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Vehicle Kilometers Traveled (VKT) for Campus Population: Case study of UiTM Main Campus

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Abstract
Vehicle kilometers traveled is the distance travel by vehicles in a specific area during a given period of time. The aim of this study is to estimate the carbon emission produced by vehicles using VKT data. This study was conducted via online questionnaire survey. The findings have shown the VKT of UiTM campus population are in the range of 0.6 to 3.7 km/day and the highest mode of transportation used by students and staff are private vehicles which contribute 85.01 kgCO_2 for a week's trip.

Keywords: Vehicles Kilometers Traveled, Carbon Footprints, Green Campus, Travel Pattern

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1.0 Introduction

According to the Paris Agreement, Malaysia has committed to reducing greenhouse gas (GHG) emissions by 45 percent by 2030 in comparison with our 2005 gross domestic product (GDP) and transportation is one of the most important sectors for reducing GHG emissions to help Malaysia meet its commitments under the Agreement. Transportation contributes directly to five targets from Sustainable Development Goals (SDGs) which focus on road safety in ensuring a healthy life and promoting a well-being for all at all ages. Besides, the rate of improvement in energy efficiency is expected to accelerate by 2030, which could result in increased access to safe, affordable, and easily accessible sustainable transportation systems, as well as the expansion of public transportation, as stated in Goal number 11 of the Sustainable Development Goals. Moreover, infrastructure should be well developed in terms of their quality, reliability, and sustainability to support economic development and human well-being. SDG 12 was highlighted as ensuring sustainable consumption where it could reflect environmental impact.

Universiti Teknologi MARA (UiTM) is Malaysia's largest university in terms of both size and population, and it is also the country's most comprehensive university system. UiTM pledges to attain a low carbon campus status by the year 2030 and effort should be taken from various angles and involve the whole campus population to ensure a greener campus for all. Transportation sector is one of the main causes of the production of carbon emissions. High levels of pollutants have been emitted as vehicles release carbon dioxide into the atmosphere and lead to climate change. Climate change caused by carbon dioxide emissions is the most challenging environmental

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problem in recent years and needs to be addressed immediately. Therefore, this study aims to measure the carbon emission produced by vehicles from UiTM campus populations. This data will be very useful as input values to UI-Green Metric World University Ranking criteria.

2.0 Literature Review

The global transportation sector is a major source of air pollution and in 2020 produced approximately 7.3 billion metric tons of carbon dioxide emissions. The carbon emission produced by the transportation sector depends on a vehicle's fuel, fuel economy and the vehicle kilometers traveled per year. Environmental Protection Agency of United States (EPA) modeling system provides emissions coefficients for carbon dioxide with units of kg per kilometer and a study found a relationship between distance traveled and emissions for a specific vehicle type, and that distance traveled for each vehicle type is an important parameter to measure the emission produced. A way of estimating carbon emissions mass for a particular vehicle type is by multiplying the distance traveled by its expected emissions coefficient (Goodchild et al., 2018). The vehicle emission is measured based on the number of vehicles used by students and staff, the kilowatt hour per meter square, the amount and types of fuels used for transportation (Delre et al., 2018). Cars with diesel contributed the highest greenhouse gases compared to petrol cars and electric cars (Muhammad Saifuddin et al., 2019). Table 1 shows the CO2 emission factor by transport mode.

Table 1: CO_2 Emission Factor by Transport Mode

Transport mode	CO_2 emission factor (g/person*km)
Car	163.2
Motorcycle	66.8
E-bike	15.3
Taxi	222.6
Bus	38.0
Non- motorized transport	0

(source: Wei & Pan, 2017)

Estimating Vehicle Kilometers Traveled can be using various methods for example Odometer Reading and Navigation Software. The odometer reading method is the regular method categorized under traffic measurement methods that can measure the exact distance of the vehicles traveling on the road. According to (Nurulhuda et al., 2020) in their study on getting data by an online survey that the respondents need to fill in the first odometer reading and second odometer reading to calculate the difference and estimate the distance. Shabadin et al., (2017) suggested a different method in obtaining the odometer reading using data from a car manufacturer to determine kilometers traveled of vehicles. The data were collected from the headquarters of different brands of vehicles such as Proton, Toyota and Perodua. Every service center will record the information from the vehicles that come to service at their center. However, there is a high chance of getting data errors such as notation error, reading error and vehicle drop-out by this method (Hossain & Gargett, 2014). The largest free community -based traffic and navigation app that uses floating car data (FCD) obtained from a driver's or passenger's smartphone to generate real -time traffic information like Google Maps. Both Google Maps and Waze rely on a simple request/response protocol, in which the smartphone client application sends periodic messages to the application server with its current position obtained from the phone's GPS receiver (Hossain, 2018). Since getting the right directions is a must when travelling and this application also helps in determining the shortest path along with travel time to that destination. Besides, these applications also provide real-time information on traffic accidents, speed limits, speed traps, and other trip information. In addition, Google Maps has support for public transportation, walking and cycling. Most of the GPS tracking companies start getting traffic data from FCD such as the number of vehicles, durations of journey, spot speeds, details on origins and destinations, and detection of an incident (Basyoni, 2016). Global Positioning System (GPS) data capturing is a new initiative to obtain the VKT which possibly helps to overcome the limitations when using regular methods such as odometer reading and traffic count data (Fan et al., 2019).

