Carbon Dioxide (CO_2) Study Plan for the Development of Monorail in Makassar City Based on Life Cycle Assessment (LCA)

Rahmadi, Mary Selintung, M. Isran Ramli

***Abstract:** Air contamination has turned into a difficult issue in huge urban communities on the planet. Urban air contamination has affects human wellbeing. The city of Makassar as a center for the development of strategic areas in eastern Indonesia are tends to experience rapid growth in various fields including the transportation sector as a support for community activities which are very important at this time. Thus in this work, assessment of the impact of Carbon Dioxide (CO_2) quantities resulting from the implementation of the development plan and operation of the Makassar City Monorail with the Life Cycle Assessment (LCA) method was done. Findings showed that, for the implementation of monorail operations, there will be a reduction in CO_2 emissions resulting from the transfer of transport modes. In pre-construction that has the impact of heavy equipment mobilization and labor mobilization, the preparatory work also results in CO_2 impacts.*

***Keywords:** Carbon Dioxide, Life Cycle Assessment, Transportation.*

I. INTRODUCTION

Air pollution has become a serious problem in big cities in the world. Urban air pollution which has an impact on human health and the environment has been widely known for approximately the last 50 years [1]. In addition to the impact on human health, air pollution can also have a negative impact on ecosystems, materials and buildings, vegetation and visibility [2]. Some studies also mention that the decline in air quality in urban areas can be expected from high fuel consumption for the transportation sector, around 53% [3]. The high use of fuel oil has caused the contribution of the transportation sector to the decline in air quality in various large cities in the world is quite large, reaching an average of 70% [4]. Indonesia's annual emissions from 3 energy sectors reach 275 million tons of carbon dioxide equivalent or about 9% of Indonesia's total emissions [5].

In terms of per capita, Indonesia's greenhouse gas emissions have grown 173% since 1980, or 75% since 1990 [5]. It is estimated, with the current government policy that tends to support the development of fossil fuels coupled with the large obstacles to the development of renewable energy, emissions from the energy sector will tend to increase sharply threefold by 2030 [6-8].

The air pollution control approach currently being implemented by the Regional Government is the legislation approach in the form of quality standards, both emission quality standards and ambient air quality standards through the Decree of the Governor of South Sulawesi No. 14 of 2002 [9]. In the ambient air quality standard is determined the highest pollution level for certain exposure time [10]. Various efforts to tackle air pollution have been carried out both in the context of prevention and mitigation, in the form of improving fuel quality, streamlining traffic management, tightening emission standards and law enforcement, but not all have been implemented optimally so that the level of congestion and air pollution still increase [11].

The city of Makassar as a center for the development of strategic areas in eastern Indonesia, tends to experience rapid growth in various fields including the transportation sector as a support for community activities which are very important at this time [12]. This can be seen from the increase in the number of vehicles in the city of Makassar, both public and private vehicles which reached around 856 thousand units in 2010 with a growth reaching 20% per year [13]. The growth rate of an area is strongly influenced by the level of income of an area the higher the amount of income of an area, the higher the crime rate in an area.

Rapid vehicle growth in large cities reflects the inadequacy of the City transportation system. People are encouraged to use private cars and motorbikes because of the absence of public transportation that is comfortable, safe, cheap and timely [14]. The growth of the number of vehicles that are not proportional to the increase in the volume of roads that tends to be static results in a slowdown to congestion in various roads. This results in a waste of vehicle fuel consumption and also the accumulation of emissions and air quality degradation

To reduce the level of congestion, the Makassar City government plans to build mass transportation equipment in the form of Monorail trains that will help smooth the economy of Makassar City.

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Rahmadi, Department of Environmental Engineering, Faculty of Engineering, University of Hasanuddin, Jl. PerintisKemerdekaan Km. 10, Tamalanrea, Makassar, 90245, Indonesia.

Mary Selintung, Department of Environmental Engineering, Faculty of Engineering, University of Hasanuddin, Jl. PerintisKemerdekaan Km. 10, Tamalanrea, Makassar, 90245, Indonesia.

