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Greenhouse Gas (GHG) Emission Reduction Model in Surabaya

Intan Ayu Pratiwi[1]*, Eka Prasetyo[2] and Helmi Dadang Ardiansyah[2]

[1]Biology Department, Airlangga University, Surabaya, Indonesia
[2]Tasma Bioenergy, Indonesia

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ABSTRACT

Surabaya as the 2nd largest city in Indonesia is a strategic location for industrial development, making this city as one of important part in the national economy and environment development. Some industrial sectors that are growing rapidly in Surabaya such as; food industrial and transportation sectors, households, as well as an increasing in the number of native and sub-urban populations. This conditions of course has a big impact on Surabaya city. The biggest impact is air quality in Surabaya. The lowest of air quality is Carbon Dioxide (CO_2) emissions existence. Carbon Dioxide is a greenhouse gas that contributes the most of global warming and climate change. This condition has a negative impact on humans, so it is necessary to monitor the growth of Carbon Dioxide emissions resulting from transportation, industrial sector, and households in Surabaya. The purpose of this study was to obtain a carbon dioxide emission prediction model in Surabaya.

Key word : *Surabaya, Carbon Dioxide, Prediction, Model*

Introduction

The industrial area in the city of Surabaya began with a high motor vehicle generation, industrial civil activities, and increasing demands of high population needs. One of them is in the transportation sector which has a crowded activity considering the activities of Surabaya. Facilitation of all vehicle's types from family cars, trucks, public transportations, freight vehicles, and motorbikes that pass in Surabaya especially in rush hours. This can increase the level of air pollution and can have an impact on local temperature rise in Surabaya. The contribution of air pollution from the transportation sector reaches 60%, the remaining 25% in the industrial sector, 10% households and 5% waste (Saepudin and Admono, 2005). This is due to the increase in the number of motorized vehicles each year which is directly proportional to the increase in motor vehicle exhaust emissions. Air pollution arising from the high use of motor vehicles in the carbon emissions form. Carbon emissions which are increasingly due to the increasing the number of motor vehicles can have a negative impact on the environment and also human.

One of the impacts caused by carbon dioxide emissions from motor vehicles is global warming. Global warming can cause the earth's temperature to rise and climate change to occur (Adiastari, 2010). Changes to the environment can increase the temperature in Surabaya city caused by CO_2 gas emissions produced by motor vehicles. The increase in CO_2 concentration is caused by the increasing consumption of fuel oil, coal, and other organic fuels in many human activities (Byeongho *et al.,* 2005). Climate change has been a hot topic of discussion in

the last decade (Kyoto Protocol, 1998). One of them is the greenhouse gas effect. Greenhouse gases are the cause of climate change which not only comes from natural factors but also many from greenhouse gases producing activities. Based on research that has been done, we know, human activity has a significant contribution to increasing the concentration of greenhouse gases in the atmosphere. Increasing the concentration of greenhouse gases in the atmosphere causes the surface temperature of the earth to be higher because it is covered in greenhouse gases atmosphere. Even in a study it is said that human life has a very significant contribution to global processes warming up (IESR, 2011).

The exhaust gases from the combustion of fuel oil contains pollutants such as CO_2 (Carbon Dioxide), NOx (Nitrogen Oxide), CO (Carbon Monoxide), VHC (Volatile Hydro Carbon) and particulate matter (Data and Information Center of Energy and Mineral Resources Ministry of Energy and Mineral Resources, Jakarta, 2012). Based on Kusumawardani and Navastara (2017) research concluded that the traffic counting survey at rush hour in the SIER industrial area, as one of the biggest industrial area in Surabaya at 2017, the daily traffic average is 98019 vehicles on 10 road sections in this area and is divided into 20 vehicle calculation points. With a total of all roads is 12650. The results of the calculation of CO_2 gas emissions using Mobilev software, obtained the total amount of emissions in the SIER industrial area is 3996.92 tons/year. The distribution of CO_2 gas emissions generated by motor vehicles is dominated by the Rungkut Industrial Highway, Kendangsari Street and Rungkut Highway. It can be concluded that the level of CO_2 gas emissions in this region is still high.

Based on Ikhlas *et al.,* (2017), Surabaya has a carbon emissions distribution in each area/region by the transportation sector the total CO2 emissions amounted to 329 Ktons/month or about 3 Ktons/year CO_2. Green open space area in Surabaya with the percentage assumption 20% from the total area of 66.526 km^2 Surabaya with a broad distribution of green open space each area/region amounted to 6.159 km^2 North Surabaya, East Surabaya area of 23.34 km^2, the area of Surabaya Center of 4.75 km^2, South Surabaya area of 14.54 km^2, and West Surabaya area of 17.72 km^2. Hence, it needs an action to reduce carbon dioxide emissions with adding the green open space and doing energy conversion from fuel oil into renewable energy that more environmentally friendly and implementing the policy about traffic and public transportation to reduce the number of private vehicles on the street in Surabaya (Prananda *et al.,* 2015). This study is devoted to present Greenhouse Gas Emission reduction from the effort of Surabaya Government. Development issue from fuel consumption prediction in Surabaya will compare with Surabaya action for number of emission reduction.

