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Calculating Green House Gas Emissions as an Effort of Climate Change Mitigation

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ABSTRACT--- ***Based on the SNC (Second National Communication) scenario the emission rate in Indonesia would expected to increase from 1.72 Gton of CO_2e in 2000 to 2.95 Gton of CO_2e in 2020 (RAN-GRK, 2010). The University of Indonesia has been implementing the Green Campus policy, one of which being to evaluate the use of electricity in order to reduce GHG emissions. The purpose of the present study was to determine the amount of greenhouse gas emissions of the scope two generated by the activities of the University of Indonesia's campus. The study was conducted by calculating the amount of greenhouse gases generated by the activities of the University of Indonesia's campus at Depok. Calculation results indicated that the GHGs generated by the use of electricity in 2010 amounted to 15,681 tons. In 2011, 17,984 tons of CO_2e were generated, an increase compared to that of 2010. Results of GHG normalization according to the student number and the building area showed a great variation in GHGs between the Natural Science Faculty and the Social Science Faculty. The former tended to produce more GHGs than the latter. In conclusion, there was an increasing trend in GHG emissions in the University of Indonesia, in which the Natural Sciences Faculty showed higher GHG emissions than those of the Social Sciences Faculty.***

Keywords--- Greenhouse gases, climate change, Green Campus

1. INTRODUCTION

Climate change in Indonesia has direct and indirect effects on health, capable of causing various diseases. Climate change will have greater impacts on the low-income population with limited health facilities, which is the population group most vulnerable to the health impacts of climate change (ICCSR, 2011).The identified primary cause of climate change is greenhouse gas emissions (GHGs) generated by human activities (Solomon, 2007). The greenhouse gases released into the atmosphere as a result of human activities are CO_2, methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (HFCs, PFCs, SF_6) (Akorede *et al*., 2012).

The level of greenhouse gas emissions (GHG) in Indonesia continues to increase. Based on the SNC (Second National Communication) scenario the emission rate in Indonesia would expected to increase from 1.72 Gton of CO_2e in 2000 to 2.95 Gton of CO_2e in 2020 (RAN-GRK, 2010). The 1997 Kyoto Protocol, ratified by 141 countries including Indonesia, expressed the need to reduce emissions by 5.2 percent from the 1990 emission rate before 2012. Reducing the rate of greenhouse gas emissions from various sources is among the mitigation measures listed in Indonesia's national action plan in the face of climate change (Ministry of Environment of the Republic of Indonesia, 2007). Indonesia is committed to reduce GHG emissions by 26 percent (0.767 Gton CO_2e) by 2020 from the emission level of BAU (Business as Usual).

Based on the principles of carbon management defined by the Environmental Protection Agency (EPA), the first thing to do for an organization to manage carbon of its organization is to determine the amount of greenhouse gases it generates. Reduction efforts will be impossible without knowing the amount and sources of greenhouse gas emissions. Therefore, mitigation action plan should be supported by data related to the amount of greenhouse gases resulting from energy consumption and other activities representing the sources of carbon emissions (EPA, 2007).

Universities and colleges assume a role to create knowledge and to integrate continuing education and research programs, as well as promoting environmental issues to the public (Lozano, 2010; Stephens and Graham, 2010; Waas *et al*., (2010) in Larsen *et al*., 2011). Academic institutions have the opportunity and responsibility to engage the public in an effort to reduce carbon emissions through the teaching and research activities. This is reason for the Board of Higher Education of the UK to impose a policy on universities to report the greenhouse gas emissions produced annually and reduce direct and indirect emissions by 80% by 2020 compared to that of 1995 (Meida *et al*., 2010).

2. METHODOLOGY

The study was conducted on all the faculty and administrative building in the campus of the University of Indonesia (UI) at Depok. It was conducted for four months from March to June 2012. Data of the use of electricity were obtained from General and Facility Directorate of UI. Data of the number of students were derived from the Education Directorate of UI. Data of building area were obtained from the General and Facility Directorate of UI and each faculty.

The GHGs was calculated using the internationally recognized IPCC method with the basic formula:

$$\text{GHG emissions} = \Sigma \text{ Ai x EFi}$$

where:

GHG emissions	=	Emissions of a greenhouse gas (CO_2, CH_4, N_2O)
Ai	=	Consumption of material of type i or amount of product i
EFi	=	Emission factor of material of type I or product i

Emission factor*: for Java–Madura–Bali interconnection system for 2010, 2011 amounted to 0.741 tCO_2e/MWh

Normalization of greenhouse gases by the number of students was performed at each faculty and then compared among faculties. In order to determine the order of the highest to the lowest the following formula was used.

