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A Study of Assessment and Mapping of Carbon Footprints to Campus Activities in Hasanuddin University Faculty of Engineering

R Zakaria^{1*}, S H Aly¹, M Hustim¹, and A D M Oja¹

¹Department of Environmental Engineering, Engineering Faculty, Hasanuddin University, Makassar, Indonesia

*Email: rasdianazakaria@unhas.ac.id

Abstract. The Hasanuddin University Faculty of Engineering in Gowa is the largest engineering campus in South Sulawesi. The lecture activities are very complex which are not only teaching and learning but also households and offices activities. Therefore, it is important to know the mapping of existing carbon footprint on the campus due to the complexity of the campus activities. The purpose of this study is to determine the level and mapping of the carbon footprint on campus. The method used is to halve emissions into primary and secondary carbon footprint emissions. The results of this study indicate that the greatest emissions is generated from the secondary carbon emissions which is electricity consumption amounting to 1,315,429.63 KgCO₂/Year, and the lowest emissions is resulted from the use of paper at 49.39 kgCO₂/Year. For the buildings the highest CO₂ emissions is generated from the Architecture Department building at 289,176.26 KgCO₂/year and the lowest CO₂ emissions is generated from the Naval B Department building at 20,599.20 KgCO₂/year. The mitigation scenario in reducing CO₂ emissions effectively is by implementing Earth Hour for 1 hour every month which can reduce electricity consumption by 582,541.78kWh/Year and CO₂ emissions at 164,428.70 KgCO₂/year. The effective scenario to decrease waste is by implementing 3R with 2% waste reduction which is 167,332.79 Kg/Year and emissions CO₂ are 4,772.41 KgCO₂/Year.

1. Introduction

The carbon footprint is a general term used to describe the total amount of GHG emissions from responsible individual or organization. Each person contributes to GHG, thus everyone has a carbon debt that must be paid [1]. The more the human activity, the more energy is used so that the larger the carbon footprint. The carbon footprint refers to all human activities that cause carbon emissions and left trace in the earth. Environmental changes due to increase of the carbon footprint are caused by human activities, so the environmental recovery must be carried on by humans. Therefore, it is necessary to study human contribution to the carbon footprint of our daily activities. The goal is that humans can limit the amount of the carbon footprint produced and thus can help restore the living environment [2].



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The carbon footprint is often used as a reference to measure how much GHG emissions generated by activity or by a process of production of goods or services. Carbon footprint is defined as a measurement of human activity which impacts the environment determined by how many carbon emissions (by-product) resulted in increased GHG, usually counted in unit ton of CO₂ [3]. All activities such as electrical consumption (lights, kitchen utensils, razors, and electronic devices), daily garbage (organic waste, papers, bottles of mineral water (drinking water) and transportations (cars and motorcycles) can produce carbon dioxide (CO₂) [4].

Makassa¹⁰ metropolitan city located in South Sulawesi Province has a population of 1,469,601 inhabitants. The high number of people with a variety of activities will certainly affect the greenhouse gas emissions generated. According to the National Development Planning Agency (BAPPENAS), Makassar produces the biggest gas greenhouse despite being the most developed city in Indonesia, in terms of economy and infrastructure sectors. There is an increase of greenhouse gas emissions, which is more than quadrupled in the year 2020 [5]. The presence of universities in Makassar may contribute to the amount of greenhouse gas emissions, which has impact to the environment either direct or indirect.

Activities that occur in the campus are extremely complex such as learn⁵g activities, administrations, usage of laboratories, and others [6]. But it is not yet known how the amount of greenhouse gas emissions produced in the educational institutions and the spread of emissions at universities. Educational activities, similar to office and household activities have the potential producing greenhouse gas emissions [7]. For example, Hasanuddin University Faculty of Engineering has buildings that have activities, such as the use of LPG, electricity, vehicles, and garbage. This research could be a reference for Gowa Campus of Hasanuddin University to become an eco-green campus.

