The difference of level CO2 emissions from the transportation sector between weekdays and weekend days on the City Centre of Pemalang

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Abstract. The high growth of human activity potentially increases the number of vehicles and the use of fossil fuels that contribute the increase of CO2 emissions in atmosphere. Controlling CO2 emission that causes greenhouse effect becomes the main agenda of Indonesian Government. The first step control CO2 emissions is by measuring the level of CO2 emissions, especially CO2 emissions from fossil fuel consumption in the transport sector. This research aims to assess the level of CO2 emissions from transportation sector on the main roads in the city centre of Pemalang both in weekdays and weekend days. The methods applied to calculate CO2 emissions using Intergovernmental Panel on Climate Change (IPCC) 2006 method. For this, a survey on the number of vehicles passing through the main roads using hand tally counter is firstly done. The results, CO2 emissions in working day, i.e. 49,006.95 tons/year compared to weekend i.e. 38,865.50 tons/year.

1. Introduction

The high growth of people in a region is the early emergence of environmental problem due to the increased variety of human needs [1]. Population growth requires new residential developments in the suburbs. The development of the settlement which today is far from community activities to encourage people to find a mode of transportation. Transportation required in support of the activities of the community everyday. Transportation is an important means for the community both in the community and facilitate mobility as well as goods. The transport needs of the community will encourage people in the purchase of the vehicle in particular motor vehicles. This has resulted in an increasing number of motor vehicles and as well as increased emissions of gasses such as CO2 as a b-product of combustion of fossil fuels used by motor vehicles. The level of concentration of CO2 gas emissions that exceeded the normal limit may negatively impact humans and the environment. Despite the use of motor vehicles resulting in increased fuel usage so that gas emissions containing pollutants will also increase. The use of motor vehicles by people on weekdays and weekend will be different to affect the magnitude of the emissions of CO2 are produced and released into the environment.
The growth of the city center of Pemalang became the center of trade, services, education, offices and health services enables an increasing number of vehicles on some streets in the city center of Pemalang and increased energy consumption as a consequence of the rapid growth of the city is the increased mobility of the population, either in the city or between city. A growing number of private two wheel vehicle, three wheels and four wheels are hard to avoid. Procurement and distribution of gasoline in the city of Pemalang have increased more or less by 2.32%, whereas solar procurement experience an increases of 3.65%[2].

Most of the sources of energy used come from fossil fuels. The use of fossil fuels results in the occurrence of air pollution due to some major pollutant derived from fossil fuel use[1], [3]. The largest fossil fuel consumption in the city of Pemalang comes from the transport sector and the sector is contributing the biggest polluters as it does occur in large cities such as occurs in large cities. Research conducted by the Soehodho mention that transportation accounts for 70% of total pollutants that enter the atmosphere in Jakarta[4]. Therefore, the study of inventory of CO2 emissions is done to inventory emissions of CO2 in the transport sector in Pemalang on 1 (one) working day and 1 (one) day off to know how big a difference levels of emissions caused by motor vehicles at the time of the working days and weekend days.

2. Literature Review

2.1. Air Pollution Resources

Sources of air pollution come from natural resources and the result of human activity (anthropogenic) such as fuel combustion in transportation, power plants and use of boilers in the industry[5],[6]. The largest anthropogenic resources that cause air pollution comes from transportation activities.

