Calculating Of Carbon Emission Of Vehicles On Campus Universitas Negeri Surabaya

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Abstract. The use of fossil fuels in motorized vehicles to meet the needs of human movement, causes motorized vehicles become a producer of more than a quarter of the world's carbon dioxide (CO_2) and a contributor to the formation of carbon gas emissions globally. Total population of Unesa campus consists of regular students and the total number of academic staff and administrative staff was 19,908 people who have the characteristic of choosing the mode of travel for campus residents to Unesa was using motorized vehicles. It was necessary to calculate the amount of CO_2, CH_4 and N_2O exhaust gas emissions produced by vehicles inside the Unesa campus.
Primary data from the observation of vehicle volume and distance of gate to the parking area were calculated with descriptive statistics. Statistical data was used to calculate the vehicle's CO_2, CH_4 and N_2O emissions.
The total CO_2 emissions produced by vehicles were 137,383.9 tonsCO_{2eq}. The CO_2 emission ratio of the entire campus population was 6,901 metric tons per person, which was in the category > 2.05 metric tons. Based on the UI Green Metric assessment, the Unesa campus received an O rating. Unesa was expected to increase energy efficiency efforts on campus and care about energy sources and the surrounding environment more.

Keywords: vehicle volume, carbon emissions, UI Green Metric.

1 Introduction

More than a quarter of the world's carbon dioxide (CO_2) emissions are in the transportation sector, especially motor vehicles. This condition is a contributor to the formation of greenhouse gases globally [1]. The characteristics of choosing the mode of student travel to campus are motorcycles, private cars and public transportation [2].
Motorcycles are the ideal mode of transportation for students due to of time optimization. The use of motorcycles can avoid congestion, ease in finding parking on campus, cheap travel costs, and speed in reaching goals [3]. A preliminary survey at Unesa

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showed that 15 respondents stated that 67% of students used motorcycles when attending and doing activities on campus. Students prefer to use vehicles for the reason of the speed of time to arrive at their destination, Refusing to feel hot. 33% of respondents are more comfortable walking because it is near residences, boarding house or dormitory and does not have a vehicle due to physical limitations.

The larger the number of motor vehicles, the more gas emissions will be produced [4]. With the increase in the number of students in 2019 from 1129 students to 18718 students in 2023, it is necessary to calculate the amount of CO_2, CH_4 and N_2O gas emissions produced by vehicles inside the Unesa.

Unesa pay attention to Sustainable Development carried out in the Unesa campus environment. This condition is proven by the UN SDGs Impact Ranking, a ranking agency that measures university performance based on the UN Sustainable Development Goals (SDGs), Times Higher Education (THE) Impact Ranking, which states that UNESA achieved 14th National ranking on May 1, 2022 [5] and on June 2, 2023, [6] THE Impact Ranking: SDGs said that UNESA was ranked 5th nationally. This is proof of the global and national commitment that Unesa has made in an effort to improve the welfare of the community.

A world university rankings in 2010, was initiated by Universitas Indonesia (UI) later known as UI GreenMetric World has concern for universities' efforts and impacts to improve campus sustainability and Sustainability Development Goals [7]. In the Energy and Climate Change (EC) indicator submitted at point EC 8, it is mentioned about the ratio of total carbon footprint divided campus population. The results of the ratio will then be ranked to show the assessment of efforts to reduce carbon footprint on campus.

2 Methods

2.1 Data

This study uses a quantitative research method. Primary data using the traffic accounting method [8] is used to determine the volume of vehicles. Statistical data is needed to calculate the amount of gas emissions on the Unesa campus obtained from recording the volume of vehicles during learning day, to find out the number of vehicles parked in the Unesa parking area on weekdays, along Monday to Friday, in units of motor vehicles. The next survey is the measurement of the distance traveled by each parking area to the campus entrance gate. The distance of the entrance gate to the parking area is measured to determine the distance traveled by the vehicle

2.2 Equation

The volume of the vehicle and the distance obtained are multiplied by the fuel consumption level of the motor vehicle [9], then the total fuel used is obtained.

$$Fuel = \sum_{ij}(V_{ij} \cdot Di_{ij} \cdot C_{ij}) \ldots\ldots\ldots\ldots \quad (1)$$