Emissions of each student = Total greenhouse gas emissions: Number of students

Greenhouse gas normalization by the building are was carried out by dividing the greenhouse gases generated by each building by the building area. The average greenhouse gases produced per square meter of building area would be determined on the basis of this normalization. Results were used to compare the average greenhouse gases among the faculty and administrative buildings. The formula used was:

Emissions per m^2 = Total GHG emissions per faculty/building area

3. RESULTS

The greenhouse gases generated from the use of electricity in 2010 and 2011 amounted to 15,681 and 17,984 tons of CO_2e, respectively. GHGs generated in 2011 was higher than that in 2010 (Figure 1). GHGs generated in the campus of UI at Depok during the period of January 2010 to December 2011 had almost the same patterns of increases and decreases. High levels of GHGs were generated in the period of February to May and then fell in the period of June to September and fell in January (Figure 2).

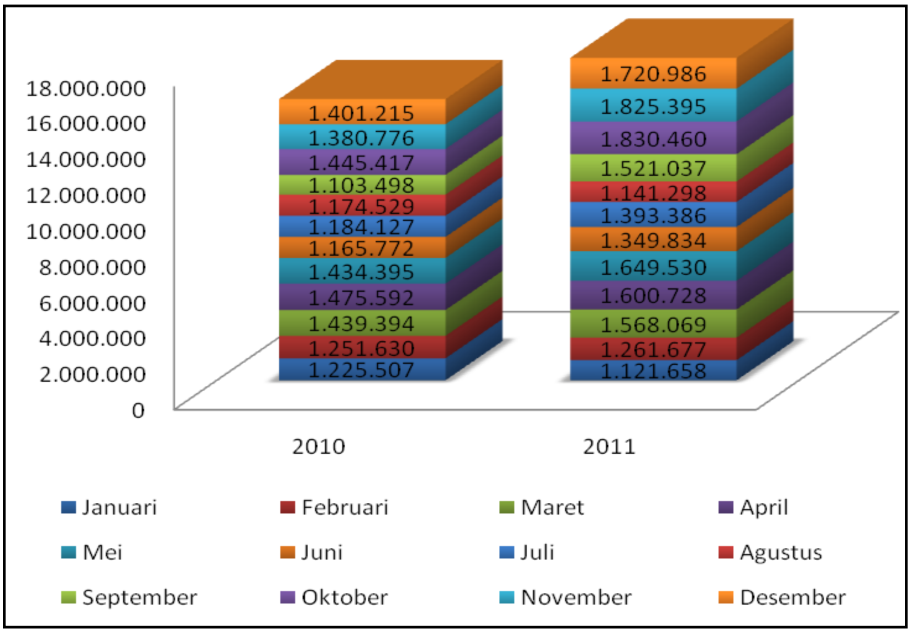

Figure 1. Greenhouse Gases (CO_2e) in the campus of UI at Depok for the period of 2010–2011

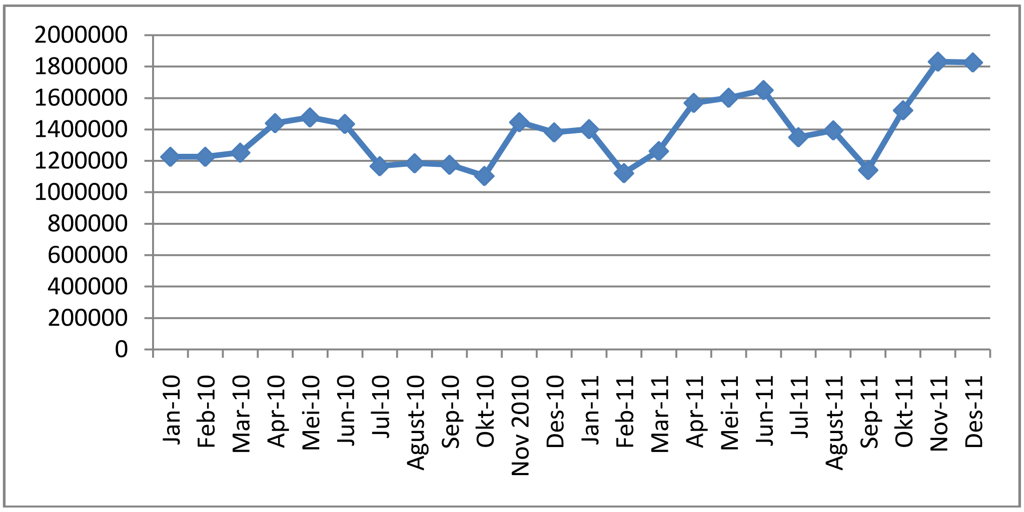

Figure 2. Greenhouse gases (CO_2e) for the period of January 2010 to December 2012

The amount of GHGs produced by each faculty and the administrative building in the University of Indonesia for 2011 also increased compared to that for 2010. Faculty of Economics (FE) constituted the largest contributor to greenhouse gases relative to other buildings (Figure 3).

