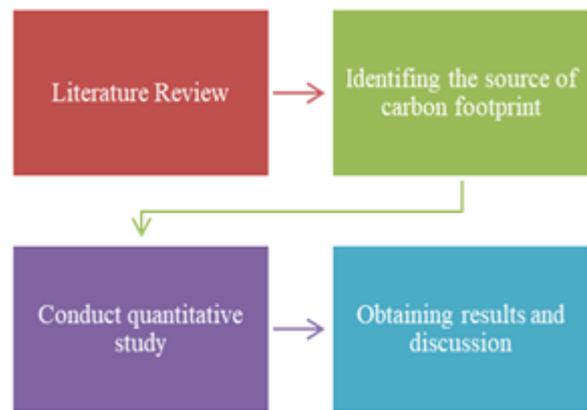


Fig.1 Methodology of research study flowchart

For the analysis and reduction of carbon footprint for a sustainable campus, the literature review is based on studies done by researchers on the past years about the emission of GHGs and ways to measure carbon footprint. The main focus of this study is the analysis of carbon footprint and steps that university students and staffs can do to reduce the emission of carbon footprint around the campus.

In this part of the study, a quantitative study is conducted by conducting a survey among university staffs and students to identify the level of awareness towards carbon footprint and to analyze their daily activity and behavior in campus towards the emission of carbon footprint. Next, the activity that contribute the highest carbon footprint emission within the campus will be analyze and identify.

Data collection plays an important role in the analysis and reduction of carbon footprint to produce a sustainable campus. The important data collected from the past studies are the carbon emission factors, ways to calculate the carbon footprint emission and many more.

IV. RESULTS AND DISCUSSION

The study was conducted at university campus and the sample size consist of 74 respondents which includes university staff and students.

The survey questionnaires were distributed online through email. Out of the 74 respondents there were 33 females (55.4%) and 44 males (44.6%) which was shown in Figure 2 below.

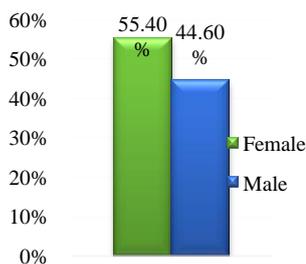


Fig.2 Genders of participant who are willing to participate in the study

Besides that, the age of the 74 respondents varies from 15 years old till 55 years old. From figure 3 below, we can see the majority of the respondents age between 15-25 years old which consists of 60.8%, followed by 28.4% of the respondent age between 26-35 years old, 9.5% of the respondent age between 36-45 years old and the least respondents age between 46-55 years old which consists of 1.3%.

Analysis of Carbon Footprint around Campus (Transportation/Travel)

For the part B of the survey which is transportation and travel, the respondents were questions on the number of times they travel around the campus in a week, the distance (km) of the respondent’s accommodation to campus and their commuting mode around campus.

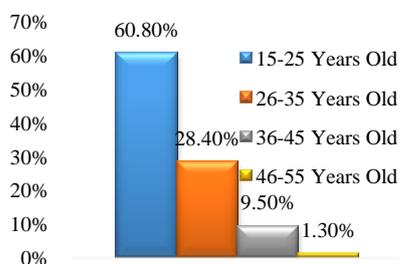


Fig.3 Age of participant

From Figure 4, we notice that 81.1% of the respondents travel around campus in a week is 1 to 5 times a week while 14.9% of the respondents travel around campus 6 to 10 times a week and the remaining 4.1% of the respondents travel around campus in a week is 11 to 15 times.

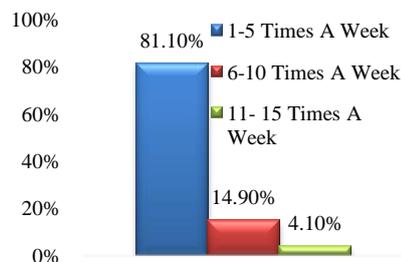


Fig. 4 Frequency of participant travelling to campus in a week

The distance travelled by the respondents from their accommodation varies from 10km up to 50km. Not just that, there were some respondents who answered 0km for the distance they travelled from their accommodation to the campus because, they live at hostels which are accommodations prepared by university for the students. Figure 5 shows the average distance travelled from accommodation to campus by respondents.

Once the distance of respondent travelled is identified, it is used to determine the mode of transport and the frequency of the respondent travelled to campus in a week and the analysis of the CO₂ emission from the respondent mode of transport around the campus in a week will take place. For the frequency of participant travelling to campus in a week, the maximum frequency travelled to campus will be considered. For example, if the respondent answered 1 to 5 times a week to campus, the maximum frequency which is 5 times a week will be considered. Therefore, the maximum CO₂ emission around the campus through transportation will be determined.

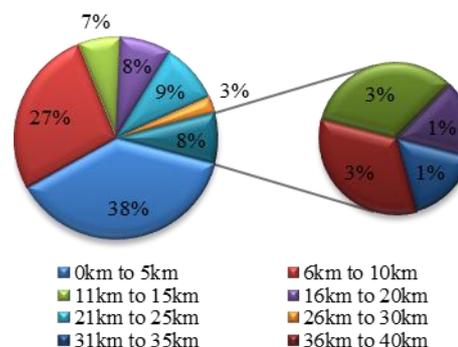


Fig. 5 Average distance travelled from accommodation to campus

Based on past research, the emission factor used to calculate the GHGs emission for transportation are shown in Table 1. For instance, the GHG emission factor if the respondent chooses to travel around the campus by personal car would be 0.242 kg CO₂e per km, if the respondent chooses to travel around the campus by carpooling with their friends would be 0.121 kg CO₂e per km and if the respondent chooses to travel around the campus by bicycle or walking would be 0.00 kg CO₂e per km. The total emission of CO₂ from transportation around campus in a week is 955.30 kg CO₂e.