$Fuel_a$ = Fuel used (Lt)
V_{ij} = sum of vehicle (vehicle unit)
D_{ij} = distance (km)
C_ij = average of vehicle comsumption (Lt/km)

To obtain CO_2, N_2O, and CH_4 emission values, vehicle emissions are calculated. Motor vehicle fuel consumption data, converted to CO_{2eq} under normal conditions [9], with the formula:

$$Emission = \sum_a(Fuel_a \cdot EF_a) \ldots\ldots\ldots \quad (2)$$

Emission = Emission CO_2 (kg)
$Fuel_a$ = Fuel used (Lt)
EF_a = Emission Factor (kg/GJ)
a = fuel type

The amount of fuel consumption is multiplied by the emission factor of each type of fuel as displayed in Table 1. Energy conversion uses the Global Warming Potential (GWP) value by converting non-CO_2 emission data into CO_2eq emission data (Table 2). The GWP CO_2 value is 1, CH_4 from 72 fossil sources, and N_2O is 289.

Table 1. Emission factor CO2, N2O, and CH4

Fuel	**CO_2 (ton/GJ)**	**N_2O (g/GJ)**	**CH_4 (g/GJ)**
Pertamax (Gasoline)	0,069	5,00	0,60
Pertalite **CO_2**	0,070	5,00	0,60
Diesel (Solar)	0,074	5,00	0,60

Source: [10]

Table 2. GWP Value Conversion of Non-CO_2 Emission Data into CO_{2eq} Emission

Pollutans	GWP	Remark
	20-year	
CO_2	1	
CH_4	72	Fuglestvedt et al. (2009)
N_2O	289	IPCC (2007)

2.3 Data Analysis

The calculation results obtained are the sum of CO2 emissions, CH4 emissions and N_20 emissions in kgCO_{2eq} units. The results of the calculation of total carbon emissions,

then divided by the total campus population (metric ton per person), which consists of the total number of regular students and the total number of academic staff and administrative staff [7]. The results obtained are the emission ratio of the entire campus population, assessed according to Table 3.

Tabel 3. Energy and climate change

Category	Skor (Total 300)
> 2.05 metric ton	0
> 1.11 – 2.05 metric ton	0.25 x 300
> 0.42 – 1.11 metric ton	0.50×300
0.10 – 0.42 metric ton	0.75×300
< 0.10 metric ton	1.00×300

3 Results and Discussion

Observation activities are carried out in the morning, afternoon and evening during active days resulted volume of vehicles on campus. Result shows that campus residents use the most motorcycle (MC) on average as many as 4749, light vehicles (LV)/ cars as many as 765 and 20 heavy vehicles.

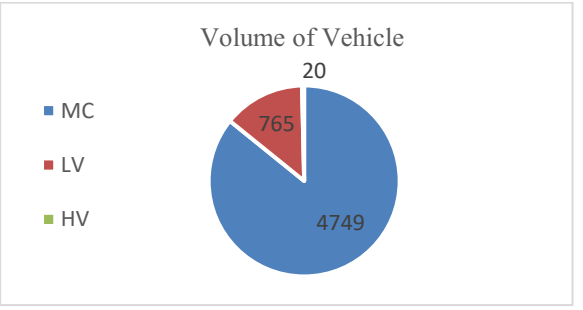

Fig. 1. Pie chart of volume of vehicle

3.1 Vehicle Distance

Vehicles enter Unesa through the main gate on the east (Gate 1), Lidah Wetan Gg.7, Lidah Wetan Gg.5 (Gate 2) and the West Gate. All gates can be crossed by motorcycles and cars except for the Lidah Wetan Gg. 7, which can only be passed by motorcycle. Assume the vehicle enters from a different position, the distance from the gate to the parking area also has a different distance. The distance by the gate to the parking area as displayed in Table 4.