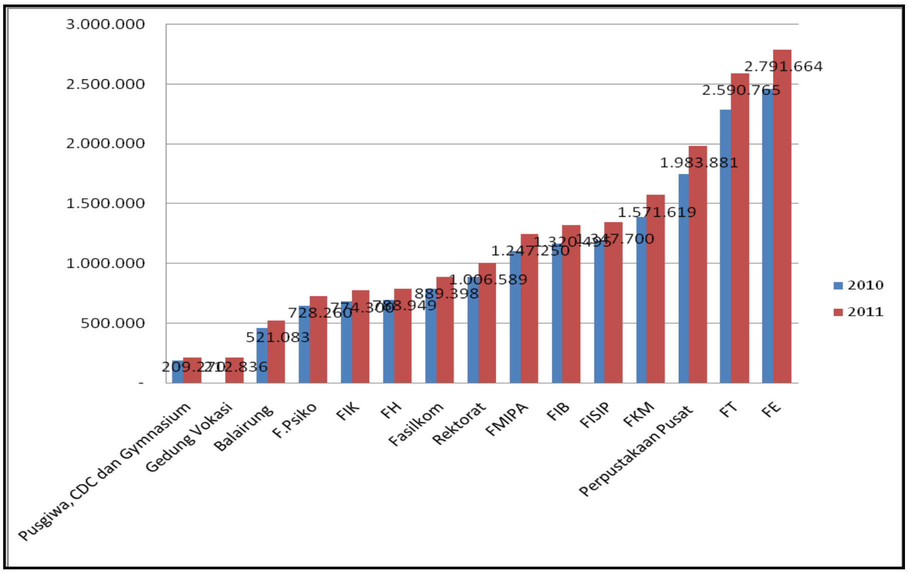

Figure 3. Greenhouse Gases (CO_2e) for every building in the campus of UI at Depok for the period of 2010–2011

In 2010, GHGs produced by each student ranged from 53.8 to 15.3 kg of CO_2e. Faculty of Computer Sciences constituted the faculty with the highest average GHG per student (53.8 Kg of CO_2e) relative to other faculties. The Faculty of Social and Political Sciences was the faculty with the lowest average GHGs per student (15.3 kg of CO_2e). In 2011, GHGs produced by each student ranged from 62.3 to 18.7 Kg of CO_2e. The Faculty of Nursing Sciences was the faculty with the highest average GHGs per student (62.3 Kg of CO_2e) relative to other faculties and the Faculty of Law was the faculty with the lowest average GHGs per student (18.7 kg of CO_2e) (Figure 4).