2.2. Motor Vehicle Emissions

The air in the atmosphere under normal conditions the gas mixture is composed of 78% nitrogen, 20% oxygen, 0.93% argon, 0.03% carbon dioxide and the rest consists of neon, helium, methane, and hydrogen. The condition of the air in the atmosphere can be said to be contaminated when changing the composition of the air. Changes in the composition of the incoming air can occur due to or inclusion of substances, energy and/or other components resulting from an activity that is potential as polluters[7]. The main pollutants produced by motor vehicles which can cause air pollution, among others, dust, carbon monoxide, carbon dioxide, hydrocarbons, nitrogen oxides and sulfur oxides [1], [3]. The resulting carbon emissions from motor vehicles is one of the causes of global warming because most emissions contribute to global warming is carbon dioxide (CO2) besides methane (CH4), dinitro oxide (N2O), perfluorocarbons (PFC), hydrofluorocarbon (HFC), and sulfurhexafluorid (SF6). According to the United Nations Framework Convention On Climate Change in addition to the six types of greenhouse gasses, there are some gasses also enter into the greenhouse gasses include carbon monoxide (CO), nitrogen oxides (NOx), chlorofluorocarbon ( CFC) and gas - gas metal organic non-other volatiles. Three main types of gas that most so-called greenhouse gasses are CO2, CH4, N2O, because it is considered as a gas layer which acts as a trap heat wave and the end - the end concentration in the atmosphere continue to rise until doubled [8]. Based on calculations in the last few years, the CO2 contribution towards global warming reached more than 60%. CO2 emissions increase, amounting to 27.0 billion tons of CO2 in 2004 or average increased by 1.6% per year. Contributor to CO2 emissions are spread is the United States (21.9% of total world CO2 emissions), followed by China (17.4%), India (4.1%). While Indonesia accounted for emissions of 1.2%. The main source of CO2 emissions comes from fossil fuel use (74% of total emissions in the world), followed by a land convention (24%) and the cement industry (3%)[9].
3. Methods
An inventory study of CO2 emissions from the transport sector this is done through a quantitative methodology in 11 (eleven) of the main roads in the city center of Pemalang based on Survey guidelines for counting traffic by manual, Number: Pd, T-19-2004-B using a hand tally counter. Selection of the city center of Pemalang as a location because it’s the center of trade, services, education, offices and health service. The kind of vehicles that surveyed was differentiated into 3 main types of motorcycle, light vehicles, and heavy vehicles. Survey on the volume of traffic on the roads done the 12 hours on 1 (one) working day (weekday) and 1 (one) holidays (weekend) which is divided into three periods of time in the morning peak hours (6:00 to 10:00 a.m.), during peak hours (11:00 a.m. to 3:00 p.m.) and afternoon peak hours (4:00 p.m. to 8:00 p.m.).

A method for calculating CO2 emissions is very diverse and constantly evolving, but the calculation of the CO2 emissions that were used by the Government of Indonesia refers to a method of the Intergovernmental Panel on Climate Change. The analytical calculation of the CO2 emissions calculated based on emission factors or the coefficients of fuel types used to then multiply by the amount of fuel consumption in accordance with the method of mathematical calculations the IPCC 2006 Guidelines. The basic model calculations of GHG emissions as follows\textsuperscript{10}:

\[ \text{GHG Emissions} = \text{Activity Data} \times \text{Emission Factor} \]  \hspace{1cm} (1)

GHG Emissions: Total GHG Emissions
Activity Data: The quantitative magnitudes of human activity or activities that can release and/or absorb GHG
Emissions Factor: A quantity that indicates number of GHG emissions that would be released from a specific activity.

Data activity in equation 1 is the abundance of fuel consumption or the consumption of energy by vehicles passing through a road section, in this case, the energy consumption is converted first into units energy Terra Joule (tj) with the formula:

\[ \text{Energy Consumption} \ (\text{tj}) = \text{Energy Consumptions} \ (\text{ltr/km}) \times \text{Number of vehicles} \times \text{Length of road} \ (\text{km}) \times \text{Heat value} \ (\text{tj/ltr}) \]  \hspace{1cm} (2)

4. Results
4.1. Data Traffic Volume
Counting the number of vehicles in the CO2 gas emissions calculations done in several main roads in the city center of Pemalang that is Sudirman street, A Yani, Pemuda, Jenderal Gatot Subroto, Slamet Riyadi, Dr. Cipto Mangunkusumo, Perintis Kemerdekaan, Moh. Yamin, Letjend. Suprapto, Mochtgar and Urip Sumoharjo as presented in Figure 1.
Based on the results of the traffic enumeration in 11 (eleven) of roads during the twelve (12) hours, the vehicles dominate on weekdays and weekend days is a motorcycle, followed respectively by car, pick-up/small trucks, freight/small buses, and large/heavy trucks/buses. Traffic volume retrieved from results of traffic counting is served in units of passenger cars by means of multiplying the value of passenger car equivalent (emp) with the existing traffic volume. The value of the emp to light vehicles is equal to 1, the value of the emp to motorcycle equals 0.25 and emp for heavy vehicles equals 1.2\[^{11}\]. The value of the emp is not the same as each vehicle types have different characteristics.

From table 1 it can be noted that after converted into units of passenger cars, total volume of vehicles on weekdays is 10,637.27 units of passenger cars /hour while on weekend days is 8,855.86 units of passenger cars/hour. Light vehicles and motorcycle is a vehicle that dominant on most location research. The number of light vehicles on weekdays is 4,971.31 units of passenger cars /hour and weekend days is 4,483 units of passenger cars/hour whereas the volume of motorcycle on weekdays is 4,347.85 units of passenger cars/hour and weekend days is 3,509.96 units of passenger cars/hour.