Table 4. Vehicle distance from gate to parking area

Distance traveled by motorcycle (meters)							
Name	A	B	C	D	E	F	G
Gate 1	336.15	392.73	484.63	535.93	883.81	962.14	985.6
Gate 2	744.56	706.53	615.33	563.35	340.14	262.42	524.59
Distance traveled by light/heavy vehicles (meters)							
Name	A	B	C	D	And	F	G
Gate 1	292.83	392.73	484.63	626.23	782.53	944.61	985.6
Gate 2	789.51	706.53	615.33	470.76	473.77	479.6	524.59

There are 2 different tables, due to the location diference of the gate to the motorcycle and light/heavy vehicle parking area. From table 4, it can be seen that the farthest distance is gate 1 to the motorcycle and light/heavy vehicle parking area G as far as 985.6 meters, while the closest distance from gate 1 to the the light/heavy vehicle parking area A is 292.83 meters.
The condition of the parking area and the distance of the gate to the nearest parking area to the building are known. Furthermore, gas emissions produced by vehicles [12] on the Unesa campus are calculated.

3.2 Vehicle Emission

The average fuel consumption, using formula (1) used by vehicles in Unesa campus as showed in Fig. 2. Motor Cycle have the largest fuel consumption due to the large volume.

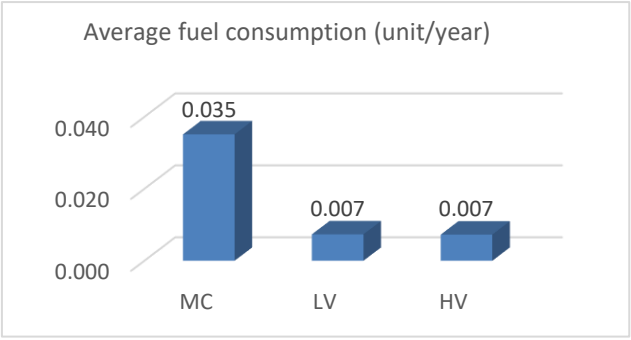

Fig. 2. Fuel Consumption

The calculation of vehicle CO_2 emissions, using formula (2), is the amount of emissions produced by vehicles on the Unesa campus, can be seen in Fig. 3. CO_2 emissions are the largest emissions compared to CH_4 and N_2O emissions. For all motor vehicles, the

total CO_2 emissions reached 77,487 tonsCO_{2eq}, CH_4 emissions reached 40,425 tonsCO_{2eq}, and N_2O emissions reached 19,472 tonsCO_{2eq}. Total emissions are 137,383.9 tonCO_{2eq}.

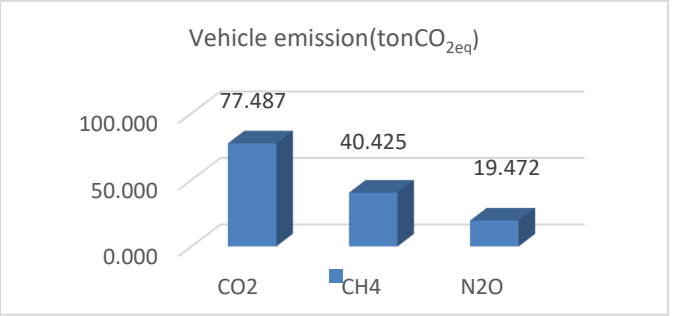

Fig. 3. Emission CO_2 produced by vehicle

The results of calculating the total CO2 emissions of vehicles on the Unesa campus are then divided by the total population of campus residents (UI Green Metric, 2018). The total population consists of regular students and the total number of academic and administrative staff at Unesa is 19,908. The result of the CO2 emission ratio of the entire campus population is 6,900939 metric tons per person. From the UI Green Metric carbon footprint assessment, the CO2 emission ratio is in the category > 2.05 metric tons, with an O rating. Based on the recommendations UI GreenMetric [7], the university is expected to increase energy efficiency efforts on campus and care about energy sources and the surrounding environment more. Unesa is expected to be able to support one of the 13th SDGs programs, Climate Change Management, through handling the reduction of gas emissions from vehicle [13].