¹¹ Based on this background, the research was conducted to determine the emissions of CO₂ from the campus activities where the study area is Gowa Campus of Hasanuddin University Faculty of Engineering. Therefore, the authors take the title "A Study of assessment and mapping of carbon footprints to campus activities in Hasanuddin University Faculty of Engineering"

2. Methodology

¹² This research was conducted at the campus of the Hasanuddin University Faculty of Engineering in Jl. Malino Km 6 Bontomarannu, Gowa and was held on 4 until 13 March 2019. This campus has 10 buildings in total. This study was conducted for seven days of research in which two days to do a collection of electronic equipment in every building, the use of paper and usage Petroleum Liquefied Gas (LPG), waste generation, and five days to calculate the amount of traffic volume at 07:00 to 18:00 pm. This research is a descriptive study which requires data to be obtained directly or indirectly. The primary data in this study were obtained from direct data collection and interviews in the field. The primary data are as follows:

- Use of electronic tools such as lights, air conditioners, mobile phones, laptop, workstations, refrigerators, fans, LCD monitors, photocopy machines, printers, water dispensers, rice cookers, TVs, electric stoves, and servers.
- Papers use by staffs
- Use of Liquefied Petroleum Gas (LPG)
- Calculation of vehicles such as motorcycles, cars, and trucks passing the street entrance of the campus gates to the parking.
- Mixed waste generation from buildings.

The secondary data were obtained from the study of literatures in the form of journals and previous researches, as well as image location through google earth, as shown in Figure 1.



Figure 1. Hasanuddin University Faculty of Engineering

³ **2.1. Carbon Footprint Mapping Using Surfer 12.0**

To find out the pattern of carbon footprint spread that occurs in the campus area, carbon footprint mapping were created using the Surfer 12.0 program. This program was used to create the visual of carbon footprint spreads from traffic activities around the school after calculating the noise level at each point of observation where the distribution is classified in color.

3. Results and Discussion

Based on the research, there are three parts of results and discussion, which are the amount of carbon emission for each building, the amount of carbon emission for every activity, and the mitigation to reduce the carbon emission.

3.1. The Amount of Carbon Emission for Each Building

In this section, CO₂ emissions are CO₂ emissions generated from each building which divided by primary and secondary. The calculation of carbon emission in every building is shown in Table 1, the histogram of the emissions is shown in Figure 2, and the map of the emissions in Figure 3.

Table 1. Calculation of carbon emission in every building

No.	Location	Emission CO ₂		Total Emission CO ₂ (KgCO ₂)
		Emission Primary	Emission Secondary	
1	Department of Naval A	78,138.22	112,610.95	190,749.17
2	Department of Naval B	163.64	20,435.56	20,599.20
3	Department of Geology	130,735.06	132,102.92	262,837.98
4	Department of Electrical	56,354.93	197,799.93	254,154.86
5	Department of Mechanical	112,050.03	166,933.56	278,983.59
6	Department of Civil	132,318.32	154,432.66	286,750.98
7	Department of Architecture	110,561.49	178,614.77	289,176.26
8	Classrooms	1,730.56	133,478.05	135,208.61
9	Center of Scientific Activities	38,255.91	134,523.12	172,779.03
10	Center of Technology	56,151.83	84,547.49	140,699.32

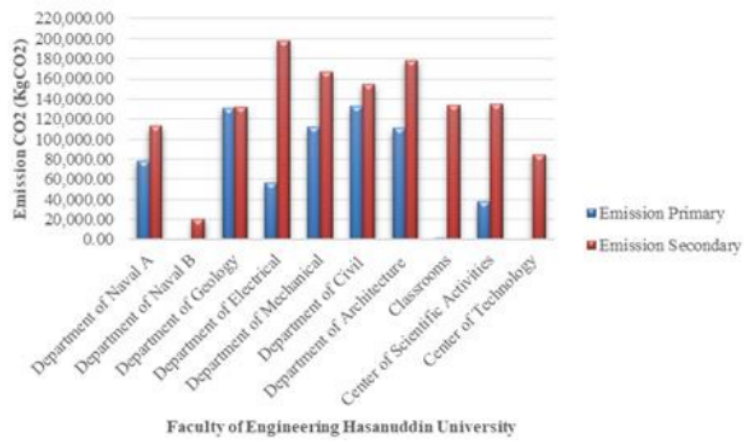


Figure 2. The histogram of CO2 emission in every building



Figure 3. The map of CO2 emission in every building

Table 1, Figure 2, and Figure 3 show that the largest CO₂ emissions are generated from Architecture Department at 289,176.26 KgCO₂/Year/Building having primary emission 110,561.49 KgCO₂/Year/Building and secondary emission 178,614.77 KgCO₂/Year/Building, due to the uses of the electronic devices found in Architecture Department, such as computers and lights.