A high reliance on private vehicles causes traffic congestion on university campuses. A study conducted by Samsuddin et al. (2021), suggests several programs such as reduction in travel time and service dependability for bus and promote the usage of electric bicycles that will provide a more environmental friendly and cost-effective mode of transportation around campus and offering more strategic walkways, expanding the walking route, and giving more covered walkways are some of the recommendations to promote walking lifestyle in campus and lowers the use of motorized vehicles for travel. Another study identified why students choose to drive personal vehicles to campus rather than bicycling, walking, or taking the bus and examine the methods to enhance the implementation of sustainability modes of transportation (Fund et al., 2012). Several programs can be implemented to promote sustainable transportation on campus such as enhancing the visibility and accessibility of campus bike lanes, the cost of parking passes on campus is being increased to encourage students to use other modes of transportation, flexible parking for carpoolers, increasing the efficiency of bus services and encouraging alternative modes of transport.

3.0 Methodology

The data collection requires two (2) primary methods namely secondary and primary data collections. Secondary data obtained from secondary sources (published data, data compilation from UiTM, etc.). The major sources of primary data obtained from Online

Questionnaire survey that was distributed via google form for a month. The questionnaire comprises four (4) sections —respondent's demographic profiles, travel patterns and mode of transport from and to campus, respondent's perception on sustainability attributes and the recommendation programs to promote UiTM as a green campus. The sections were designed to meet the objectives of study. The data was analysed using visual methods (google maps) and simple statistical tools (SPSS). The data was presented in various patterns such as tables, charts and graphs to show the frequencies and trends of the data obtained. The amount of carbon emitted by UiTM population is calculated based on established modeling as Formula 1 and emission factors as in Table 2 below;

Formula 1 - *CO2 Emission = Distance Travel Frequency Travel x Emission Factors*

Table 2: Emission factor by vehicle type

Vehicle type	Emission factor
Petrol	0.24234 kgCO_2e/km
Diesel	0.22428 kgCO_2e/km
Hybrid	0.16170 kgCO_2e/km
Motorcycle	0.14238 kgCO_2e/km
4x4	0.31529 kgCO_2e/km
Sports	0.29024 kgCO_2e/km

(source: Delre et al., 2018

Scope and limitation

The study area covers UiTM Shah Alam main campus populations. Based on the survey tool, Raosoft, the targeted sample size for this survey is 382 respondents with a population of students and staff of 47,717 and 4,762 respectively (Figure 1). However, the following data analysis is based on 100 populations due to the limitation that this study was conducted during pandemic Covid-19 and some restriction movement of student and staff were applied. The VKT data is only measured when the respondent is travelling within campus with a start and end point at the dedicated gate according to zone.

Figure 1: Schematic map of UiTM main campus

4.0 Findings & Discussion

The **demographic profile** of the respondents shows that 54% of the male and 46% female respondents participated in this survey, with age ranges from 18-35 years (78%), 35-55 years (21%) and only 1% age above 55. They are 24% resident (staying in the college) and the remaining 76% are non resident.

Table 4: Travel Information

Item	Particular	Frequency	Percentage
Mode of transportation	Private car	52	52
	Motorcycle	25	25
	Bus	18	18
	E-hailing	5	5
	Total	100	100
Starting point	Gate A	43	43
	Gate B	57	57
	Total	100	100
Frequency to campus	Once a week	17	17
	Twice a week	17	17
	3 times a week	12	12
	4 times a week	19	19
	More than 5 times a week	30	30
	Once in a while	5	5
	Total	100	100
Type of fuel used	Petrol	82	82

	Diesel	18	18
	Total	100	100
Navigation software used	Yes	59	59
	No	41	41
	Total	100	100

The trend of **travel information** for both students and staff indicated that 52% respondents use private cars as their primary mode of transport to campus, 25% use motorcycles and the rest prefer public transport such as bus and e-hailing. By fuel used, the trend shows that 18% used diesel and 82% petrol fuel. The total carbon emissions emitted can be calculated through the emission factor according to the type of vehicles and fuel used. For the frequency of going to campus per week, the data shows 30% travel more than 5 times followed by 19% travel 4 times, 17% travel two and only 5% travel occasionally. From the analysis, 59% agreed that the navigation software can be used to plan their trip (Table 4)

