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Predicting the Reduction of Green House Gas Emission from Wastewater Disposal at South Part of Surabaya City

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ABSTRACT

This research aims to predict the magnitude of the emissions of CO_2 and CH_4 generated from the activity of domestic and non-domestic instalation of wastewater disposal in the south part of Surabaya on 10 years duration. The method in this research is compiled by calculating the magnitude of waste domestic waste in units of liters/person/day. The calculations are based on the approach of discharging fresh water obtained from the account of Surabaya Drinking Water Enterprise (*PDAM*)at every home. From non-domestic facilities, the magnitude amount of clean water from the account of use of water *PDAM* can be calculated. The analysis results retrieve a prediction on the magnitude of emissions at the end of 10 years duration on the south part of Surabayafrom domestic activities by the value 224,941 kg/year CO_2 and 53,076 kg/yearCH_4, while the non-domesticactivities generate 112,094 kg/year CO_2 and 26,449 kg/yearCH_4. Prediction on magnitude of the potential energy shows the gas emissions of CH4 electric at the end of 10 years durationforsouth region of Surabaya activities by the domestic value of 748,773 kWh and of the activities of non-domestic by the value of 47,000 kWh. Prediction on magnitude of the reduction in greenhouse gas emissions with the transfer of emission of CH_4 into biogas in South of Surabaya by 10 years durationsfordomestic activities are 53,076 kg/year CH_4 and of activities of non-domestic are 26,449 kg/year CH_4.

KEYWORD: CO_2, CH_4, emission, reduction, Green house gas emissions.

1. INTRODUCTION

All countries in the world have a responsibility for the onset of global warming. Global warming caused by human activities are conducted either in developed countries and in developing countries. Global warming gives enormous impact against the world's climate and sea-level rise. In General, global warming due to the intensity of greenhouse gases are increasing. According to Wahyono [1] the increasing intensity of greenhous gas was caused by increasing amounts of gases that cause the greenhouse gas.

Along with the increase of the population of the city, can lead to the occurrence of an increased volume of wastewater from the results of their activities. The occurrence of the wastewater volume is added when not followed by adequate means and infrastructures will pose a considerable impact on the environment. The construction of the waste water disposal installation to be one of the options for dealing with the waste that comes from the domestic and non domestic activities taking into account the factor of quality fluctuation and quantity [2-5]. Wastewater also has an impact that is often forgotten, namely gas generated on the domestic and non domestic waste water disposal installation form carbon dioxide gas (CO_2) and methane gas (CH_4) which is a greenhouse gas, beside which is derived from the activity of the transportation [6] and the wearing of incinerator in city [7]. The resulting gas can be exploited to become one of alternative energy, in the form of biogas energy. Biogas is a gas end products of digestion/anaerobic degradation (in an environment without oxygen) by bacteria-bacterial methanogen [8]. The potential of methane gas at waste water disposal installation can be utilized as generating electrical energy.

The city of Surabaya is one of the major cities in Indonesia, where the population is dense enough. based on population, data [9] Surabaya as much as 2,853,661 persons. Data percentage of disposal of wastewater in the city of Surabaya as much 87.5% use septic tanks, another septic tank as much as 9.02% and directly dumped into rivers, lakes and the sea as much as 3.13%. Therefore this research was conducted to predict the potential of greenhouse-gas emissions of CO_2 and CH_4 produced from domestic and non-domestic activities in the city of Surabaya, particularly in South of Surabaya.

2. REVIEW OF LITERATURE

Greenhouse gases isarousedand caused a global warming or also called the potential greenhouse gas warming, and the effectiveness of CH_4 in absorbing heat has 21 times greater than that of CO_2[10]. Although carbon dioxide (CO_2) have smaller warming potential, but it has mostof concentration in the atmosphere.

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The anaerobic process is occured in septic tank, where the process is used as the stabilization on mud. Anaerobic process produces gases that are usually used to meet the energy needs in the operation of the plant. Many of the advantages gained in the anaerobic processing causedon the energy required in the process, such as it takes fewer nutrients, resulting in less sludge, producing methane gas potential as an energy source sufficiently when required reactor volumes is small [11].

According to Polprasert [12], the contained gas within biogas depends on several factors such as the composition of the waste to be used as the raw materials, organic load of typical analysis for digester and time as well as the temperature of the anaerobic decomposition. In spite of variations in the existing gas content in biogas, it can be estimated that the gas content range values: methane (CH_4) ranged from 55-65%; carbon dioxide (CO_2) ranges from 35-45%; Nitrogen (N_2) ranged from 0-3%; Hydrogen (H_2) ranges from 0 to 1%; and hydrogen sulfide (H_2S) ranges of 0-1%.

