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The Carbon Footprint Estimation based on Campus Activities in ITERA (Institut Teknologi Sumatera)

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Abstract ITERA (Institut Teknologi Sumatera) is one of young university situated in Lampung Province, Indonesia. In 2018, the average population of campus (students, faculties, and staff) was about 9584 persons. The objective of this paper is to inventory Green House Gasses (GHGs) and then to calculate carbon footprint using equation by UI Greenmetric Guideline 2018 except for fuel and LPG consumption, paper use, and organic waste generation by using GHGs Protocol. Three scopes of GHGs emission were used to classify based on both direct and indirect source(s). The first scope was presented by LPG consumption and fuel consumption of campus's car. Electricity consumption became scope 2 while the scope 3 involved paper use, organic waste generation including food waste and Yard trimmings, and transportation activities of both motorcycles and cars. The estimated GHGs emission was about 2846.541 metric ton CO2eq during 2018-2019 (one year) with the portion of each scope resulting 10.2%, 62%, and 28.2%, respectively. Electricity usage was being the highest contributor of carbon footprint. The inventory of GHGs will help top management of campus to evaluate and determine some strategies for minimization, reduction, and mitigation notably in electricity sector by some strategies such as substituting electric devices into eco-friendly products, applying energy management ISO 50001, and others.

Keyword:

Carbon footprint, Green House Gasses (GHGs), Campus activities, ITERA

1. Introduction

Global climate change is a big issue and threats to the social and environmental determinants of health, food production, drinking water, and other problems. It can rises air temperatures and changes natural disasters and variable rainfall pattern [1]. Anthropogenic Greenhouse Gas (GHG) emissions become the main reason for global climate change. Sufficient quantities of carbon dioxide have trapped the gasses causing increased heat in the lower atmosphere [1, 2]. Carbon footprint estimation is an important method because the

footprint information was a useful way of pursuing more effective climate change policies [3]. Indonesia is second the world's largest emitter of greenhouse gasses after Brazil, mainly due to forest conversion and carbon-rich peatlands [4]. Besides, CO2 emission from fossil fuel combustion was one of CO2 sources coming from the use of coal [5].

Emission profile from GHG inventory by the Ministry of Environment and Forestry in 2017 was 1,150,772 GgCO2e. The emission increases 124,879 compared to CO2 emission in 2000. The CO2 emission had been cut by 24.7% toward NDC (Nationally Determined Contributions) target 2030 and 834 million metric ton CO2eq or 29% reduction toward Business as usual (BaU) scenario. The Indonesia government has set an unconditional reduction target of 29% and conditional reduction target up to 41% of the BAU by 2030 [6]. However, analyses from WRI (World Research Institute) in 2017 projected over 50 percent of total emissions would increase by 2026-2027. Reduction emissions is an essential in order to achieve the Paris Agreement. The reduction effort should be undertaken by all sectors including public institutions. As a public educational institution, ITERA (Institut Teknologi Sumatera) as a young institute has a commitment to be more environmental sustainability. The institution has progressive development. The objective of the study was to make data inventory of greenhouse gases produced by the institution. By quantifying the GHG can lead to a basic data for mitigation development plan and strategy to fulfillment of its social responsibility [7].

2. Methodology

2.1 Campus condition of Institut Teknologi Sumatera

The Institut Teknologi Sumatera is one of the young institutes of higher education established in 2012. The campus is situated in Lampung Province, specifically in South Lampung (See Figure 1). The campus has developed progressively in all aspects such as infrastructure, education quality, research and development, and others. In 2019, there were 3 departments and 31 study programs available in ITERA. The population of the campus consists of all registered undergraduate students, lecturers, and staff including employees in administrative, operative, and maintenance roles. Total population of students, lecturers and staff was around 9584 including tenant in the canteen (with assumption 96 people).

