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Design and Development of a Carbon Footprint Calculation Model for Universiti Tenaga Nasional

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Abstract: ***Carbon footprint is the amount of a greenhouse gas (GHG) produced as a result of human activities, usually expressed in equivalent kilograms of carbon dioxide (CO2). As the amount of greenhouse gases emission increases, the global temperature increases. In the context of a global awareness of the climate change, carbon footprint has recently become extensively calculated and ways to reduce it are proposed. The purpose of this research is to calculate the amount of carbon footprint discharged by students in College of Engineering (COE), Universiti Tenaga Nasional (UNITEN). From this research a model to calculate the carbon dioxide emission released from the activities done by the COE students particularly, is developed. Literature reviews are done leading to an explanation of what emission categories should be presented in a CO2 calculation for a university. This includes emission sources in each buildings, activities and services in COE particularly. Conducting survey is one of the methods to get the data from the students and staffs directly. From this data, the calculation is done and tabulated in the Excel template. From this template model, the carbon footprint for each or total students of COE can be known. Referring to this data, CO2 reduction strategy in COE particularly and UNITEN generally can be proposed.***

Keywords: Carbon Footprint, Global warming and Survey

I. INTRODUCTION

Atmospheric concentration of CO_2 has risen broadly due to human activities and now has reached dangerous levels. Based on an article published recently, CO_2 levels on Earth have officially hit 415 parts per million (ppm), according to readings taken at the Mauna Loa Observatory in Hawai'i [1]. Reducing in CO_2 emissions are known as one of the major concerns for many countries including Malaysia. There are more than 150 governments including the major industrial and developing countries concurred on a system tradition on climate change [2]. Many governments have signed with the international convention such as United Nations Framework Convention on Climate Change (IPCC), Kyoto protocol, Bali roadmap and Copenhagen Agreement for taking an effort for the response to global warming [3].

On a larger scale, some governments are taking measures to limit emissions of carbon dioxide and other greenhouse gases. One of the ways is to put taxes on carbon emissions or higher taxes on gasoline so that people and companies will
have greater incentives to conserve energy and pollute less [4].

Malaysia has announced the intention of reducing 45% of carbon emission by the year 2030 [5]. As far as the government's programs in reducing carbon footprint are done, the number of organizations that participate is unfavorable. This may be due to lack of government's approach to the organization about the importance of measuring the carbon footprint. Carbon emission should be calculated every year to know how much carbons are being emitted by each person in the form of equivalent kilogram of CO_2 (kg CO_2 e) or equivalent tons of CO_2 (ton CO_2 e). This calculation will provide a statistic of carbon footprint in a yearly basis, hence delivering better understanding on carbon footprint and helps one to get the ideas to overcome it.

UNITEN is a private institution that has a number of students registered every year. UNITEN manages its operation in two different campuses which are Putrajaya and Muadzam Shah campuses. This research will play a role in calculating the carbon emission in UNITEN. The aim is to determine and provide a statistic of carbon footprint in UNITEN for each year. As a preliminary study, a model to calculate the carbon footprint is developed for one of the colleges, which is COE that is located in Putrajaya campus. The carbon footprint from other colleges from the same campus and the other campus are not calculated now but will be included in the future research. So the main objective of this paper is to develop a model for calculating the amount of CO2 emission by each and total engineering student in COE, UNITEN. However the research only concerns on the sources of CO2 emission by students activities excluding the exhalation of CO2 from human and carbon emission from food (foodprint) as it will be neglected in this study. From this model example, it is anticipated that the total emission for the whole campus could be calculated and presented in the future.

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II. METHODOLOGY

There are two major types of carbon footprint assessment which are product and organization carbon footprint [4]. Product carbon footprint quantifies the emissions covering the activities of the product's lifecycle, while organization carbon footprint quantifies the emissions from an organization's activities. The most widely recognized protocol for businesses and organizations greenhouse gas is GHG Protocol, which is an international standard commonly referred for carbon footprint [6].