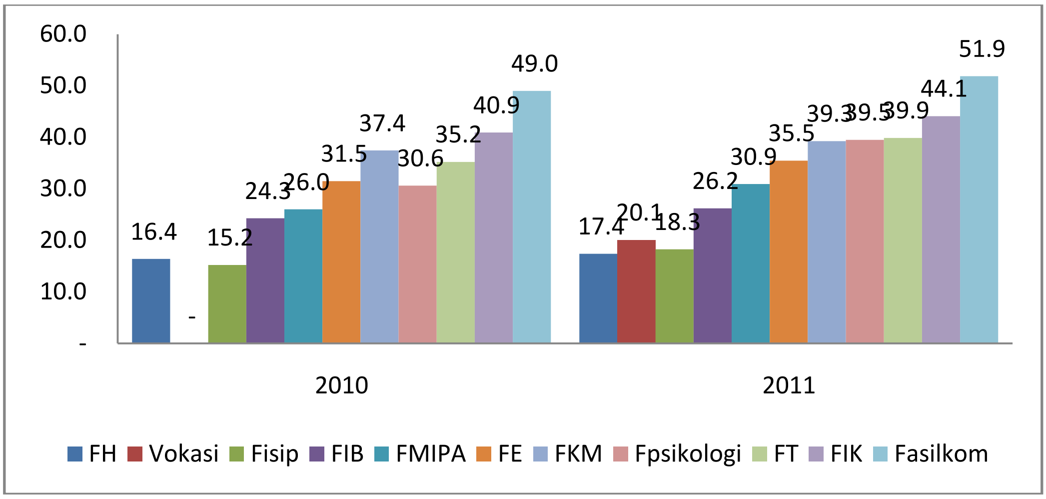

Figure 4. GHG Normalization by the Number of Students in 2010 and 2011

In 2010, the range of GHGs produced by each square meter of building area increased relative to that in 2010, ranging from 16 to 3.2 kg of CO_2e. The Faculty of Public Health produced the highest GHGs (16 kg of CO_2e) per square meter of building area relative to that of other faculties. The Faculty of Psychology constituted the faculty with the lowest average GHGs (3.2 kg of CO_2e) per square meter. In 2010, GHGs produced by each square meter of building area increased relative to that in 2010, ranging from 16 to 3.2 Kg of CO_2e. The buildings of the Public Health Faculty and the Psychology Faculty produced the highest and the lowest GHGs (16 kg and 3.2 kg of CO_2e), respectively, per square meter relative to other faculty buildings (Figure 5).

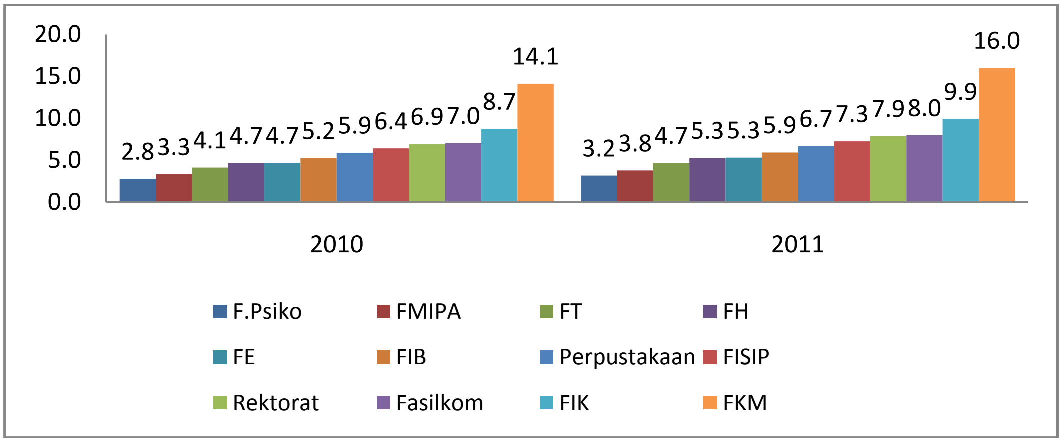

Figure 5. GHG normalization by building area for the period of Year 2010–2011

4. DISCUSSION

4.1 Trends of Increasing Greenhouse Gases

GHGs generated by the campus of the University of Indonesia at Depok from electricity use tended to rise annually. The increase in amounts of GHGs resulting from the use of electricity could be caused by the increasing use of electricity or by increased electricity emission factors. The case studies conducted in UI showed that electricity emission factors for the Java–Madura–Bali (JAMALI) electrical interconnection for 2010 and 2011 together were the same (0.741). Thus, it could be deduced that the factor affecting the amount of greenhouse gases produced by the campus of UI at Depok was the use of electricity.

There were a couple of factors capable of affecting the increase in GHG in the campus of UI at Depok. The first was the number of populations in the campus of UI and the second was the lifestyle. The number of students and staff in the campus of UI at Depok increased annually. In the first semester of the 2009–2010 school year the number of students of UI was 40,604 and increased by 42,492 in the first semester of the 2010-2011 school year. A study found a positive correlation between population size and the amount of GHG produced (Larsen & Hertwich, 2010).

With regard to lifestyle, technology is increasingly more sophisticated. The types of gadgets held by students are also more diverse. Quite often people have more than a single electronic communication device (cell phones, Ipad, etc.). Most students also have a laptop brought to the campus every day to perform tasks or simply to download movies.

This would certainly contribute to the increased use of electrical energy. A study showed that the energy needs of a region increases with the number of population and lifestyle (Feni, *et al*., 2010).

February to May constituted the period of active lecture. During the period, many classes were used for lectures, requiring more energy to power the air conditioners and computers in the classrooms. June to August was the period of decreased GHGs, coinciding with the holiday period. During the holiday, there were certainly no lectures and the number of students performing activities in the campus was also reduced relative to that of the period of active lecture. Additionally, the absence of teaching and learning activities meant that there were no classrooms used for lectures. Energy requirements for the use of air conditioners, computers and lights in the classrooms certainly dropped dramatically relative to the period of active lectures. As a result, GHGs produced during the holidays also reduced.