Figure 1. Location site of ITERA (Source: Google Street, accessed in August 2020)

2.2 Data inventory and limit

Based on the GHG protocol, the estimation boundaries regarding direct and indirect emissions contain three groups/scopes. Scope 1 categorizes as a direct emission that comes from sources controlled by an organization. Scope II as indirect emission was corresponds to the organization's consumption of purchased electricity, and scope III for other indirect emissions relates to the activities within the organization but originated from sources that are not controlled by it [8]. Data collection was listed based on those three groups from the primary and secondary data sources. Primary data was collected by manual counting for instance a number of vehicles entering campus, and bus trip. Another collection was by interviewing the tenant in canteen about LPG usage. The secondary data came from the human resources department, tenant, operational and maintenance department regarding electricity usage and the number of population.

Activities and emission factors considered in scope I was mobile and fixed sources. The considered fixed source came from liquefied petroleum gas (LP gas) that was used for each tenant to heat and cook in the canteen. Another considered activity was institute operational vehicle. The emission factor for combustion of LPG used was from *National Greenhouse Gas Inventories guidelines from the* Ministry of Environment of The Republic of Indonesia 2012. The operational vehicle calculation was based on an average monthly expense. Scope II was an average of electricity consumption in a year during 2018-2019. The scope III was calculated for transportation (motorcycle and car) waste generation, and paper use. Those data were collected during April 2019. The data was further analysis by Microsoft excel to address total emission for each activity and scope. Some equations were used from UI Greenmetric Guideline except for fuel, LPG consumption, paper use, and organic waste generation in which those were calculated using GHGs Protocol.

2.3 Carbon foot print calculation

Carbon footprint calculations were mostly calculated according to UI Greenmetric Guideline for Eq. 3-6 which had been adopted from carbonfootprint.com. Other equations were taken from GHG's Protocol with various sources of factor emission. Equation 1 represented Total Emission (TE) from fuel consumption for operation vehicles where FC is fuel consumption (liter), HV is a heat value of pertalite (46,546 MJ/l) and EFp is Emission factor of pertalite as much as 0.0693 kgCO2 (Ministry of Environment, 2012).The equation to calculate TE of LPG usage can be seen at Eq 2. The number of LPG usage was denoted by LPGU, HV is a heat value of LPG 47,3 MJ/kg and Efs is an emission factor of LPG usage by 0.0693 (Ministry of Environment, 2012). The total emission of electricity usage was calculated by Eq. 3 where the EU is electricity usage per year in KwH/1000 and 0.84 is the coefficient to convert KwH to metric ton.

The considered mobile source (transportation) were car and motorcycle. Total emission of car was calculated by Eq. 4 where NC is a number of cars entering the university, TD is the approximate travel distance of a vehicle each day inside campus only (in kilometers). The number of 240 presents a number of working days per year and 0.02 is the coefficient to calculate the emission in metric ton per 100 km for the car. By Eq 5 was used to obtain total emission of motorcycle where NME is a number of motorcycles entering campus. The cofficient of 0.02 was to calculate the emission in metric ton per 100 km car. NME and NC were then counted manually during the operational hour in a day. Total emission of waste was calculated based on waste generation (mixed waste) in ITERA. The waste generation in ITERA can be categorized as household waste from dormitory and non-

household waste from campus area and canteen. The waste generation in dormitory was calculated with coefficient waste generation following a research in Sukarame district (a district near ITERA) of 0.2 kg/person/day [10]. Meanwhile, the waste generation in campus and canteen was calculated based on Indonesia national standard (Standar Nasional Indonesia/SNI) 19-3983-1995 related to waste generation specification for small and medium-sized cities with coefficient 0.01-0.015 kg/person/day. The equation was shown in Eq 6. The emission factor for total emission was used 427 kgCO2eq/ton for mixed waste [9]. Furthermore, the equation for EF of paper usage (kg CO2-eq/kg of paper) provided in Eq. 7 is 1.22 according to [11] in [12]. Total emission per year was calculated by Eq. 8 corresponding to the sum of CO2 emission for each considered activity.