M. Isran Ramli, Department of Environmental Engineering, Faculty of Engineering, University of Hasanuddin, Jl. PerintisKemerdekaan Km. 10, Tamalanrea, Makassar, 90245, Indonesia,

But on the other hand it cannot be separated from the components called air; therefore there is a need for an assessment or analysis of the amount of CO_2 emissions resulting from the Makassar City Monorail development plan to overcome the congestion level of Makassar City. Thus in this work, assessment of the impact of Carbon Dioxide (CO_2) quantities resulting from the implementation of the development plan and operation of the Makassar City Monorail with the Life Cycle Assessment (LCA) method was done

II. METHODOLOGY

Research Location and Time

The implementation of the primary survey was carried out in two stages, the first stage, namely the preliminary survey, was conducted in August 2013, then the second phase, the main survey was conducted in October 2013.

Population and Samples

Population is a collection of the objects under study, the population in this study are all users of city transportation (pete-pete) in Makassar City, this population is uncertain and varies every day, so this population is approached as an infinite / unclear population .The computed sample size for this work is 1570 respondents for the infinite population approach and 1560 respondents for the finite population

Data Collection

Data collection techniques were carried out by questionnaire surveys based on stated preference method. The primary data and modal choice, obtained through the survey results with questionnaires, which is used in this study is that the individual characters of the survey mode users will find information about the respondent's background and what modal choices they will use to switch to the Monorail mode so that they know how much is the reduction in vehicle usage by modal shift to the Monorail. Secondary data used in this study is the monorail plan / concept. Secondary data in this study were obtained through literature study, internet search and data retrieval to relevant agencies

Data Analysis Method

CO_2 Emissions before Monorail Operation and after operation. The emission calculation phase is carried out by grouping based on the GHG emission source and converting the value of GHG emissions to be equivalent to carbon dioxide emissions. Processing and analysis of data for GHG emissions is carried out by calculating CO_2 emissions. Using Simapro software, all stages of the life cycle have been modeled, given that all necessary data has been collected.

III. RESULT AND DISCUSSION

The volume calculation referred to here is obtained from the dimensions of the Monorail construction itself multiplied by the length or planned route. All dimensions of the monorail construction component are obtained from the drawing of the monorail construction plan. and the width of each monorail construction component. There are four important components in the calculation of volumes including pile cap, column / pillar, crosshead and beam / girder, of the four components having such a large impact in terms of implementation and operation of the Monorail in Makassar City. As for the volume calculation results can be seen from Table 1. From Table 1, it is observed that that has a large enough volume that is in the column or pillar component that is equal to 20498.688 m^3, where for the volume of the pile cap is 49593.6 m^3 for the cross head of 16393.44 m^3 and the last beam / girder component is 14581.6 m^3. So that the total of the total volume carried out is 231967,328 m^3. The volume calculation value is used as the basis for determining the amount of CO_2 emissions that occur.

Table. 1 Results of calculation of the main construction volume of the Monorail

No	Monorail construction component	Volume	Unit
1	Pile Cap	49593.6	m^3
2	Column/Pillar	20498.688	m^3
3	Cross Head	16393.44	m^3
4	Beam/Girder	145481.6	m^3
Total		231967.328	

During the construction process equipment are used that can emit CO_2 emissions that can affect the surrounding environment. Table 2 provides an explanation of the amount of CO_2 emissions that occur during the construction process. From Table 2 it is obtained that the amount of CO_2 emissions from the construction process of the four stages of the work implementation, in the implementation phase of the earthworks contributed 79% with CO_2 emissions of 3969.22 tons of CO_2, pile cap contributed 12% with the amount of CO_2 emissions of 577.77 tons of CO_2, column / pillar of 5% with total emissions of 238.81 tons of CO_2, in the implementation of cross head work of 4% with total CO_2 emissions of 190.98 tons of CO_2, at the implementation stage of beam / girder work is 0.005% with total CO_2 emissions of 24.78 tons CO_2.