According to Liu [13],the chemical compound contained in feces is $C_{100}H_{331}O_{86}N_{151}S_{0,1}$and for urine is$C_{100}H_{331}N_{151}S_{0,2}$. In order to calculate the emissions of carbon dioxide gas (CO_2) and methane (CH_4),with the septic tanks using the dry weight of feces and urine [14]. The alternative energy not only has a cheap sources, but also sustainable and environmentally friendly [15]. Biogas energy conversion for power generation can be done by using a gas turbine, microturbine and otto cycle engines. Technology selection is strongly affected by the potential of biogas as concentrations of methane (CH_4) and biogas pressure load as well as the availability of existing funds [16].Inthe power plants, biogas is produced by the equivalent energy of 60-100 watt light bulb in 6 hours activation.

According to Bent [17] 1 kg methane gas is equivalentto 6,13 x 107 J, while 1 kWh isequivalent with 3,6 x 107 J. For methane gas with the density 0,656 kg/m^3can generate 4,021 x 10^7 J. For 1 m^3methane gas, it generating electricity of 11,17 kWh[17].For carbon dioxide 1 m^3 $CO_2$is equivalent with 0,672 kg CO_2. 1 kg $CO_2$is equivalen with 21 kg CH_4. Itcan be assumed that a component of biogas containing CH_4 (60%) and CO_2 (38%) and others (2%).

3. METHODOLOGY

The method in this research is compiled by calculating the magnitude of waste domestic waste in units of liters/person/day. The calculations are based on the approach of discharging fresh water obtained from the account of Surabaya Drinking Water Enterprise (*PDAM*)at every home. The usage of clean water is calculated by amount of waste water produced for the domestic population and population equivalent of non domestic.Waste water is predicted for 10 years and the calculated emissions of CO_2 and CH_4 as well as electric energy potential in south of Surabaya are also predicted.

According to the empirical formula showed by Liu [13], the existed in the feces is $C_{100}H_{331}O_{86}N_{151}S_{0,1}$ and *urine*is$C_{100}H_{331}N_{151}S_{0,2}$. From the empirical formula, it can be used to calculate the emissions generated. In the research performed by Wati [19], she has calculated the average mass of CH_4 and CO_2 generated from the dry weight of feces and urine. The research mentionsfor*feces* has a mass of CH_4 by as much as18.17 gr/person/dayandthe mass of CO_2 by as much as 43.82 gr/person/dayas for the urine has a mass of CH_4 by as much as 2.55 gr/person/dayand the mass of CO_2 by as much as 45.56 gr/person/day.

Black Waterfound in the septic tanks are the two types of human waste. They are feces and urine, which mentioned inthe research. Wati [14] calculated the total volume of carbon dioxide (CO_2) and methane (CH_4) that exist in the septic tank, where the average of mass CH_4 total is20.72 gr/person/dayand the average of mass CO_2 total is 89,38 gr/person/day.

4. RESULTS AND DISCUSSION

The survey results obtained from the average number of people in each head of household are 5 persons.The calculation is performed to obtain the amount of wastewater generated by each head of household and the average waste water produced each head of household in South of Surabaya.The results of these calculations are based on the use of clean water each head of household multiplied by 70% to acquire waste water produced. After generating the average number of people each head of household (HH), it can be calculated the mass of CO_2 and CH_4, where:

Mass CH_4average/HH= person in head of household x mass CH_4 total= 5 x 20,72 gr/person/day= 103,6 gr/HH/day. Mass CO_2average/HH = person in head of householdx mass CO_2 total= 5 x 89,38 gr/person/day = 446,9 gr/HH/day

The values can be calculated by the total mass emissions generated on septic tanks or from the results of a questionnaire survey regarding wastewater disposal instalation scattered in South of Surabaya, in which all respondents have septic tanks.By using those approaches, calculation of total CO_2 emissions and CH_4 produced each home using data head of household can be performed.The magnitude of the resulting emission predicted in South of Surabaya population consists of 10 years prior data. The data is, later on, calculated by generating the carbon dioxide and methane in the post 10 years prediction. The calculations are presented in Figure 1 and Figure 2.