Table 1 shows that in weekdays, Moch. Yamin street has the highest traffic density with total volume of vehicle is 1,454.84 units of passenger cars/hour, and Perintis Kemerdekaan is the second-highest traffic density after Moch. Yamin street with total volume of vehicle is 1,306.27 units of passenger cars /hour then followed by Jend. Sudirman, Jend. Gatot Subroto, Letjend. Suprapto, Mochtar, Pemuda, Dr. Cipto Mangunkusumo, Urip Sumoharjo, Ahmad Yani and Slamet Riyadi while on the weekend days, Moch. Yamin street has the highest traffic density with total volume of vehicle is 1,155.79 units of passenger cars/hour, and Perintis Kemerdekaan is the second-highest traffic density after Moch. Yamin street with total volume of vehicle is 1,089.74 units of passenger cars/hour then followed by Jend. Sudirman, Jend. Gatot Subroto, Mochtar, Letjend. Suprapto, Pemuda, Dr. Cipto Mangunkusumo, Ahmad Yani, Urip Sumoharjo, and Slamet Riyadi.
Based on the results of the calculation of the CO2 emissions at table 2, on weekdays amounted to 5,594.40 kg/hour or 49,006.95 tons/year of CO2 emissions while on weekend is 4,436.70 kg/hour or 38,865.50 tons/year with the largest emissions of contributors is light vehicles followed by heavy vehicles later motorcycles. On weekdays, the percentage of light vehicles accounted for 54.27% of total emissions.
emissions generated while on weekends, light vehicles accounted for the percentage of 59.56% of the total emissions generated. Roads with the highest emissions of CO2 is the largest Jend. Letjend. Suprapto street where vehicles that dominate on this road are heavy vehicles (trucks and buses) as well as lighter vehicles.

From table 2 it can be noted that in weekdays, Letjend. Suprapto street has the highest emissions of CO2 with total emissions of CO2 is 13,476.17 tons/year, and Moch. Yamin has the second-highest emissions of CO2 after Moch. Yamin street with total emissions of CO2 is 9,390.37 tons/year then followed by Jend. Sudirman, Perintis Kemerdekaan, Jend. Gatot Subroto, Pemuda, Mochtar, Ahmad Yani, Dr. Cipto Mangunkusumo, Urip Sumoharjo, and Slamet Riyadi while on the weekend days, Letjend. Suprapto street has the highest emissions of CO2 with total emissions of CO2 is 9,771.73 tons/year, and Moch. Yamin has the second-highest emissions of CO2 after Moch. Yamin street with total emissions of CO2 is 6,849.57 tons/year then followed by Jend. Sudirman, Perintis Kemerdekaan, Jend. Gatot Subroto, Pemuda, Mochtar, Ahmad Yani, Dr. Cipto Mangunkusumo, Urip Sumoharjo, and Slamet Riyadi.

Based on the results of the survey in table 1 and calculation in table 2, the number of vehicles passing through a road can not be inferred automatically that the CO2 gas emissions will be high because that determine the high or low of CO2 gas emissions are the type of vehicle which passes through the road. For example, on the weekdays data traffic volume of Perintis Kemerdekaan street is 1,306.27 units of passenger cars/hour and Letjend. Suprapto street is 1,159.38 units of passenger cars/hour but total CO2 gas emissions of Perintis Kemerdekaan street lower than Letjend.Suprapto street where the CO2 gas emissions of Perintis Kemerdekaan street is 5,635.87 tons/year and Letjend. Suprapto street is 13,476.17 tons/year. The types of vehicles that pass through Perintis Kemerdekaan street dominated by light vehicles and motorcycles while the types of vehicles that pass through Letjend. Suprapto dominated by light vehicles and heavy vehicles. Heavy vehicles is the type of vehicle that produces the largest of CO2 gas emissions because heavy vehicles have a large engine capacity. The larger engine capacity, the more fuel required therefore CO2 gas emissions produced are high.

5. Conclusion

The levels of CO2 emissions generated by motor vehicles at 11 (eleven) roads of Pemalang City on working days larger than a weekend. Based on the results of the calculation of the CO2 gas emissions, on working days amounted to 5,594.40 kg/hour or 49,006.95 tons/year of CO2 emissions while on weekend 4,436.70 kg/hour or 38,865.50 tons/year.

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