TE of Fuel Consumption (Operational vehicle)	=	FC * HV * EFf	(1)
TE of LPG usage	=	LPGU * HV * EFL	(2)
TE of Electricity usage	=	EU * 0.84	(3)
TE of Car	=	(NC* 2 *TD * 240 /100) * 0.02	(4)
TE of Motorcycle	=	(NME* 2 *TD * 240/100)* 0.01	(5)
TE of Waste	=	WG x EFw	(6)
TE of paper usage	=	PU x EFp	(7)
Total Emission/year	=	Total emission from electricity usage + fuel consumption (operational vehicle) + transportation (bus, car, motorcycle) + waste generation + paper usage	(9)

3 Result and discussion

3.1 Total emission scope 1

Scope 1 consists of fuel consumption for operational vehicles and LPG usage. The type of fuel mostly used in ITERA was pertalite. The total use of the gasoline was around 967 Liter. The data was based on total expenditure during 2018-2019 in which the total costs afterward converted to liter of gasoline. The total emission of fuel consumption was 249.53 metric ton CO2eq. The LPG usage data was collected by interviewing all tenants in the canteen where can consume 3 kg LPG cylinders three times a day for each tenant. There were 46 tenants active in 2 canteens so that there were about 4416 LPG cylinders for a year. The calculation results for 39.54 metric ton CO2eq. Total emission in scope I was visualized by Fig 1.

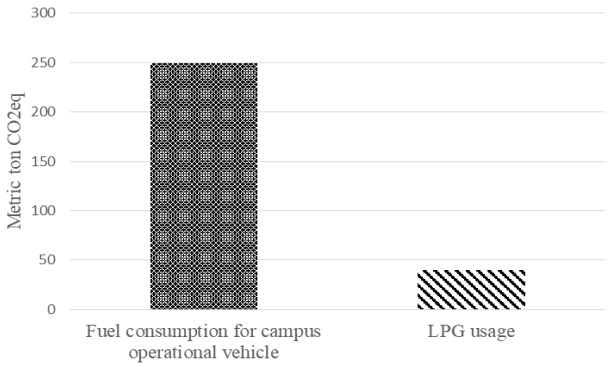

Figure 1. Total Emission for each activity in scope 1

3.2 **Total emission in scope II**

Scope II contain electricity usage only. The electricity source in ITERA was all from State Electricity Company-Indonesia. The obtained data was postpaid electricity from November 2017-Oktober 2018 for total kWh/month. All electricity needs were for 7-8 buildings including dormitory and campus building. The graph shown electricity usage is provided in Figure 2. During November to January, the electricity usage was dramatically dropped because those months were the semester break for students. During semester break, the operational cost for offline studying activities decreased and minimized. However, activities for research, administrative, and others were still available and needed to use the electricity. Total emission caused by electricity consumption was 1753.35 metric tonCO2-eq/per year or 0.183 metric/person.

Figure 2. Electricity consumption for each month

3.3 **Total emission in scope III**

Total emission in scope III was calculated by many aspects related to transportation (motorcycle and car), domestic waste, and paper use. The transportation limited to two types of motorcycle and car since the shuttle bus was just operated in the last 2019 and not a part of time span of research. The motorcycle entering to campus was counted 4218 motorcycles in a year with travel distance about 2.6 km. However, a number of car entering to campus was counted 683 with travel distance around 2.6 km. The travel distance of 2.6 km was used with an assumption the distance from main gate to farthest location and the return. Total emission emitted from motorcycle activities was 526.406 metric tonCO2-eq or 0.055 metric/person meanwhile TE emitted from car activities was 170.477 metric tonCO2-eq or 0.018 metric/person. Another considered factor was waste generation in scope III. The

reduction for waste generation was done by putting organic waste into *Biopori* Infiltration Holes Technology application particularly in dormitory. The dormitory itself is occupied mostly by first year students since ITERA has human development program for students living in dormitory. The reduction could be reached up to 30% for organic waste generated by dormitory occupants. The occupancy in dormitory was for around 1200 students. Mixed waste generated in dormitory was about 57.6 ton/year meanwhile mixed waste generated in campus was around 34,012 ton/year. Thus, the total mixed waste generated in ITERA was about 91.612 ton/year before reduction and or 64.12 ton/year after reduction. The total emission caused by mixed waste was 26.992 metric tonCO2-eq. Besides, paper use was also able to emit CO2 emission. The paper use in ITERA for all administrative purpose was up to 65.45 ton of paper. In a year, total emission of paper use was about 79.85 metric tonCO2-eq.