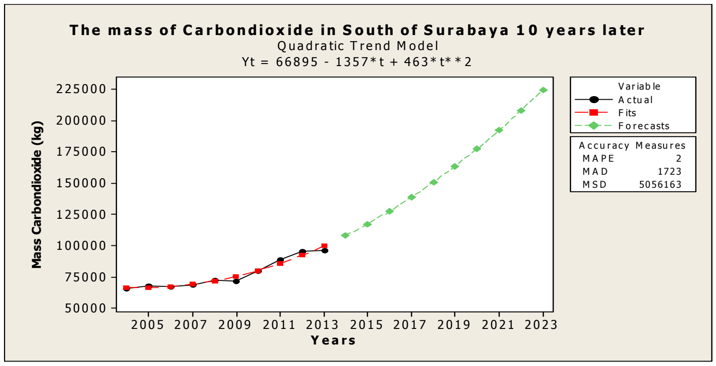

Figure1 CO_2 Mass domestic activity prediction in south of Surabaya

From Figure 1, it can be seen that the predictions has an increase in mass of CO_2 in first period of predictions for 2005, where the amount of65,444 kg/yearcontinuing up to 2015 period by 107,985 kg/year. The peak periods of the year 2023 amount by224,941 kg/year.From Figure 2, it can be seen that the predictions of rising mass of CH4 in periods of the 2005 amounted by 15.441 kg/year continuing up to 2015 period amountedby 25,479 kg/year.The peak periods of the year 2023 amountedby 53,076 kg/year. This pattern indicates that the population is directly proportional to the increased carbon dioxide and methane in south of Surabaya as the time pass by.

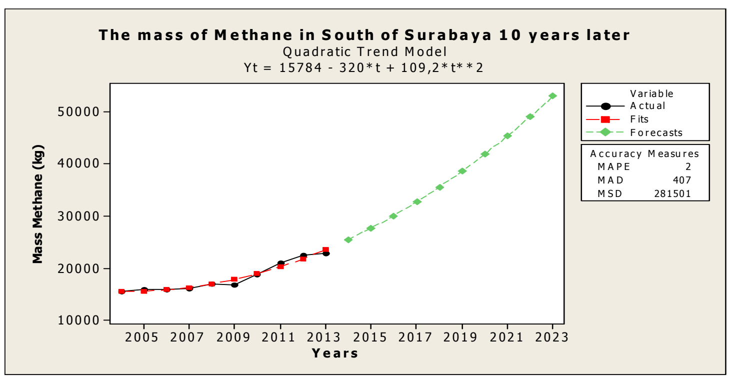

Figure 2 Prediction of the mass of CH_4 domestic activities in south of Surabaya

The potential magnitude of predicted electrical energy is generated from domestic activities in the South part of Surabaya. The data from the results of the calculation of the magnitude of the mass of methane is converted into electrical energy (kWh) 10 years prior and then carried out the calculation of the potential electric energy (kWh) 10 years post with based calculation of Bent [15], where 1 m^3 gas metana = 11.17 kWh, as presented in Figure 3.

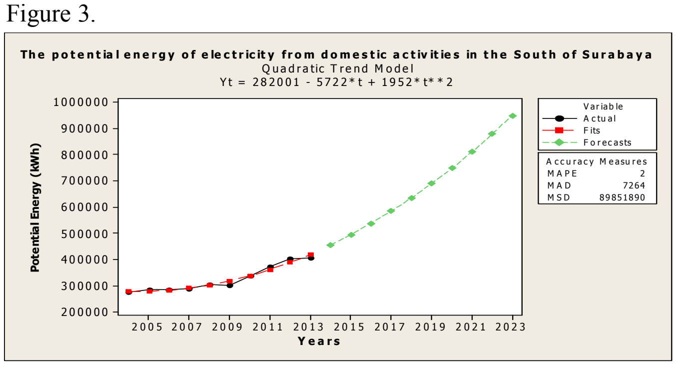

Figure 3 The potential energy of electricity from domestic activities in south of Surabaya

From figure 3, thereis an increase value in the potential energy of electricity annually over the magnitude of the methane gas produced in the first period of the predictions for 2005. The amountstated by275,883 kWh/yearcontinuing up to 2015 period by the amount of455,216 kWh/yearas well as the peak periods of the year 2023 to 748,773 kWh/year.The existence of the utilization emissions into renewable energy is directly proportional to the reduction that occurs by greenhouse gases. Therefore, in Figure 4 is presented emission reduction greenhouse gases with diversion of methane from domestic activities.