Table. 2 CO_2 emissions generated by the construction process

No	Implementation Phase	Equipment	Volume	Emission Co_2 (ton)
1	Land Works	Excavator	49593.6	2563.99
		Whell loader	49593.6	1224.96
		Dump Truck	49593.6	174.07
		Labor	12398.4	6.20
2	Pile Cap	Ready Mix	49593.6	29.76
		Concrete Pump	49593.6	381.87
		Vibrator	49593.6	104.15
		Labor	123984	61.99
3	Column /Pillar	Ready Mix	20498.688	12.30
		Concrete Pump	20498.688	157.84
		Vibrator	20498.688	43.05
		Labor	51246.72	25.62
4	Cross Head	Ready Mix	16393.44	9.84
		Concrete Pump	16393.44	126.23
		Vibrator	16393.44	34.43
		Labor	40983.6	20.49
5	Beam/Girder	Crane	1377	24.51
		Trailer	1377	0.28
		Labor	688.5	0.344
Total				**5001.91**

The process of converting raw materials into semi-finished materials or finished materials requires a certain amount of energy. The size of the energy needed depends on the level of complexity of the production process that must be passed. The more complex the process, the greater the energy consumption, which results in increased emissions that are measured in tons of CO_2. Emissions generated to produce one ton of cement are different from one ton of steel, the amount of emissions for the four types of materials such as steel, cement, fine aggregate and coarse aggregates caused by production so that different emission quantities from the four types of material can be seen in Table 3.

Table. 3 CO_2emissions generated by the production process

No	Material Type	Volume (Ton)	Conversion Factor (Kg CO_2/ ton)	Emission $CO_{2Eqivalen}$ (ton)
1	Steel	46393.466	1.000	46.39
2	Cement	86059.879	2.400	206.54
3	Fine Aggregate	161913.195	12.200	1975.34
4	Rough Aggregate	242869.79	12.200	2963.01
Total				5191.29

From Table 3, it is obtained that the amount of CO_2 emissions from the production process of the four materials, that steel contributes 1% with the amount of CO_2 emissions of 46.93 tons of CO_2, cement of 4% with the amount of emissions 206.54 tons of CO_2, fine aggregate of 38% with the amount of CO_2 emissions amounting to 1975.34 tons of CO2, coarse aggregate of 57% with total CO_2 emissions of 2963.01 tons of CO_2.

From Figure 1, it can be seen from the three construction processes that CO_2 emission, the largest contribution is the transportation process that gives the most CO_2 emissions, this is due to the process of transporting material to the location of the Monorail construction work by involving several modes of transportation. This proves that the use of equipment and the distance of material transport and the amount of material volume are very influential in determining the amount of CO_2 emissions that occur during the construction process.

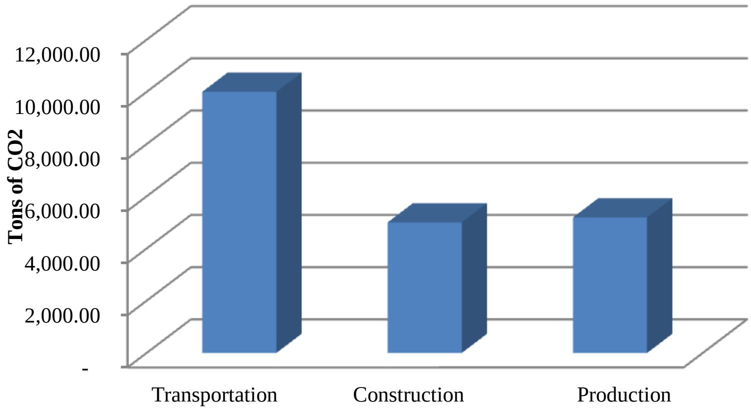

Fig. 1 The magnitude of CO_2 emissions in the main structural work

IV. CONCLUSION

Thus it can be concluded that work conducted that the implementation process of construction will cause the magnitude of the impact in the form of CO_2 produced from the construction process in the form of pre-construction, construction process. For the implementation of monorail operations, there will be a reduction in CO_2 emissions resulting from the transfer of transport modes. In pre-construction that has the impact of heavy equipment mobilization and labor mobilization, the preparatory work also results in CO_2 impacts. In the construction process divided into three processes where the transportation process, the production process and the construction process in this process that produces CO_2 quantities in the construction process are in the transportation process this is due to the process of transporting materials or materials requires quite a lot of transport equipment with high amounts of traffic. Precast work so as to reduce the amount of CO_2 emissions that occur during the construction process.

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