GHG protocol divides emission source into 3 scopes which are direct, indirect and other indirect emissions [7]. Direct emissions (Scope 1) are the activities controlled by an organization or community. Indirect emissions (Scope 2) is associated with purchased or acquired electricity, heating, cooling or steam. The other indirect emissions (Scope 3) are from upstream and downstream emission which resulting from the extraction and production of the purchased materials and fuels. Based on this standard, the basic carbon footprint approach is estimated similarly across all analysis categories as follows [8]:

Step 1: Determine activity/consumption data in each sector (kilowatt-hour (kWh) used, kilometer (km) distance travelled, volume (m^3) and other data).

Step 2: Derive associated GHG emission factors (kg CO_2 e/kWh used, kg CO_2 e/km distance travelled or kg CO_2 e/L fuel consumption, kg CO_2 e/m^3, volume used and other emission factor).

Step 3: Multiply activity/consumption data by the associated emission factor to estimate the emissions in kilogram (kg) CO_2 e for each sector and add up to determine the overall carbon footprint.

Two main parameters are needed in order to calculate carbon emission from an activity or process. First is the activity data (AD), which shows the quantification of the process. The unit of measurement is assigned to the activity data of an organization. For example, for an activity involving the consumption of electricity, the unit can be in the form of kilowatt-hour (kWh) while the transportation activities can be measured in terms of distance-based in kilometre (km) or fuel-based in litre (L). The other parameter needed is the emission factor (EF). This parameter shows how much emission, in CO2 equivalent, is being emitted for a unit of the activity data. Emission factor values may be found from direct measurement of processes, or from publicly available data such as the GHG conversion factors from the UK's Department for Environment, Food and Rural Affects (Defra) / Department of Energy and Climate Change (DECC) [9]. The GHG conversion factors reporting in Defra / DECC's are suitable for use by UK based organizations of all sizes, and for international organizations reporting on UK operations. With the two parameters stated, a main equation is developed by researchers as shown below in order to calculate the carbon footprint of a process or consumption of goods [3] [4] [7] [10]:

$$\text{Carbon footprint (kg } CO_2 \text{ e)} = \text{Activity data (AD)} * \text{Emission factor (EF)} \quad (1)$$

The emission factors used in this study are shown in Table 1 below:

Table. 1 Emission factors for each activity data

Activity Data	Type	Unit	GHG	Emission Factor
Transportation	Petrol (average biofuel blend)	Liters (L)	kg CO2 e	2.19697
	Diesel (average biofuel blend)			2.61163
Electricity	Malaysia (commercial rate)	Kilowatt-hours (kWh)	kg CO2 e	0.10919
Paper Consumption	Closed Loop Source	Mass (kg)	kg CO2 e	0.683
Water Consumption	Water Supply	cubic meters (m3)	kg CO2 e	0.344

As stated earlier, this preliminary study is done to calculate the CO2 emission by COE students. However, consideration of other colleges' students should be taken as ratio calculation of COE students. This is because there are some activities inclusive of contribution from other colleges' students. Hence this project requires some calculation method in order to develop a model of carbon footprint calculation for COE students only from all the sources in Putrajaya campus of UNITEN. Identifying the CO2 emission sources in Putrajaya campus of UNITEN is the first step of this project. There are 4 main sources that emitting high amount of carbon by students in this campus. One of the sources of CO2 emission is from transportation. There are three types of vehicles which are car, motorcycle and UNITEN bus used by students for their transportation. The data needed from transportation is for instance; the number of COE students, the percentage (%) of student using car/motorcycle/bus, the frequency of usage per week and the amount spent for petrol in a week. The average petrol price per liter is used for calculation. Another source of CO2 emission is from electricity which is obtained from the electricity consumption. Thirdly, the papers consumed by students and lecturers from COE for academic purposes are taken into consideration. Paper consumption by lecturers is included in calculation method because sometimes lecture notes, quizzes, class activities and assignments are printed by some lecturers for students. Therefore, it is also a part of students' contribution in paper consumption. The paper consumption is from the test pads, examination answer booklet and A4 papers. Last but not least is the water consumption which is obtained from the water consumption. The total carbon emission can then be obtained by multiplying the emission factor of each sources with activity data.