4.2 Greenhouse Gas Normalization

4.2.1 Greenhouse Gas Normalization by the Number of Students

GHG Normalization by using the variable student numbers means dividing the average GHGs produced by each region every year by the number of students of the faculty concerned. This method was used in a 2010 study at the NTNU University (Larsen *et al*., 2011). Normalization was also carried out in a study aimed at measuring the performance of GHGs at all universities in the US (Banai & Theis, 2011). In the present study, GHGs normalization by the number of students was performed on the faculty buildings. It was not performed on administrative buildings since the exact number of students performing daily activities in the building was not known.

Normalization by the variable student numbers provided an interesting insight. Those faculties initially producing a great total GHGs showed a lesser average GHGs per student after normalization by the number of students. The Economics and Engineering Faculties initially had high GHGs relative to other faculties but, after normalization by the variable number of students, they became faculties with a fairly high average GHG per student. The Faculty of Computer Science initially had a low total GHGs relative to other faculties but, after normalization, it turned into a faculty with a higher average GHG per student than other faculties.

During the 2010–2011 period, the Faculty of Computer Science was faculty with the highest GHGs relative to other faculties. This indicated that the students of the faculty used more electricity than those of other faculties. In 2010, each student of the faculty produced average GHG emissions of 53.8 kg per month, equivalent to 0,645 tons per year. In 2011, the figure increased to 56.8 kg per month, equivalent to 0.681 tons per year.

A study conducted in the NTNU University showed that GHGs produced by the Natural Sciences and the Social Faculties were around 10.8 tons 0.58 tons per year, respectively (Larsen *et al*., 2011). A 2009 study in University of Sydney showed that the Natural Science, Veterinary Science and Agriculture Faculties had GHGs greater than the Economics, Law and the Arts Faculties (Baboulet, 2009). This was the case with the campus of UI at Depok, where there were variations in GHGs among faculties. Those faculties studying exact sciences had higher GHGs than those faculties studying social sciences. Results of GHG normalization showed that the majority of faculties studying exact sciences (Computer Science, Nursing Science, Engineering, Public Health) belonged to the big five in GHG production. Differences in GHGs produced by each student among faculties could be caused by differences in the activity of students in a given faculty. Those faculties with a high average GHG per student indicated that their students performed a lot of activities that used electricity in their respective faculty, leading to a greater use of electricity. Students of the faculties studying exact sciences had an average GHG greater than those of the faculties studying social sciences. Most likely, this was due to the fact that the students of the faculties studying exact sciences performed many lab works by the used of electricity-powered equipments. Hence, different mitigation methods were required for different faculties.

4.2.2 Normalization by Regional Area

GHG normalization by the use of the variable regional area was carried in a study conducted by Klein-Banai C. (2011) to determine the performance of GHGs produced by universities in the United Kingdom (UK) (Banai & Theis, 2011). Normalization was also performed in the present study to determine the average GHGs produced by each square meter of building area. The existing data of building area were those of the current building area. Thus, it was assumed that there were no changes in building area for 2010 to present. The Public Health Faculty buildings constituted the region with the highest average GHGs per square meter relative to other regions. The rectorate buildings constituted an administrative region with the largest average GHG per square meter relative to other administrative areas.

In the present case study, the high GHGs per square meter of the Public Health Faculty buildings could be caused by the higher intensity of use of the buildings than that of other faculties. The high intensity of the use of the buildings could be due to the tight schedule of lectures or the longer operating time of the faculty than that of other faculties. A study by Riedy and Daly (2010) found that a place operating for a longer duration, more than from 9 a.m. to 5 p.m., had larger GHG emissions per square meter than other places. However, GHG emissions per square meter do not a sound approach to defining the GHG contribution of each region (Banai & Theis, 2011). In addition, variations in GHGs produced by each square meter of buildings indicated that there were inefficiencies in the buildings. Buildings with the same function are expected to have the same average GHGs per square meter. Therefore, faculty buildings ideally have the same amount of GHGs per square meter.

5. CONCLUSIONS

- The amount of greenhouse gases generated by the scope two in 2011 was greater than that in 2010. This indicated that the GHGs produced by the campus of the University of Indonesia would tend to rise annually.
- GHG normalization by the number of students and regional area showed variations in the amount of greenhouse gases generated between the exact science faculties and the social science faculties, indicating that mitigation for each faculty would be different accordingly.
- Supports of human resources were necessary to reduce the increase in greenhouse gases generated by the campus of UI.
- The leadership's commitment to participating in the reduction of greenhouse gases as well as strengthening human resources through increasing environmental education, especially regarding environmental health and energy efficiency for greenhouse gas reductions should be improved

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