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Carbon dioxide estimation at Lampung University based on vehicle volume

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Carbon dioxide estimation at Lampung University based on vehicle volume

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Abstract. Of all activities related to carbon dioxide generation in Lampung University, vehicle exhaust is a main source of anthropogenic carbon dioxide (CO_2). Carbon dioxide (CO_2) may trap the earth's heat which worsens the climate change. As For the physical condition of humans, high concentration of CO_2 exposure may cause death, unconsciousness, convulsions and fetus damage. Even in lower concentration, CO_2 exposure can cause hyperventilation, vision damage, lung congestion, central nervous system injury, and other health problems. A case survey was conducted to measure CO_2 emission based on two type of vehicles; private car and motorcycle to obtain the number of vehicle entry per gate. A mathematical model was also used to estimate CO_2 production. Several factors such as fuel consumption, emission factor, and number of running per day (distance) were used as inputs. CO_2 emission in the next five years was also estimated using the same method by previously extrapolated the earliest 5 years population data of Lampung University. The result shows that motorcycles are responsible for 1.636 ton of CO2 emission or approximately 55% of the total CO2 emission in Lampung University. Meanwhile, cars contribute to 1.34 ton of CO2 emission or approximately 45% of the total CO2 emission. It was also estimated that Lampung University would have an increase in vehicle number by 7.81%.

1. Introduction

It is an undeniable fact that transportation sector has become one of the biggest contributors of greenhouse gas (GHG) emissions around the world [1]. Report from IPCC in 2007 stated that more than a quarter of carbon dioxide (CO_2), shares of methane (CH_4), and nitrous oxide (N_2O) around the world was caused by transportation [2].

Based on the stated above fact, countries around the world has started to formulate strategies to tackle the challenge of GHG. Bali Climate Declaration in 2007 is one of the committed ways that emphasized joint efforts of developed and developing countries on climate change [3]. Green Campus concept is one of committed actions taken by Indonesian government to tackle the climate change issue in a small platform, in this case, university level.

Lampung University, is one of several campuses in Indonesia that has committed to provide a long term environmental improvement within the campus community, proved by its participation in UI GreenMetric along with other universities around the world. The aim of this program is to trigger participating universities to: a) provide more green space as well as the development of sustainable energy by 15%, b) increase the effort for energy efficiency in their buildings by 21%, c) establish programs related to waste treatments by 18%, d) decrease water usage by 10%, while at the same time, increase conservation program, e) limit the number of motor vehicles in campus by 18%, and f) raise

awareness that university plays a vital role in creating a new generation that is sustainability-conscious.

By early 2018, Lampung University has a 70 Ha of area with 29,462 number of people including students, lecturers, and academic staffs. This number triggers high and active movement from one building to another with 82.5% of it includes vehicles. Therefore, a high consumption of fossil fuel is to be expected along with the CO_2 emission as the result of vehicle exhaust. Estimation of current CO_2 concentration from vehicle exhaust is essentially needed in order to build an efficient countermeasure.

Conducting this research, some objectives were set. Those are: (a) to estimate CO_2 concentration from vehicle exhaust in Lampung University, (b) setting futute planning for countermeasures of CO_2 emision in Lampung University.

2. Research Methods

The estimation of CO_2 in the Lampung University was based on the vehicle volume. In which the estimation was focused by the consumption of fuel from vehicle movement. Some data collection were needed. The estimation of CO2 was performed by the simple mathematical model based on the fuel consumption

2.1. Subject and study area

This research was performed on two types of vehicle: cars and motorcycles; within the area of Lampung University in 2018 with a case survey study using random sampling method. Eight (8) faculties were chosen to become control points, as they generate most vehicle movements, with three main entrances: Gate 1, Gate 2, and Gate 3; as starting points as seen in Figure 2.1.

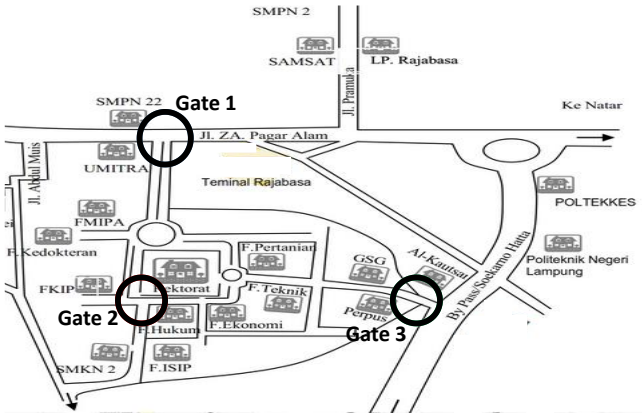

Figure 1. Layout of Lampung University.