Research Procedure

This research conducted through the qualitative method. Data collective has been done with data statistics and official literature. In transportation sector, calculating number of greenhouse gas of Surabaya used data from Sugiyono (2012). Sugiyono (2012) present predictive data of fuel consumption in Surabaya for gasoline and diesel oil from 2005 until 2030. IPCC standard (2007) present calculation method for greenhouse gas emissions and reported in unit of carbon of dioxide equivalent (CO_2e).

$$tCO_2e = E\ CO_2 \times EF\ CO_2 + E\ CH_4 \times EF\ CH_4 + E\ N_2O \times EF\ N_2O \quad \text{..... Eq. 1}$$

Note:

tCO_2e : Equivalent of emission per year for greenhouse gas emission in ton
$E\ CO_2$: Number of CO_2 emission per year
$EF\ CO_2$: Emission Factor of CO_2 emission for 100-year GWP 100 (1)
$E\ CH_4$: Number of CH_4 emission per year
$EF\ CH_4$: Emission Factor of CH_4 emission for 100-year GWP 100 (25)
$E\ N_2O$: Number of N_2Oemission per year
$EF\ N_2O$: Emission Factor of N_2Oemission for 100-year GWP 100 (298)

Environmental Protection Agency of America already listed factors to calculate number of emissions each gas base on fuel type. And some assumption is selected to calculate specific gravity of gasoline and solar respectively. 0.885 and 0.74. Improvement of Surabaya for Greenhouse Gas Emission (GHG) Issue was reported in Surabaya Environment Report (2017) and calculation of Greenhouse Gas (GHG) emission conducted as Surabaya action. Potential reduction of greenhouse gas emission presented using planning of Surabaya for green issue.

Results and Analysis

Pratiwi and Ayu (2020) reported that Surabaya had increased data of number of vehicles, population,

economic domestic in 2014 to 2017, but explained that in preliminary study the improvement of air quality because good government policy in green sector. Comparing data of greenhouse gas emission by year using Sugiyono (2012) data. Table 1 depicts for prediction of GHG number for transportation sector in Surabaya. Number of GHG will increase because number of vehicles increase.

Reported from State of the Environment Report (SoER) of Surabaya 2017, Surabaya already improved of investment to green sector. Some action was collected to this present that have clear number and impact to reduce of Greenhouse Gas. Initiate program for green energy already started in 2016, and in 2017 already run for developing municipal solid waste (MSW) to energy (PLTSa) with capacity 2 MW. Based on Table 2, MSW Power Plant called PLTSa Benowo can reduce 15156 tCO_2e per year. 1.65 MW from total capacity send to electrical grid and the rest for process facility.

Solar Cell also driven by Surabaya government regarding report SoER (2017). Total installed capacity 3000 W spread out in government building, school and public facility. This action can reduce greenhouse gas to be 9851 tCO_2e per year.

Renewable Electricity applied in Surabaya is not only by Solar Cell but also by wind turbines. Pilot project of Wind turbine created for education facility and lightning by Surabaya Government for Kenjeran Beach Amusement Park. Total power gen-

Table 1. Prediction of Total Greenhouse Gas (GHG) for Transportation Sector in Surabaya.

	Unit	2005	2010	2015	2020	2025	2030
Motor Gasoline	Million Litters	410.00	480.00	550.00	630.00	720.00	830.00
Diesel Oil		340.00	350.00	350.00	350.00	360.00	360.00
Motor Gasoline	Million Tons	0.36	0.42	0.49	0.56	0.64	0.73
Diesel Oil		0.25	0.26	0.26	0.26	0.27	0.27
Motor Gasoline	Million MMBtu	0.05	0.05	0.06	0.07	0.08	0.09
Diesel Oil		0.03	0.04	0.04	0.04	0.04	0.04
Motor Gasoline	kg CO_2 Emission	3322345.31	3889575.00	4456804.69	5105067.19	5834362.50	6725723.44
Diesel Oil		2455761.93	2527990.22	2527990.22	2527990.22	2600218.51	2600218.51
Motor Gasoline	kg CH_4 Emission	136.07	159.30	182.53	209.08	238.95	275.46
Diesel Oil		104.92	108.00	108.00	108.00	111.09	111.09
Motor Gasoline	kg N_2O Emission	27.21	31.86	36.51	41.82	47.79	55.09
Diesel Oil		20.98	21.60	21.60	21.60	22.22	22.22
Motor Gasoline	tCO2e	3333.86	3903.05	4472.25	5122.76	5854.58	6749.03
Diesel Oil		2464.64	2537.13	2537.13	2537.13	2609.62	2609.62
Total tCO2e	5798.49	6440.18	7009.37	7659.88	8464.19	9358.64	