The mode of transportation used by students and staff were categorized into five (5) groups—private car, motorcycle, bus, bicycle and e-hailing. Most students prefer to go to campus with their private car as probably most of them stay outside and far from UiTM Shah Alam and 27.54% of students prefer to travel by motorcycle to campus which is more convenient and can avoid traffic jams in the peak hours. 22 out of 69 students have chosen to use public transportation such as buses and e- hailing to campus. Total **carbon emission** emitted by students for a week travel within UiTM Shah Alam campus area calculated was 39.41 $kgCO_2$. We can draw the conclusion that petrol-using private cars produce the most CO_2 with 17.53 $kgCO_2$ followed by CO_2 emissions from buses which contribute 11.60 $kgCO_2$ to the environment. Referring to Table 6, 96.77 percent of staff drive their own vehicles to work and only one percent used e-hailing to get to campus. It is possible that this is the case because most staff are already married. As a result, having access to private transportation is important to them because some of them need to pick up and drop off their kids at school and others need to arrive at work on time. Besides, it may be because it is convenient for the staff to travel from one zone to another zone within the campus to attend different classes since each faculty is located quite far from one another. The total carbon emissions emitted by staff for a week's trip within the UiTM Shah Alam campus area is estimated at 45.60 $kgCO_2$. It can be concluded that even the number of students higher than staff in this survey, but the staff generates more carbon emissions than students because the staff is more frequent go to the campus (Table 5, 6)

Table 5: The total carbon emission emitted by students' transportation

Type of vehicle	Fuel Type	Proportioned samples (%)	Number of users	Carbon Emission ($kgCO_2$)
Private Vehicle	Car-Petrol	40.58	28	17.53
	Car-Diesel	-	-	-
	Motorcycle-Petrol	27.54	19	8.07
Public Transport	Bus	26.09	18	11.60
	E-hailing	5.80	4	2.21
Total		**100**	**69**	**39.41**

Table 6: The total carbon emission emitted by staffs' transportation

Type of vehicle	Fuel Type	Percentage (%)	Number of users	Carbon Emission ($kgCO_2$)
Private Vehicle	Car-Petrol	77.42	24	38.40
	Car-Diesel	-	-	-
	Motorcycle-Petrol	19.35	6	5.65
Public Transport	Bus	-	-	-
	E-hailing	1.00	1	1.55
Total		**100**	**31**	**45.60**

Cross tabulation analysis

The relationship between the entrance gate and the destination of UiTM Shah Alam population is shown in Fig. 3. UiTM Shah Alam campus has 2 entrance and exit gates and the travel destination is divided into four zones as shown in the schematic map above. The number of students and staff using gate A was 43. In total, 27 students and staff went to zone A, 6 to zone B, 10 to zone D, and none to zone C. However, 57 students and staff enter the campus through gate B. School of Engineering located in zone A and most of them prefer to use gate B for the entrance. This is because the travel distance measured by Google Maps shows the distance traveled to the School of Engineering from gate B is closer than gate A. Anyone using gate B has to travel 0.8 km while gate A is 1.4 km. In contrast to the faculty of law, which is located in zone D, the distance of the location from gate A is 1.6 km and gate B 3.4 km. It can be inferred that the distance traveled by students and staff to reach their destinations is measured and based on the entrance they use because some places are closer if you use gate A and vice versa.

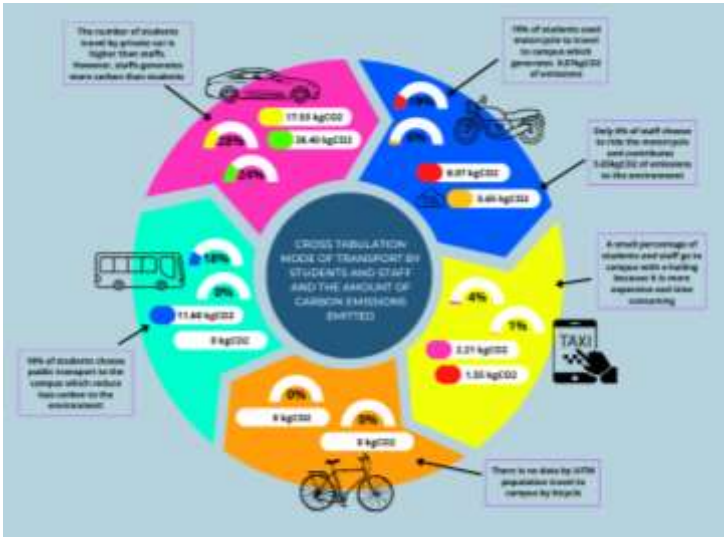

Figure 4: Cross tabulation between mode of transportation and the amount of carbon emission