III. DATA COLLECTION

All data are collected from UNITEN Facility Department and Management (FDM), administration and survey that have been conducted among engineering students. There are about 3,500 of COE students out of approximately 5000 students studying in UNITEN Putrajaya Campus during the research done. The survey was conducted in the weightage of 100 COE students.

From Figure 1, majority of the students uses car for their transportation which is almost half of the total COE students. The second highest vehicle used to travel by the students is UNITEN bus which is about 29%. Another 22% of the students rides their motorcycle to come to UNITEN, while only 2% of students riding bicycle or walk to the classes. Figure 2 shows the amount spent for car petrol by students who are staying in and out of the campus. Majority of the students staying in campus spends about RM30 to RM40 in a week while students staying out of the campus spends about RM40 to RM50 in a week. Hence, RM40 will be taken as an average amount for all the COE students in the calculation.

From the interview and data collected from FDM that manages UNITEN busses, the amount spent for diesel fuel is different for each month. The use is high during the long semesters and less if it is on the semester break or during the short semester as the number of students is less. The total amount spent is about RM 90,000 for one year. The data obtained is in the form of the amount spent to buy diesel, but in the calculation of carbon footprint, the data should be in the form of Liter (L). This is also the same for petrol. As conversion, the amount spent is multiplied with the diesel/petrol price per liter. Ratio is used in calculating the carbon footprint for COE students only since any students in the campus can use the bus.

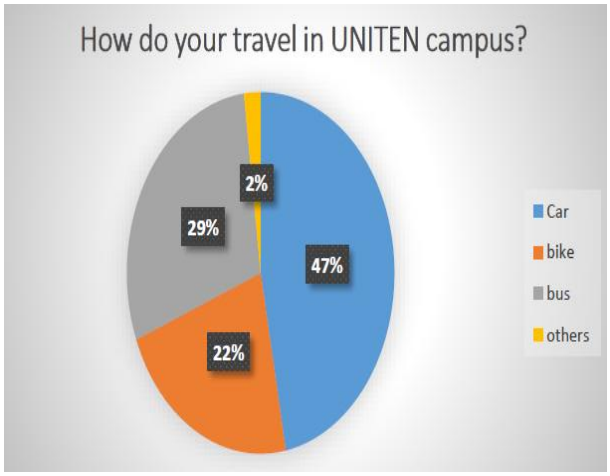

Fig. 1 Method of transportation of COE students in UNITEN

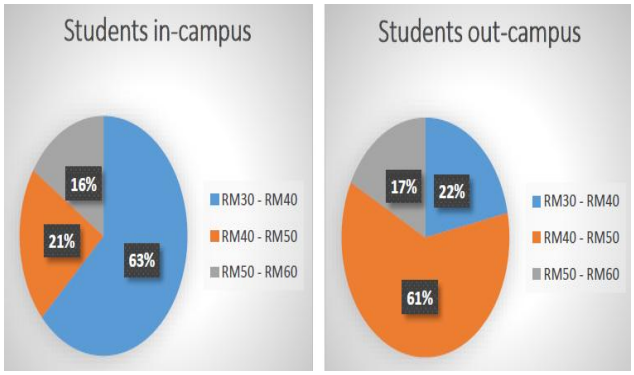

Fig. 2 Amount spent by COE students on petrol in a week

The total electricity consumption of COE building per annum is around 2,000,000 kWh. Since the COE buildings are not fully utilized by the engineering students, contribution of COE and other colleges' students are involved. Therefore ratio is used in calculating the carbon footprint for COE students only.