Table 2. Calculation Greenhouse Gas for PLTSa Benowo

No considering full cycling for truck, plant activities, and power required		
Assumption		
Installed Capacity	2000	W
Peak Hours	24	Hour
Operating Day	365	Days/Year
Power Operating	17520	MWh/Year
Emission factor Calculation for Electricity Generation		
CO_2	862	kg /MWh
CH_4	0.02041	kg /MWh
N_2O	0.00855	kg /MWh
Emission from Electricity Generation		
CO_2	15102240.00	Kg
CH_4	357.58	Kg
N_2O	149.80	Kg
Total emission reduction	15155819	$kgCO_2e$
	15156	tCO_2e

erated is 400 W and Greenhouse Gas reduction is 1263 tCO_2e per year (Table 4).

Program 3R (reduce, reuse, recycle) from Surabaya government shows good promise in greenhouse gas reduction. 3R can utilize the waste in community. The impact is reduction the total waste of Surabaya from 1571319 kg/day to be 1477320 kg/day in 2017 (State of the Environment Report (SoER) of Surabaya 2017). This potential also reduces waste truck transportation to bring to final collecting point in PLTSa Benowo. Total reduction is 0.30 tCO_2e as Table 5 and Table 6.

Total prediction of Greenhouse Gas in Transportation sector in 2020 is 7659.88 tCO_2e. And result from general calculation as impact Surabaya government policy is 26270.3 tCO_2e. The benefit of Greenhouse gas reduction derived from pilot project of PLTSa Benowo contribute 15156 tCO_2e, Policy implementation in solar cell and wind turbine, 9851 and 1263 tCO_2e respectively, and the rest

Table 5. Assumption Data per Year

No considering full cycling for truck, plant activities, and power required		
Assumption		
Operating Day	365	Days/Year
Truck Capacity	18	Ton/truck
Average Distance(Centre of Surabaya to PLTSa Benowo)	27	km /trip
Operating of Truck	2	trip
Fuel consumption	0.4	l/km

Table 3. Calculation of Greenhouse Gas for Surabaya Solar Cell

No considering full cycling for truck, plant activities, and power required		
Assumption		
Installed Capacity	3120	W
Peak Hours	10	Hour
Operating Day	365	Days/Year
Power Operating	11388	MWh/Year
Emission factor Calculation for Electricity Generation		
CO2	862	kg /MWh
CH4	0.02041	kg /MWh
N2O	0.00855	kg /MWh
Emission from Electricity Generation		
CO2	9816456.00	kg
CH4	232.43	kg
N2O	97.37	kg
Total emission reduction	9851.282	$kgCO_2e$
	9851	tCO_2e

Table 4. Calculation Greenhouse Gas for Wind Turbine in Kenjeran Beach Amusement Park

No considering full cycling for truck, plant activities, and power required		
Assumption		
Installed Capacity	400	W
Peak Hours	10	Hour
Operating Day	365	Days/Year
Power Operating	1460	MWh/Year
Emission factor Calculation for Electricity Generation		
CO2	862	kg /MWh
CH4	0.02041	kg /MWh
N2O	0.00855	kg /MWh
Emission from Electricity Generation		
CO2	1258520.00	kg
CH4	29.80	kg
N2O	12.48	kg
Total emission reduction	1262.985	$kgCO_2e$
	1263	tCO_2e

Table 6. Calculation of Greenhouse Gases for Impect of 3R Program in Surabaya

Parameter	2016	2017	Unit
Total Waste	1571310	1477320	kg/day
	573528	539222	ton/year
Trip of Truck	31863	29957	trip/year
Total Trip of Truck	63725.35	59913.53	trip/year
Total Distance	1720584.45	1617665.40	km/year
Truck Fuel Consumption	688233.78	647066.16	litter/year
	509.29	478.83	ton/year
	70.79	66.56	mmBtu/year
CO_2	4971	4673.65	Kg
CH_4	0.21	0.2	Kg
N_2O	0.04	0.04	Kg
Total emission	4.99	4.69	tCO_2e
Total emission reduction	0.30	tCO_2e	

is 0.30 tCO_2e from community development with 3R program. Using this data Surabaya can reduce 18610.42 tCO_2e. Complexity of Greenhouse shall be further checked and include Greenhouse gas reduction from industrial sector in Surabaya. Maulana *et al.,* (2014) reported that the type of housing in Surabaya gives different results of CO_2 emission. Reduction of Greenhouse also shall consider with public transportation improvement, and green open space. Taufik *et al.,* (2019) calculated Greenhouse Gas reduction with open space in Surabaya.