2.2. Data collection

There are two types of data used in this study: secondary and primary data. Secondary data such as volume of vehicle was obtained from previous inventory study owned by Lampung University. Meanwhile, primary data: distance between gates and faculties and the number of vehicle entry per gate were obtained from the survey using random sampling method.

A time series of population number in Lampung University was also needed. The population data was used to predict the number of population within the next five years, by extrapolation. The plotting of population number in the next five years, helped to predict the vehicle population that may exist in Lampung University and its CO_2 emision.

2.3. Formula and equation

CO_2 emission concentration was estimated by calculating the number of vehicle movements in several faculty buildings with road segments connected to the entrance gates of Lampung University.

Approach was done [4] by classifying vehicles into motorcycles and cars with the fuel being used is petrol. Estimation of CO2 emission shall be calculated with Eq.1.

$$EM(CO_2) = FC \times EF_F \quad (1)$$

Where,
FC = Fuel consumption
EFF = Emission factor (kgCO2/L)

Value of emission factors were obtained by referring to emission conversion factors provided by DEFRA (2017) as shown in Table 1.

Table 1. Emission factor by fuel

Fuel	Emission Factor (kgCO2/L)
Petrol	2.1876
Diesel	2.57843

Source: [5]

As for Fuel Consumption (FC), it can be calculated using Eq.2. as stated below.

$$FC = A_C \times V \times R_D \quad (2)$$

Where,
A_C = average consumption of fuel by each type of vehicle (L/km)
V = number of each type of vehicle
R_D = amount of running per day/distance (km)

Oetomo, et al. (2006) used a table provided by IRMS (International Road Management System) to determine the average value of fuel consumption by each type of vehicle as seen in Table 2.

Table 2. Fuel consumption by each type of vehicle

Vehicle ID	Type of vehicle	Fuel consumption (L/km)
Veh 1	Motorcycle	0.02
Veh 2	Sedan/Jeep	0.09
Veh 3	Passenger vehicle	0.1
Veh 4	Goods distribution vehicle	0.1
Veh 5A	Small Bus	0.12
Veh 5B	Bus	0.2
Veh 6A	2 axis-light truck	0.15
Veh 6B	2 axis-mid truck	0.2
Veh 7A	3 axis-truck	0.3
Veh 7B	Trailer	0.3
Veh 7C	Semi-trailer	0.3

Source: [6]

3. Result and Discussion

3.1. Trip distance

This research taken into account just eight faculties as primary work units in Lampung University as trip destinations. Those faculties were: (1) Mathmatics and Science Faculty (FMIPA), (2) Education

Faculty (FKIP), (3) Medical Faculty (FK), (4) Agriculture Faculty (FP), (5) Engineering Faculty (FT), (6) Economics and Bussinees Faculty (FE) , (7) Law Faculty (FH). Trip distance was calculated with origin of trip were the three gates in Lampung University. The trip distance will influence how much the fuel was consume for the purpose of movement within Lampung University.

The longest distances from trips into those eight faculties were the trips from Gate 1. And the lowest distance were from Gate 3. The trip distance from Gate 1 were around 1 km until 1.3 km. While from Gate 3, the trips were around 0.4 km to 0.9 km.

3.2. Number of Vehicles in Lampung University

The number of vehicles in Lampung University is shown in Table 3 below. Based on the table, the vehicles in Lampung University was dominated by motorcyles with number of 20964 (86%) while private car was 3334 (14%).

Table 3. Number of vehicles at Lampung University in 2017

No	Destination	Number of Motorcycle			Total	Number of Private Car			TOTAL
		Student	Lecturer	Staff		Student	Lecturer	Staff	
1	FMIPA	3543	15	87	3645	48	124	26	198
2	FKIP	6100	39	104	6243	560	195	26	781
3	FK	557	5	32	594	324	60	40	424
4	FP	2236	101	104	2441	63	154	26	243
5	FT	2303	34	88	2425	178	130	20	328
6	FE	432	0	55	487	4	109	17	130
7	FH	1453	10	74	1537	795	95	14	904
8	FISIP	3402	61	129	3592	168	73	85	326
Total of Motorcylce					20964	Total of Private Car			3334

(Source: Lampung University inventory, 2017)

3.3. CO_2 Emision Estimation

Calculation of CO_2 Emision was performed based on Eq.1 and Eq.2 was shown in Table 4 and Table 5. It is estimated that motorcycles contribute to at least 1.636 ton/day of CO_2 emission or pproximately 55% of the total CO_2 emission in Lampung University. Meanwhile, cars contribute to at least 1.34 ton/day of CO_2 emission or approximately 45% of the total CO_2 emission as shown in Figure 2.