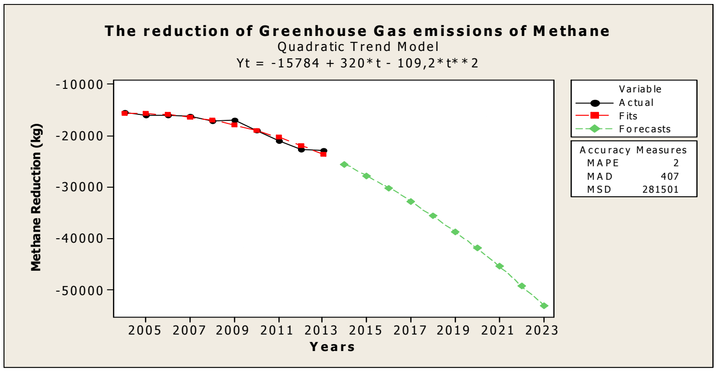

Figure 4 The reduction of greenhouse gas emissions with the transfer of CH_4 from domestic activities in south of Surabaya

The influence in the utilization of methane also affects greenhouse gas reduction that became a phenomenon of global warming. Every year, when the gas causes greenhouse gas such as methane exploited then the greenhouse gas, itwill self reduced as shown in Figure 4.In the period of 2005, the value reduced to -15,441 kg/year and continuing to decrease to the 2015 period amounted to -27,672 kg/yearas well as the peak periods in the year 2023 in the amount -53,076 kg/year.

From the survey results,the sampling point locations are dertermined. The location consists of offices, shops, malls, restaurants, hotels and hospitals in south of Surabaya. From the results, it obtained an average usage of clean water from each sampling.It will look for 70%, which is the waste water. From the use of clean water, it will be obtained by the assumption of value of a population equivalent.The average results from each sample was presented in Table 1.

Table 1 The number and the average data of wastewater generated from non-domestic activities of population equivalent

Non Domestic		m3/years	m3/month	m3/day	person/month	person/day
Mall	total	583696.4	48641.4	1621.4	315853	10528
	average	83385.2	6948.8	231.6	45122	1504
Hotel	total	24551.1	2045.9	68.2	13285	443
	average	4910.2	409.2	13.6	2657	89
Restaurant	total	9376.5	781.4	26.0	5074	169
	average	1172.1	97.7	3.3	634	21
Shop	total	12583.2	1048.6	35.0	6809	227
	average	2097.2	174.8	5.8	1135	38
Office Space	total	83482.7	6956.9	231.9	45175	1506
	average	2036.2	169.7	5.7	1102	37
Hospital	total	132295.8	11024.7	367.5	71589	2386
	average	44098.6	3674.9	122.5	23863	795

From the above results, it can be seen that the magnitude of wastewater is generated at each point in a location.It has an average right from 70 for non domestic survey locations scattered across the southern part of Surabaya. From each location, itis calculated to get a population equivalent per month and per day average.In Table 2,the present amount of wastewater generated an annual in South of Surabaya is illustrated.From Table 2,a calculation or aggregation to obtain data whilst the magnitude of wastewater from non domestic activities in South of Surabaya are performed, where it is necessary for the needs of performing calculations in predictions 10 years post. Figure 5 shows the curve prediction of 10 yearson the magnitude of wastewater generated from non-domestic activities in south of Surabaya.

Table 2 The amount of wastewater generated from non-domestic activities in south of Surabaya

Non-Domestic	2012	2013	2014	2015	2016
Mall	469211	500267	532373,1	562179.8	583696.4
Hotel	18367	20677	22942,5	23733.5	24551.1
Restaurant	5309	5961	7667,1	9095.8	9376.5
Shop	9156	9853	10439,1	11796.4	12583.2
Office Space	60043	65329	68201,7	73740.1	83482.7
Hospital	119452	120996	122813,6	126238.7	132295.8
Total	681538	723083	764437,1	806784.3	845985.7
Average	113589.7	120513.8	127406,2	134464.1	140997.6

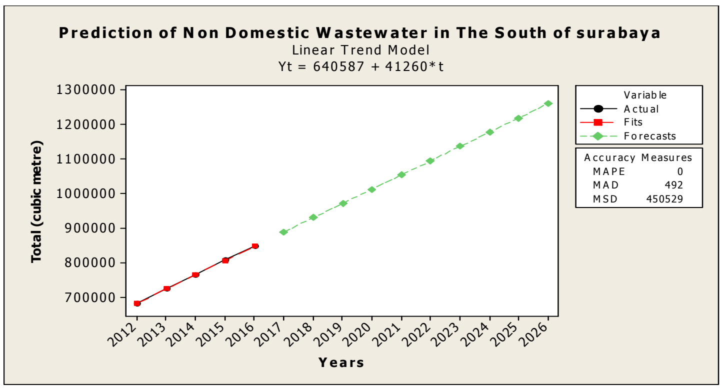

Figure 5 Prediction of wastewater generated from non-domestic activities in south of Surabaya