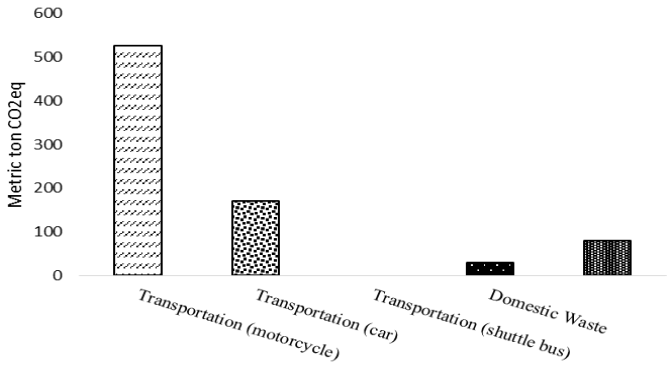

Figure 3. Total Emission for each activity in scope III

3.4 **Future discussion and recommendation**

According to above-mentioned results can be seen that activities in scope II had the largest source of greenhouse gas emission. It accounts 61.6% contribution to carbon footprint. Scope I had smallest emitter about 10.2% and scope III was about 28.2%. The graph for percentage of total emission for each activity is provided in Figure 4. Total emission for all scopes was accounted 2846.541 metric tonCO2-eq by considering seven aspects that is fuel consumption, electricity consumption, LPG usage, transportation for car and motorcycle, domestic waste and paper usage. The highlight for emission reduction can be further focused in energy consumption. The problem of great consumption in electricity usage also occurred in several universities for example The Cuajimalpa campus of the Autonomous Metropolitas University in western region of Mexico city. The campus was found an issue about electricity consumption with 24% of total emission [7]. Another example was from Universiti Teknologi Malaysia that electricity consumption became highest contribution as much as 1.89 MtCO2 [13]. In Indonesia, Faculty of Engineering, State University of Semarang showed that electricity usage was a highest contribution in carbon footprint [11].

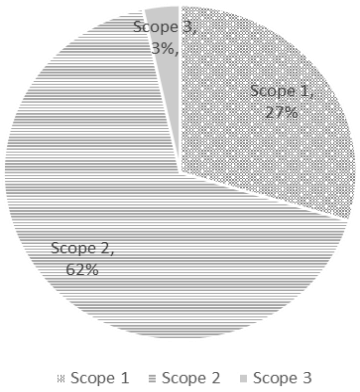

Figure 4. Percentage total emission for each scope

The reduction efforts for electric usage is one of the areas with opportunities for improvement. ITERA has a commitment to be environmentally sustainable campus and is currently working with the biggest solar power generation with capacity 1 MWP. The news had been reported by some online news (such as Kumparan and Kompas) [14, 15]. This was a big deal for ITERA to be more sustainable. Other prepared strategies were to change all lamps in all rooms into LED, providing online energy monitoring to know the electric current and voltage, and implementation smart building. Strategy to reduce energy consumption is by adopting an energy management system such as ISO 50001 that can reduce energy consumption about 6% [8]. Scope III was also becoming big issue to be solved. The campus can incentivize travel by buses notably in inside campus. Carpooling should be encouraged and perhaps rewarded with free parking spaces. Encouragement of using bike was also needed [8]. Further research and continuity of inventory data should be conducted to be more specific for regulation and right handling.

4 Summary/ Concluding Remarks

Data inventory regarding carbon footprint has been done by considering seven aspects of fuel consumption, electricity consumption, LPG usage, transportation for car and motorcycle, domestic waste and paper usage. Those aspects were divided into three groups depending on the how the activites emit the emission. Scope I was fuel consumption for operational car and LPG usage. Scope II was electricity usage meanwhila scope III was for transportation (car and motorcycle), domestic waste, and paper usage. The scope II became the largest contributor to the total emission with 61.6% (1753.35 metric tonCO2-eq) followed by scope III of 28.2% (804.11 metric tonCO2-eq) and scope I of 10.2% (289.08 metric tonCO2-eq). Total emission was accounted 2846.54 metric tonCO2-eq. The scope II related electricity consumption became major issues to be priority to concern about. Some strategies can be applied such as substituting electric devices into eco-friendly products, applying energy management ISO 50001, and others.

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