Table 4. Estimation of CO_2 emision from motorcyles

No	Destination	Rd (km)			Ac (l/km)	V			Total Vehicle	EM (CO2) Kg			TOTAL EMISION
		G1	G2	G3		G1	G2	G3		G1	G2	G3	(ton)
1	FMIPA	1	0,8	0,4	0,02	1761	737	1147	3645	81,189	27,189	21,147	0,130
2	FKIP	1	0,8	0,4	0,02	2497	1665	2081	6243	115,126	61,400	38,375	0,215
3	FK	1,3	1	0,6	0,02	208	79	307	594	12,460	3,651	8,489	0,025
4	FP	1,1	0,5	0,7	0,02	1261	529	651	2441	63,957	12,191	21,007	0,097
5	FT	1,1	0,4	0,7	0,02	808	916	701	2425	40,992	16,894	22,608	0,080
6	FE	1,4	0,8	1	0,02	244	73	170	487	15,716	2,694	7,858	0,026
7	FH	1,2	0,6	0,8	0,02	622	293	622	1537	34,417	8,098	22,945	0,065
8	FISIP	1,3	0,7	0,9	0,02	1967	599	1026	3592	117,890	19,320	42,582	0,180
Estimation of CO_2 motorclye comes into Lampung University (a)													0,818
Total CO_2 motorclye come and out from Lampung University (a*2)													1,636

Table 5. Estimation of CO_2 emision from private car

No	Destination	Rd (km)			Ac (l/km)	V			Total Vehicle	EM (CO2) Kg			TOTAL EMISION (ton)
		G1	G2	G3		G1	G2	G3		G1	G2	G3	
1	FMIPA	1	0,8	0,4	0,1	96	40	62	198	22,051	7,384	5,744	0,0352
2	FKIP	1	0,8	0,4	0,1	312	208	260	781	72,011	38,406	24,004	0,1342
3	FK	1,3	1	0,6	0,1	148	57	219	424	44,469	13,0315	30,298	0,088
4	FP	1,1	0,5	0,7	0,1	126	53	65	243	31,834	6,068	10,456	0,0484
5	FT	1,1	0,4	0,7	0,1	109	124	95	328	27,722	11,425	15,289	0,0544
6	FE	1,4	0,8	1	0,1	65	20	46	130	20,976	3,595	10,488	0,035
7	FH	1,2	0,6	0,8	0,1	366	172	366	904	101,213	23,815	67,476	0,193
8	FISIP	1,3	0,7	0,9	0,1	179	54	93	326	53,496	8,767	19,3232	0,0812
Estimation of CO_2 motorclye comes into Lampung University (a)													0,669
Total CO_2 motorclye come and out from Lampung University (a*2)													1,338

(Source: Analysis)

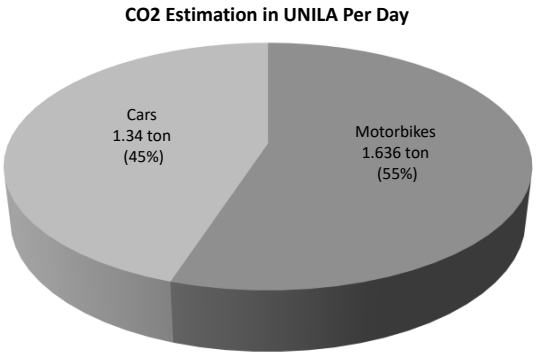

Figure 2. Percentage of CO2 emission each type of vehicles in Lampung University.

It also estimated that by 2023, Lampung University would sustain an increase in number of students. Thus, an increase of vehicle number shall be expected. Using linear extrapolation and the same calculation method that is based on the earliest 5 years data, it was estimated that Lampung University would an increase in vehicle number by 7.81%. Early countermeasure shall be efficiently planned and practiced in order to achieve a greener campus. Figure 3. shows the result of CO_2 emission estimation in present time and the next 5 years.