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The highest contribution towards the emission of CO₂ in this study would be the commuting mode. Based on Figure 6, most of the survey respondent prefer to drive alone which makes a total of 48.6% followed by 25.7% of the survey respondent prefer to walk and 18.9% of the survey respondent prefer to carpool to get to their destination around the campus. Therefore, the total emission of CO₂ from respondent who drive alone around campus in a week is 920.70 kg CO₂e.

Furthermore, in order to produce a sustainable campus and to reduce the emission of CO₂ around the campus through transportation, students and staffs should practice using a more sustainable commuting mode around the campus such as, bus shuttle service, cycling or walking.

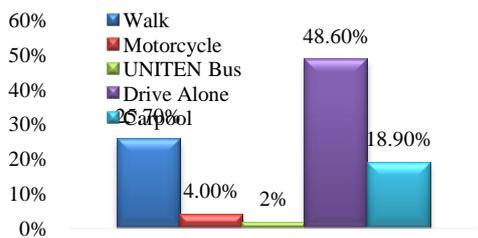


Fig. 6 Mode of transportation around campus

One of a sustainable campus initiatives is to provide walkway shed and cycling lane for students and staff to get around the campus without worrying of walking or cycling under the hot sun or rain. Hence, in the survey questionnaires, the respondent was asked which commuting mode they would choose between driving, cycling and walking to travel around the campus to support in building a sustainable campus. Based on Figure 7 below, the highest percentage choose by the survey respondent were walking which is 41.9% while 35.1% of the survey respondent choose to cycle around the campus and the remaining 23% of the survey respondent still prefer to drive around the campus to reach their destination.

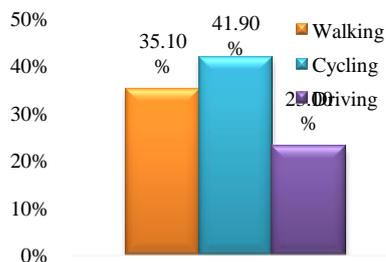


Fig. 7 Respondent sustainable commuting mode around campus

The total emission of CO₂ from the survey respondent choice for a sustainable mode of commuting around the campus in a week is 255.94 kg CO₂e. Consequently, the emission of CO₂ have been reduced by 664.76 kg CO₂e. Hence, interviews were made with some of the student to find out why the remaining 23% of the survey respondent still prefer to drive around the campus to reach their destination.

This is because, some of the student stay out of the campus premise and therefore it is hard for them to travel from their accommodation to the campus without driving. Not only that, some student find that it is inconvenient to leave their vehicle at the library carpark and to use the shuttle bus service to travel around the campus because of the shuttle bus schedule and delay which will cause the student to be late for their classes, furthermore, during peak hour, the bus will be pack making them to wait for the next shuttle bus which make the waiting time even longer. The campus walkway and cycling lane, are some of the other initiatives that have been done to support a sustainable campus by enforcing car parking sticker. By enforcing car parking sticker, the management can reduce the usage of cars around the campus and increase the number of students to use bus shuttle service, carpool, walk or cycle to travel around the campus premise in order to reduce the emission of CO₂ from transportation around campus.

Transportation/Travel Recommendations

Figure 8 shows some of the initiatives that can be done in order to reduce the emission of CO₂ through transportation and to build a sustainable campus.

The first initiatives would be to improve the transportation options around the campus. Some examples to improve the transportation options is to increase the number of shuttle buses and to improve the condition and design of campus sidewalks and bike path around the campus.

The second initiative is to have incentives for alternative mode of transportation. Some of the incentive that can be done would be the benefits and resources for carpooling or subsidized access to public transports. For instance, to students that practice carpooling, there could be special parking spot without implementing the parking sticker or to give social activity marks to students that practice carpooling around the campus. Furthermore, to encourage the students who do not stay in the campus accommodation to use the public transport, there could be subsidizing for the public transport tickets where student can claim 50% of their public transport ticket. Besides that, there could be transport to send the student to nearby public transport stations on the weekdays as well as weekends to encourage them to use the public transports to reduce the emission of CO₂.



Fig.8 Initiatives to reduce emission of CO₂ through transportation.

Parking management such as priority parking for carpools is another initiative that could be practice to reduce the emission of CO₂ through transportation. For land use management, the number of car parks should be reduced and increase sheds for walkways, bicycle lane, and bicycle parking. Enhancing the landscape around the campus could make walking experience and cycling enjoyable. Awareness, policy and institutional reform would be supporting and promoting the initiatives through campus. Some student might not be aware of the causes of GHG's and how the commuting mode they choose could affect the emission of CO₂. Therefore, there should be initiative to educate the students on how important it is for them to reduce the emission of CO₂ and what are the ways they can choose to travel around the campus and to reduce the emission of CO₂ to build a sustainable campus.

V. CONCLUSIONS

In a nutshell, there are many ways that's can be done in order to reduce our CO₂ emission thru our daily routine such as using public transport to get to our destination instead of driving, use recycle bags instead of plastic bags when shopping, avoid using plastic straws in restaurants and switching off the electricity when not in use. But the simplest initiative that can be done by everyone to reduce our CO₂ emission is to practice green mode of commuting. There is a degree of awareness towards the reduction of carbon emission among the staff and students on the sustainability practices, many are still not implementing green habits towards their daily routine. The cooperation among staffs, students and managements plays a big role in this transformation towards building a sustainable campus for future generations.

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