3.2. The Amount of Carbon Emission for Every Activity

In this section, CO₂ emissions are CO₂ resulting from campus activities which then classified into primary and secondary. The calculation of emissions in the Hasanuddin University Faculty of Engineering for every activity can be seen in Table 2, the histogram of the emissions can be seen in Figure 4, and diagram of CO₂ emissions can be seen in Figure 5.

Table 2. Recapitulation result of total CO₂ emissions for every activity

No.	Activity	Type of Emission CO ₂	Emission CO ₂ (KgCO ₂)		
			Day	Month	Year
1	Consumption of LPG		3,382.90	67,657.92	708,716.71
2	Waste Generation	Primary	175.98	703.94	178,095.59
3	Vehicles		3.57	92.95	743.57
4	Electricity Consumption	Secondary	3,653.97	109,619.14	1,315,429.63
5	Usage Paper		0.16	4.12	49.39
Total Emission CO ₂ (KgCO ₂)			7,216.58	178,078.06	2,203,034.88

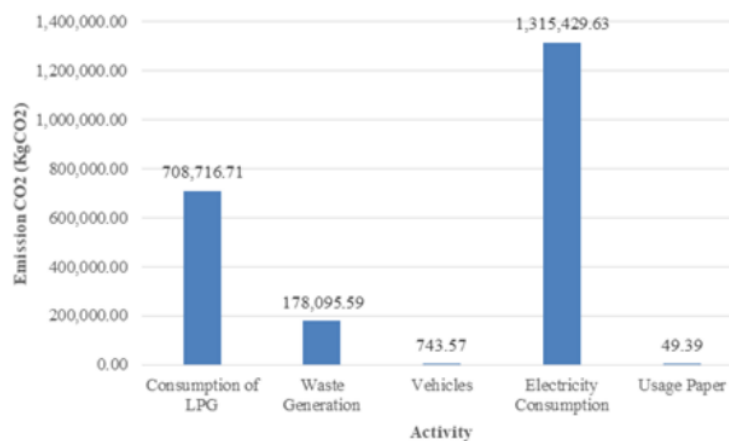


Figure 4. The histogram of CO₂ emissions total per activity/year

From Table 2 and Figure 4 the largest CO₂ emission was on electricity usage at 3,653.97 KgCO₂/Day, 109,619.14 KgCO₂/Month, and 1,315,429.63 KgCO₂/Year, due to the large number of electronic devices found in each buildings. This is reinforced by previous research stating that the factor which has most influences on CO₂ emissions is electric power, because teaching and learning activities require electronic devices to take place [8]. Based on the BAPPENAS emissions baseline (2014) for the energy-based sector and using LEAP software, stated that in 2020, the production of greenhouse gas emissions in the province of South Sulawesi are more than quadrupled to as much as 15,000,000 tons of CO₂eq [5], for 2019 the emissions was 14,000,000 tons of CO₂eq so that the Hasanuddin University Faculty of Engineering in Gowa campus contributed 1,315 tons of CO₂eq or equivalent to 0.0075% of the total greenhouse gas emissions in South Sulawesi. Because of this high increase, mitigation of gas emissions from campus activities was conducted.