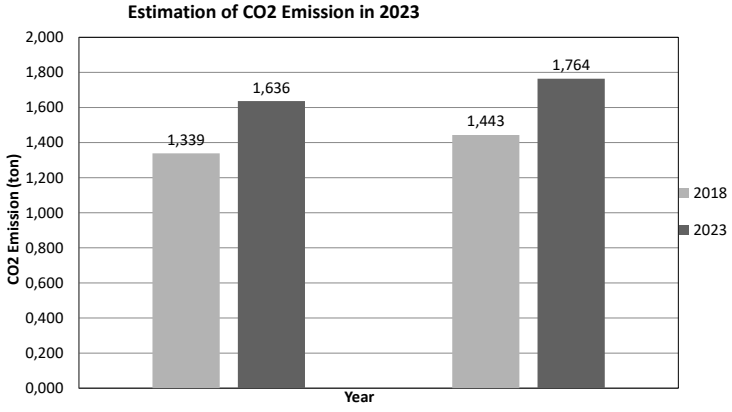

Figure 3. Estimation of CO_2 emission in UNILA (present time and the next 5 years)

Based on this result, an immediate future planning is needed to reduce the concentration of CO_2 emission. Centralized parking system for student's motorcycle can be a technical solution for this problem as it might reduce the running distance of vehicle. Hence, a decrease in CO_2 emission by is also to be expected. Figure 4. shows where the centralized parking system shall be located.

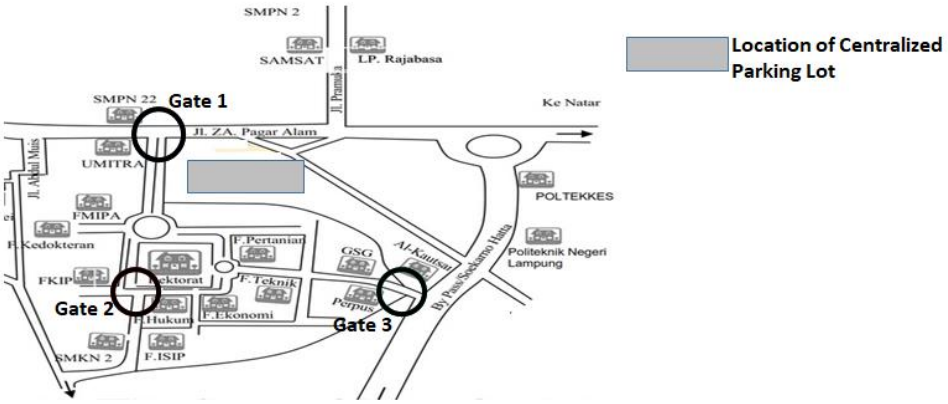

Figure 4. Expected location of centralized parking system

4. Conclusion

The vehicle movement in Lampung University was dominated by motorcyle with its number was around 20964. For private car, it was around 3334. By considering petrol as vehicle's fuel, CO_2 estimation finding showed that motorcycles contributed about 55% or 1,636 ton/day while cars created about 45% or 1,34 ton/day. The projection for the next five years shown that there will be 7.81% of vehicle increament with CO_2 emision were 1,764 ton/day for motorcyles and 1,443 ton/day for cars. Centralized parking system for student's motorcycle can be a technical solution for this problem as it might reduce the running distance of vehicle. Hence, a decrease in CO_2 emission by is also to be expected.

References

[1] Ghadimzadeh A., Makmom A. A., Hosea M. K. Asgari N., Shamsipour R., Askari A., *Review on CO2 Emission from Transportation Sector in Malaysia*, IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 9, Issue 5 Ver. I (May. 2015), PP 61-70

[2] IPCC, 2007. *Climate change, impacts, adaptation, and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change.* Parry, M.L., Canziani, O.F., Palutikof J.P., van der Linden, P.J., Hanson, C.E., (eds) Intergove.

[3] Allan, R. et al., 2007. [Online] Available at: http://www.climate.unsw.edu.au/news/2007-bali-climate-declaration-scientists. "*Bali Climate Declaration by Scientists"*. Climate Change Research Center, University of New South Wales, Sydney, Australia.

[4] Hidayat, E., 2013. *Sequestration of CO2 Emissions from Motor Vehicles Through Vegetation Technology on Road Side.* Jurnal Sosek Pekerjaan Umum, Vol. 5 No. 2 Juli 2013, p. 76 – 139.

[5] DEFRA, 2017. [Online] Availabe at: https://www.gov.uk/government/publications/green house-gas-reporting-conversion-factors-2017. UK Government.

[6] Oetomo et al., 2006. *Kajian Instrumen Pungutan Bagi Pengguna Jalan Untuk Dana Pemeliharaan di Provinsi Jawa Barat.* Jurnal Teknik Sipil Vol.13 No.1, p. 41-53.