From figure 5, it can be seen that the trend prediction has an increase in the amount of waste water from non domestic activities on each year.The visible magnitude of waste water produced each year starting in 2012 are681,538 m^3up to the amount of waste water predicted to increase up to the year 2026 by1,218,222 m^3. The total population is equivalent to the proportional number of improvement against the waste water resulting from the activities of non domestic itself.The magnitude prediction on the emissions resulting from the activities of non domestic at Surabaya southern population equivalents is required in this research. Afterwards,the research calculatesthe emissions generated for carbon dioxide and methane in 10 years post, as already presented in Figure 6 and Figure 7.

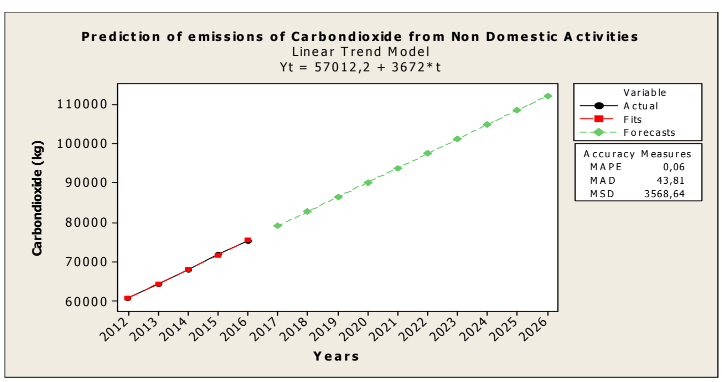

Figure 6 The great prediction of CO_2 emissions from the non-domestic activities in south of Surabaya

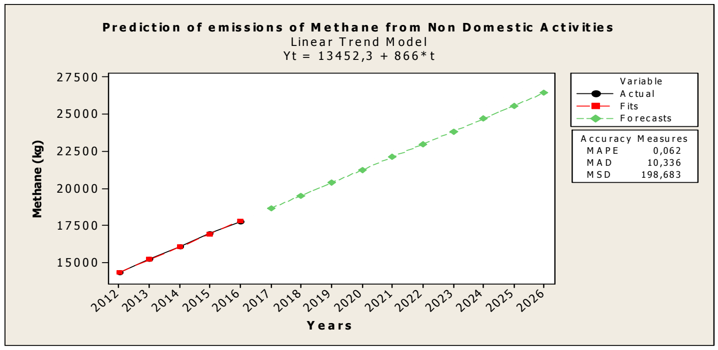

Figure 7 The great prediction of CH_4 emissions from the non-domestic activities in south of Surabaya

From the above figures, it can be seen there is an increase in prediction of trends of emissions of CO_2 and CH_4every year. From Figure 6, the visible magnitude of emissions of CO_2 and CH_4 are produced annually in 2012 by 60,656 kg $CO_2$and 14,312 kg CH_4, until up in the peak 2026of 112,094 kg $CO_2$and 26,449 kg CH_4.

The potential magnitude of predicted electrical energy is generated from non-domestic activities in the south part of Surabaya. It needs a data from the results of the magnitude calculation of the mass of methane. Furthermore, it is converted into electrical energy (kWh) 10 years prior and then carried out the calculation of the potential electric energy (kWh) 10 years postby the based calculation of Bent [15],where 1 m^3 methane gas = 11,17 kWh, as already presented in Figure 8.In Figure 8,it can be seen that the potential electrical energy directly proportional rise against methane annually. This indicates if the emissions such as methane greenhouse gases utilized, then greenhouse gases happens will be increasingly reduced.