In terms of paper consumptions, both lecturers and students use papers for academic purposes such as for printing, writing notes, tests and examinations. According to the survey results shown in Figure 3, 50% of the students use 2 reams of test pad per semester, while 35% of them use one ream of paper. On average, 2 reams of test pad are considered for the carbon footprint calculation. For lecturers, the data on the number of reams of A4 papers given to all lecturers in COE is obtained from the person in-charge in COE administration office, where all lecturers are entitled to get 1 ream of A4 papers per semester. For the examination, the paper consumption counted is from the answer booklet used. Each answer booklet contain at least 8 sheets of papers per booklet. It is assumed that each students are taking on average of 5 subjects per semester. At the end of the calculation, the total number of papers used is about 2 million paper sheets. The number of paper sheets is then multiplied with 4.5 grams per paper sheet.

Last but not least is the total amount spent for the water consumption which is almost RM3 million per year. In the calculation of carbon footprint, the data should be in the form of cubic meter, hence the amount spent is multiplied with the price of water per liter.

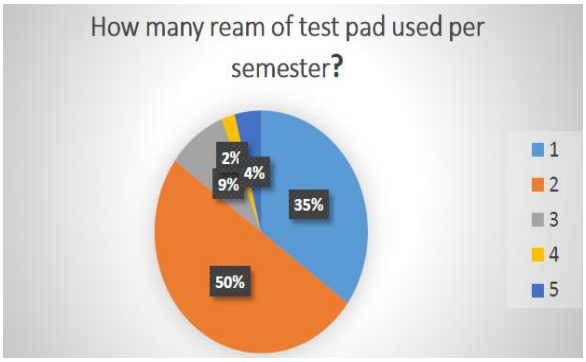

Fig. 3 Number of ream of test pad used by student per semester

IV. RESULTS AND DISCUSSIONS

From the data collected, calculation of CO2 emissions is done using equation (1) and performed in the Excel template. The results are then tabulated in Table 2 and Figure 4:

Table. 2 Total CO2 Emission for each activity data

Activity Data	Type	Amount spent per year (approximately)	Total CO2 Emission per year (approximately)
Transportation	Petrol	2,000,000 L	4,500,000 kg CO2 e
	Diesel	55,000 L (ratio is considered)	
Electricity	Malaysia (commercial rate)	2,000,000 kWh (ratio is considered)	200,000 kg CO2 e
Paper Consumption	Closed Loop Source	9,000 kg	6,200 kg CO2 e
Water Consumption	Water Supply	1,300,000 m^3 (ratio is considered)	310,000 kg CO2 e
TOTAL CO2 EMISSION PER YEAR			**5,016,200 kg CO2 e**

From Table 2, it can be seen that the total carbon footprint for COE students per year is approximately 5 millions kg CO_2 e. To get the carbon footprint for each student, this amount is divided into the total students of COE. As the result, each student will produce approximately 1,400 kg CO2 e. Comparing all the activity data, the highest CO_2 emission comes from transportation, followed by water consumption and electricity, while the least is from paper consumption.

V. CONCLUSIONS

All in all, the model for calculating the carbon footprint has been developed for COE, UNITEN. This preliminary calculation or model can be employed as an example for calculating the carbon footprint for other colleges in UNITEN. It is also recommended that the carbon footprint for both campuses of UNITEN to be calculated by using this model template. The results also show that the total carbon footprint for COE students per year is approximately 5 millions kg CO2 e, while each student of COE produces approximately 1,400 kg CO2 e. From this data, ways to reduce the CO2 emission can be proposed and done so that total carbon footprint can be reduced, hence reducing the effect of global warming. Among the things that can be done to reduce this numbers is by using energy efficiently, reduce the dependency on travelling with vehicles (might use bicycle or walking), use electricity and water wisely (more on awareness) and many more. As a recommendation, the research must be continued in order obtain carbon emission for the whole university by including all students and staff in the calculation. Once it is done, the model can be used to calculate the carbon emission per year and per capita.

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