4 Conclusion

The total CO_2 emissions produced by vehicles on Unesa reached 77,487 tons of CO_{2eq}, CH_4 emissions reached 40,425 tons of CO_{2eq}, and N_2O emissions reached 19,472 tons of CO2eq. Total emissions of 137,383.9 tons of CO_{2eq}. The CO_2 emission ratio of the entire campus population is 6.900939 metric tons per person, in the category of > 2.05 metric tons. Based on the recommendations UI Green Metric, Unesa received an O rating. It is expected that Unesa will increase energy efficiency efforts on campus and care about energy sources and the environment more.

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Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Shahid, S., Minhans, A., & Puan, O. C. 2014. Assesment of Greenhouse Gas Emission Reduction Measures In Transportation Sector Of Malaysia. Jurnal Teknologi. 70 (4): 1-8.
2. https://www.researchgate.net/publication/265554054_Assessment_of_Greenhouse_Gas_Emission_ReductionMeasures_in_Transportation_Sector_of_Malaysia
3. Hasnianto, R. 2016. Studi karakteristik dan pemilihan moda angkutan mahasiswa dalam menuju kampus di universitas islam sultan agung semarang. Fakultas Teknik Universitas Negeri Semarang.
4. http://lib.unnes.ac.id/42808/1/5113416012%20-%20Riko%20Z98.pdfAuthor, F.: Article title. Journal 2(5), 99–110 (2016)
5. Bagus, G., Wicaksana, A., & Prabawa, S. 2019. Pemilihan Moda Sebagai Dasar Perencanaan Transportasi Ideal Masa Depan Bagi Mahasiswa Pada Wilayah Perkotaan. SENADA (Seminar Nasional Manajemen, Desain Dan Aplikasi Bisnis Teknologi), 2, 443–449. https://eprosiding.idbbali.ac.id/index.php/senada/article/view/226
6. Seo, Y., & Kim, S. M. 2013. Estimation Of Greenhouse Gas Emissions From Road Traffic: A Case Study In Korea. Journal of Elsevier Renewable And Sustainable Energy Reviews. 28: 777-787. https:// DOI:10.1016/j.rser.2013.08.016
7. Tiga SDGs Unggulan Masuk 10 Besar Bawa UNESA Duduki Rank 14 Nasional. https://unesa.ac.id/tiga-sdgs-unggulan-masuk-10-besar-bawa-unesa-duduki-rank-14-nasional
8. THE Impact Ranking: SDG5 UNESA Peringkat ke-5 Nasional. https://www.unesa.ac.id/the-impact-ranking-sdg5-unesa-peringkat-ke-5-nasional
9. UI Green Metric, 2018. UI GreenMetric World University Ranking.Universities,Impacts, and Sustainable Development Goals (SDGs). https://greenmetric.ui.ac.id/
10. Wulandari, N. W, Ariyaningsih & Yorika, R., 2021. Analisis.Jumlah Emisi CO2 Kendaraan Bermotor.padasKoridor Jalan Pada Jam.Puncak di.Kelurahan.KlandasannIlir, Kecamatan Balikpapan Kota, Kota.Balikpapan. Jurnal Penataan Ruang Vol. 16, No. 1, (2021) ISSN: 2716-179X (1907-4972 Print). https://iptek.its.ac.id/index.php/jpr/article/view/7916.
11. Prasetya, Galih Budi. 2017. Alternatif Pengurangan Emisi Gas Rumah Kaca Dari Kendaraan Bermotor Di Universitas Negeri Malang. Magister Thesis.Universitas Brawijaya.
12. Keputusan Menteri Energi dan Sumber Daya Mineral Nomor 163.K/HK.02/MEM.S/2021 tentang Penetapan Faktor Emisi Gas Rumah Kaca Sistem Ketenagalistrikan
13. IPCC. 2007: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Inter-governmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA., XXX pp https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg3_full_report-1.pdf
14. Nurdjanah, Nunuj. 2015 Emisi CO_2 Akibat Kendaraan Bermotor Di Kota Denpasar Co2 Emissions From Vehicle In Denpasar. Jurnal Penelitian Transportasi Darat, Volume 17, Nomor 1, Maret 2015: 1-14. https://ppid.dephub.go.id/fileupload/informasi-setiap-saat/JURNAL_DARAT_2015.pdf.
15. SDGs Indonesia. 2023. BERANDA – SDGs Indonesia. https://sdgs.bappenas.go.id/