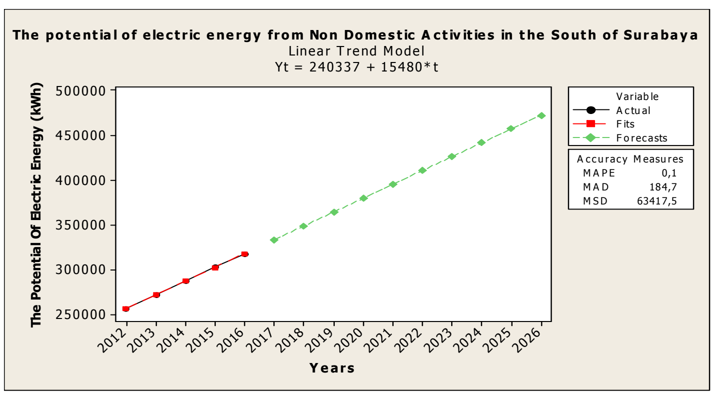

Figure 8 Prediction of Potential electric energy from non-domestic activities in south of Surabaya

The existence of the utilization emissions into renewable energy is directly proportional to the reduction that occurs by greenhouse gases. The influence of the methane utilization affects greenhouse gas reduction that became a phenomenon of global warming. Every year, when the gas causes greenhouse gases such as methane exploited, the greenhouse gases itself will be reduced. Therefore, in Figure 9, it is presented the emission reduction greenhouse gases with diversion of methane from non-domestic activities.

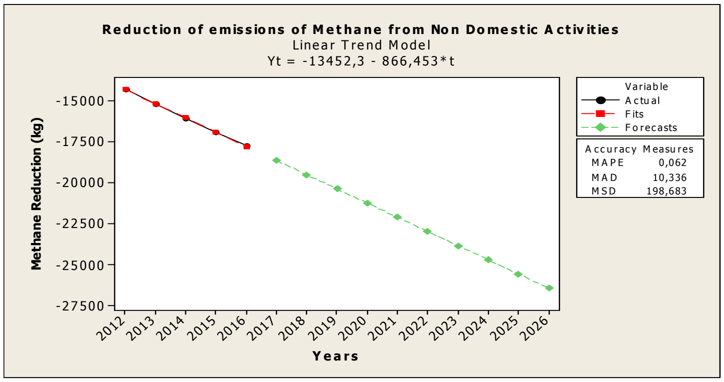

Figure 9. Prediction of CH_4 emission reduction of non-domestic activities at south of Surabaya

In Figure 9,there is a reduction number at the period 2012 until -14,312 kg/year$CH_4$and the reduction keeps increase to period until 2017 to-18,651 kg/year CH_4as well as the peak periods in 2026 to-26,449 kg/year CH_4. From the results, it can be concluded that the influence of utilization emissions itself reduce the impact of global warming. According to IPCC, 1990 [16] , it is necessary to reduce a green house gasses in order to stabilize the atmosphere by reducing CO_2 (> 60%), CH_4 (15-20%), N_2O (70-80 %) and other substances. Based on Ministry of Environment of Indonesia, 2009 [17], the composition of green houses gasses in Indonesia are CO_2 (59,1%), CH_4 (19,1%), N_2O (4,2%), others (17,6%). The data shows that the biggest contributor of green house gasses in Indonesia is CO_2 (Carbon dioxide) and CH_4 (Methane). Based on Indonesia President Regulation No 61/2011 [18], waste management is categorized as a national action plan for reducing green house gasses. One consideration in this regulation is the commitment of Indonesia government in the G-20 meeting at Pittsburg to reduce the green house gasses to 26% or equivalent to 767 million tons CO_2 by self-approach. It is conducted 41% or same as 1189 million tons CO_2 if it is helped by international on year 2020. In specific of waste management, it is targeted to reduce 48 million tons CO_2 by self-approach or 78 million tons CO_2 if it is helped by international on year 2020. In accordance to this information, it is necessary to calculate in precise by prediction equation on green house gasses reduction from domestic and non-domestic waste management. The novelty in this research is a regression equation and it can help to calculate the reduction of green house gasses in a population scale at Indonesia. When the reduction target of green house gasses in Indonesia is fulfilled, it can give a broad impact to global warming.

5. CONCLUSION

1. The magnitude prediction of the emissions at the end of 10 years post for south of Surabaya from wastewater disposal instalation domestic activities are 224,941 kg/yearCO_2and53,076 kg/year CH_4.While the wastewater disposal instalation non-domestic activities are112,094 kg/year CO_2 and26,449 kg/year CH_4.
2. The magnitude prediction of the potential energy on the gas emissions in CH_4 electric at the end of the 10 years post for South of Surabayafromwastewater disposal instalation domestic activities is748,773 kWh/year and from waste water disposal instalation non domestic activities is47,000 kWh/year.
3. The magnitude prediction of the reduction in greenhouse gas emissions with the transfer of emission of CH_4 into biogas in South of Surabaya for 10 years post at waste water disposal instalation domestic activities is-53,076 kg/year CH_4 and from waste water disposal instalation non domestic activities is-26,449 kg/year CH_4.

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