It used to analyze and understand the correlation between three variables which are population categories, mode of transport and amount of carbon emissions emitted. From this analysis, it can be concluded that 28 percent of students and 24 percent of staff travel to campus by private car. Staff generates more carbon because they travel to campus more frequently than students. Moreover, 19 percent of students and 6 percent of staff ride the motorcycle to campus while 18 percent of students choose public transportation to get to campus and no staff travel by buses. For e-hailing services, only 4 percent of students and 1 percent of staff used it. Lastly, bicycle is not an option as transportation for UiTM Shah Alam population even though it is the most sustainable mode of transportation which produces zero carbon to the environment (Figure 4)

About 70% of respondents agreed to encourage active mode transportation such as cycling and walking because it is known as the most sustainable mode of transportation that can reduce the number of vehicles in campus areas and indirectly control pollution. A total of 50 students and 18 staff also suggested improving the efficiency and increasing the frequency of the public transport system. The punctuality of the bus schedules and poor comfort levels are the most common issues for bus users. This problem usually occurs during peak hours where students must wait a long time for the bus to arrive. Sometimes, the bus capacity is insufficient and too crowded during the morning rush hour, so they must wait for another bus which causes students to be late to class. This is also the reason why students prefer to use private vehicles rather than public transport. 61% of respondents agreed with the recommendation for campus to provide more covered walkways because the most frequent issue encountered when walking on campus is the lack of a covered walkway particularly when moving between zones thus can promote walking lifestyles in campus. Besides, half of the percentage admit that by introducing carpooling and providing e-scooter or e-bicycle for UiTM campus population can reduce carbon footprint, use less fuel and save time, cost and environment (Figure 5).

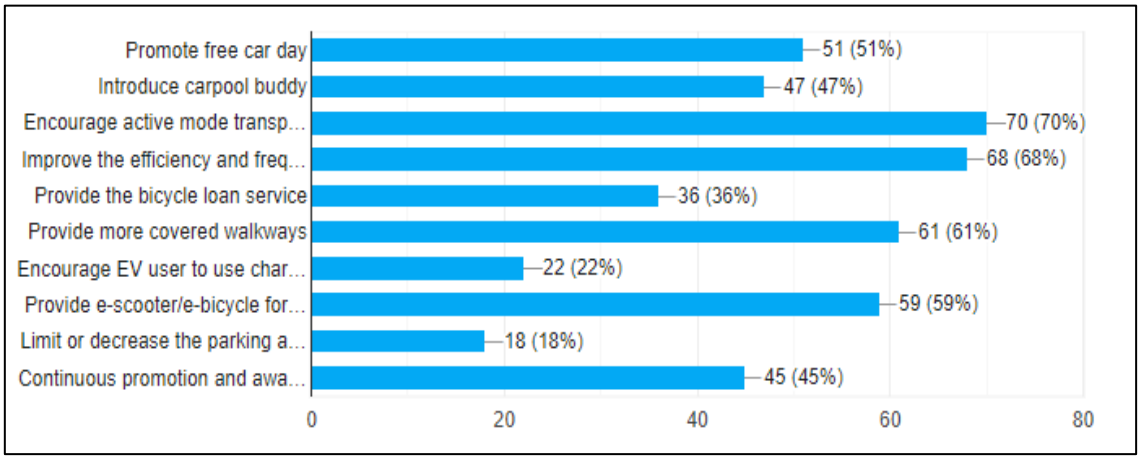

Figure 5 Recommendation of program to support zero emission initiatives

6.0 Conclusion & Recommendations

Overall, this study has identified the vehicle kilometers traveled and the travel pattern by UiTM Shah Alam population. The distance was estimated from Google Maps by measuring the location from the entrance gate and the destination of the respondent. From the data analysis, it can be concluded that the distance traveled from gate A in the range of 0.6 km to 2.9 km while for gate B in between 0.7 km to 3.7 km. The distance is then used to find out how much carbon is released in the campus area. The total emissions released by UiTM Shah Alam population for both students and staff are 85.01 kgCO2 for a week's trip. The highest mode of transportation used by students and staff are private cars which also contribute the largest emissions with the emission factors of 0.24234 kgCO2e/km followed by emission from buses which use diesel. Diesel fuel has a slightly higher carbon content than petrol but tends to have lower overall carbon emissions. Diesel engines have a higher compression ratio than petrol engines and are more efficient than petrol engines, so they emit less CO2 and greenhouse gasses than petrol engines. Besides, the travel pattern of the students and staff of UiTM Shah Alam campus can be identified. It is important to know which zones are the most visited by the UiTM Shah Alam students and staff. All the programs recommended encourage UiTM Shah Alam students and staff to improve air quality as well as improve their transportation lifestyle to be more convenient and efficient such as use public transport, carpooling which produce low carbon or practice sustainable way of commuting such as cycling and walking as the main transportation option since it is not generating any carbon emissions. All the objectives of this study have been successfully achieved.

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