Conclusion

Surabaya government presented good policy in environment issue. As per calculation with some assumption and repressive data, Surabaya can reduce Greenhouse Gas Emission to 18610.42 tCO_2e. Renewable energy plays big portion in reduction of Greenhouse Gas Emission comparing another program such as 3R in Surabaya. Specific investigation can conduct with consider industry activity and social activity to describe distribution of Greenhouse Gas Emission.

References

Abdullah, T. and Boedisantoso, R. 2019. Perhitungan Ruang Terbuka Hijau Berdasarkan Emisi Karbon Dioksida. *Journal Pijar MIPA.* 14 (1) : 95-99.

Adiastari, R. Kajian Mengenai Kemampuan Ruang Terbuka Hijau dalam Menyerap Emisi Karbon di Kota Surabaya. Institut Teknologi Sepuluh Nopember. 2010.

Byeongho, L., Tae, S. H., Shin, S. W. and Yeo, Y. 2005. Carbon Dioxide Reduction Through Urban Green Open Space in the case os Sejong City Master Plan. *International Conference on Sustainable Building Asia.*

Data and Information Center of Energy and Mineral Resources Ministry of Energy and Mineral Resources, "Assessment of Greenhouse Gas Emissions Transportation Sector", Jakarta.

Ikhlas, N., Abdullah, T. and Boedisantoso, R. 2017. Calculation Method of Green Open Space based on Carbon Emission from Transportation Sector in Surabaya," IPTEK. *The J. for Tech. and Science*. 28(2).

Institute for Essential Services Reform (IESR). 2011. Potensi Penurunan Emisi Indonesia Melalui Perubahan Gaya Hidup Individu". 2011.

Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report (AR4).

Kusumawardani, D., and Navastara, A. M. 2017. Analisis Besaran Emisi Gas CO2 Kendaraan Bermotor pada Kawasan Industri SIER Surabaya. *J. Teknik ITS.* 6 : 2.

Kyoto Protocol to the United Nations Framework Convention on Climate Change. 1998.

Maulana, Affan Sani; Setiawan, Rulli Pratiwi. Keterkaitan Tipe Hunian dengan Emisi CO2 di Kota Surabaya. Jurnal Teknik POMITS Vol 3. 2014

Prananda, J., Hantoro, R. and Nugroho, G. 2015. The Prediction of Carbon Dioxide Emission using ARIMA for Support Green Energy Development in Surabaya Minicipallity," KnE Energy, New, *Renewable Energy and Energy Conservation Conference and Exhibition.*

Pratiwi, I.A. and Ayu, R.P. 2020. Surabaya Strategy to Answer Air Pollutant Improvement. *Eco. Env. & Cons.* 26 (March Suppl. Issue): EM International

Saepudin, T., and Admono, A. 2005. Kajian Pencematan Udara Akibat Emisi Kendaraan Bermotor di DKI Jakarta, *J. Teknol. Indones.*

Solid, gaseous, liquid and biomass fuels: Federal Register (2009) EPA; 40 CFR Parts 86, 87, 89 et al; Mandatory Reporting of Greenhouse Gases; Final Rule , 30Oct09, 261 pp. Tables C-1 and C-2 at FR pp. 56409-56410. Revised emission factors for selected fuels:

Federal Register (2010) EPA; 40 CFR Part 98; Mandatory Reporting of Greenhouse Gases; Final Rule, 17Dec10, 81 pp. With Amendments from Memo: Table of Final 2013 Revisions to the Greenhouse Gas Reporting Rule (PDF) to 40 CFR part 98, subpart C: Table C–1 to Subpart C—Default CO2 Emission Factors and High Heat Values for Various Types of Fuel and Table C–2 to Subpart C—Default CH4 and N2O Emission Factors for Various Types of Fuel.

State of the Environment Report (SoER) of Surabaya 2017 by Surabaya Environmental Service.

Sugiyono, A. 2012. Prakiraan Kebutuhan Energi untuk Kendaraan Bermotor di Perkotaan: Aspek Pemodelan. *Jurnal Sains and Teknologi Indonesia*. 14: (2).

Surabaya government, Regulation of Surabaya Mayor no 76/2016 for Regional Development Plan Work of Surabaya. 2016.