3.3. The Mitigation to Reduce the Carbon Emission

From the results of the research, the largest emissions is resulted from the use of electricity and also from the waste generated even though it is not the biggest contributor but also we can anticipate an increase in emissions so that the mitigation scenarios can be prepared. There are six scenarios we can use. For the electricity usage there are 3 scenarios, electricity shut down until 30 minutes, 1 hour, and 2 hours, while for waste generation, we use 3R waste manufacturing scenarios in order to reduce waste to 2%, 5%, and 10%. For mitigation scenario, an effective campus activity can be done is to shutdown electricity for 1 hour and a reduction in waste generation to 2%, details are as follows:

3.3.1. *One Hour Electricity Shutdown Scenario.* This scenario is based on earth hour activity [9]. The scenario to shutdown the electricity for 1 hour. Below is the electricity consumption after 1 hour shutdown in Gowa campus Hasanuddin University Faculty of Engineering.

Table 3. The electricity consumption before and after 1 hour shutdown

No.	Location	Total (kWh)		Reduction %
		Before	After	
1	Department of Naval A	418,605.12	366,279.48	1.07
2	Department of Naval B	75,968.64	66,472.56	0.19
3	Department of Geology	491,077.44	429,692.76	1.26
4	Department of Electrical	741,052.80	648,421.20	1.89
5	Department of Mechanical	620,559.36	542,989.44	1.59
6	Department of Civil	535,772.16	468,800.64	1.37
7	Department of Architecture	644,676.48	564,091.92	1.65
8	Classrooms	548,029.44	479,525.76	1.4
9	Center of Scientific Activities	500,051.52	437,545.08	1.28
10	Center of Technology	84,541.32	73,973.66	0.8
Total kWh		4,660,334.28	4,077,792.5	12.5

From the results above we can see that electricity usage is 4,660,334.28 kWh/Year. The total usage after Earth Hour, electricity usage is 4,077,792.5 kWh/Year, we can see electricity consumption was reduced by the scenario and the total reduce was 582,541.78kWh/Year or equivalent to 12.5%. And for the emission, we can see the following Table 4 below:

Table 4. The results of CO₂ emissions before and after 1 hour shutdown

No.	Location	Emission CO ₂ (KgCO ₂)		Reduction %
		Before	After	
1	Department of Naval A	112,604.78	98,529.18	0.29
2	Department of Naval B	20,435.56	17,881.12	0.05
3	Department of Geology	132,099.83	115,587.35	0.34
4	Department of Electrical	199,343.20	174,425.30	0.51
5	Department of Mechanical	166,930.47	146,064.16	0.43
6	Department of Civil	144,122.71	126,107.37	0.37
7	Department of Architecture	173,417.97	151,740.73	0.44
8	Classrooms	147,419.92	128,992.43	0.38
9	Center of Scientific Activities	134,513.86	117,699.63	0.34
10	Center of Technology	84,541.32	73,973.66	0.22
Total Emission CO ₂ (KgCO ₂)		1,315,429.63	1,151,000.92	3.36

From the results above we can see that CO₂ emissions was at 1,151,000.92 KgCO₂/year. The electricity usage before Earth Hour has total CO₂ emissions of 1,315,429.63 KgCO₂/year, we can see that with this activity the CO₂ emissions can be reduced to as much as 164,428.70 KgCO₂/year or equivalent to 3.36%. The graphic consumption of electricity before and after 1 hour shutdown is shown in the following Figure 5.

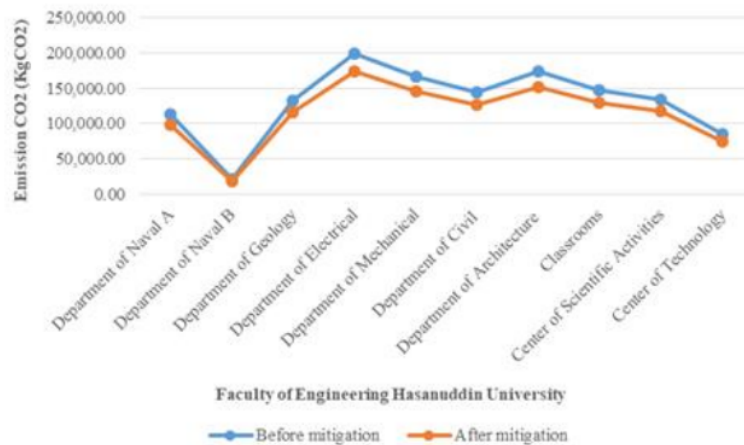


Figure 5. CO₂ emission before and after 1 hour shutdown

3.3.2. *Reduction of Waste Generation to 2 % Scenario.* According to the ministry of environment and forestry (2017), waste management is up to 80% and waste reduction has reached 20% in the last 5 years [10]. The percentage of organic waste component is 60%, plastic 14%, paper 9%, metal 4.3%, rubber 5.5%, fabric 3.5%, Glass 1.7%, and others 2.4% [11]. The decrease is due to the application of 3R Principle or Reduce, Reuse, Recycle. The following is the Table of the results of the application of garbage collection after the implementation of the 3R program:

Table 5. The generated waste before and after reduce to 2%

No.	Location	Waste Generation (Kg/ Year)	
		Before	After
1	Department of Naval A	776.6	761.068
2	Department of Naval B	383.24	375.5752
3	Department of Geology	1,155.88	1,132.76
4	Department of Electrical	1,257.96	1,232.80
5	Department of Mechanical	970.64	951,22.2
6	Department of Civil	4,863.76	4,766.48
7	Department of Architecture	1,445.84	1,416.92
8	Classrooms	4,052.84	3,971.78
9	Center of Scientific Activities	2,445.08	2,396.18
10	Center of Technology	782.32	766,673.6
Total (Kg/ Year)		18,134.16	17,771.48

From the results we can see that waste generation is 17,771,48 Kg/Year. The total waste before 3R program is 18,134.16 Kg/Year, with this scenarion the waste generation can be reduced as much as 167,332.79 Kg/Year. The CO₂ emissions that can be reduced can be seen in the following Table:

Table 6. The CO₂ emissions before and after implementation of the 3R program reduce to 2%

No.	Location	Waste Generation (Kg/ Year)	
		Before	After
1	Department of Naval A	7,626.99	3,688.52
2	Department of Naval B	3,763.80	3,688.52
3	Department of Geology	11,351.90	11,124.86
4	Department of Electrical	12,354.43	12,107.34
5	Department of Mechanical	9,532.66	9,342.00
6	Department of Civil	47,766.99	46,811.65
7	Department of Architecture	11,624.16	13,915.60
8	Classrooms	39,802.94	39,006.88
9	Center of Scientific Activities	24,013.13	23,532.87
10	Center of Technology	7,683.16	7,529.50
Total (KgCO ₂ / Tahun)		175,520.16	170,747.75

From these results we can see that the CO₂ emissions from waste generation are 170,747.75 KgCO₂/Year. The waste generation prior to 3R program is at 175,520.16 KgCO₂/Year, we can see a reduction of CO₂ emission of 4,772.41 KgCO₂/Year.

4. Conclusion

- The measurement of CO₂ emissions generated by the Gowa Campus, Hasanuddin University Faculty of Engineering are 2,032,682.58 KgCO₂/Year, 178,078.06 KgCO₂/Month, and 7,216.59 KgCO₂/Day. For Primary CO₂ emissions are equal to 717,203.56 KgCO₂/Year, 68,454.80 KgCO₂/Month, and 3,563.45 KgCO₂/Day, and for secondary CO₂ emissions are 1,315,479.02 KgCO₂/Year, 109,623.26 KgCO₂/Month, and 3,654.13 KgCO₂/Day.
- From the mapping of CO₂ emissions can be seen that the highest usage of building/year is the Architecture Department, with the total of CO₂ emissions are 289,176.26 KgCO₂/Year/Building, with primary CO₂ emissions are 110,561.49 KgCO₂/Year/Building, and secondary CO₂ emissions are 178,614.77 KgCO₂/Year/Building.
- Mitigation scenarios that can be used to reduce the biggest CO₂ emissions are by implementing Earth Hour every 1 hour a day for every month which can reduce electricity consumption at 582,541.78kWh/Year and CO₂ emissions at 164,428.70 KgCO₂/year. The second scenario is to reduce waste generation by implementing the 3R which can reduce waste up to 2% in the amount of 167,332.79 Kg/Year and emissions CO₂ in the amount 4,772.41 KgCO₂/Year.

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