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Cost and Environmental Benefit to Take Advantage in Utilizing Shore Connection

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Abstract:- Shipping activities as energy users generate air pollution and Greenhouse Gas emissions. One of the potential mitigation actions that can reduce these emissions is by utilizing the shore connection at the port. The purpose of this study was to obtain a profile of emissions from vessels anchored at the Terminal Teluk Lamong, East Java, Indonesia as well as the potential for reducing emissions and the efficiency of ship fuel costs. The study used mixed method, by analyzing ship visit data to obtain a profile of emissions produced from anchored vessels and the potential of the emission reduction of vessels that have used shore connection facilities, and also were analyzed through in-depth interviews with port operators, shipping companies and regulators. The study shows that CO_2 is the highest ship exhaust emission, while air pollution was dominated by NO_x, SO_2 and CO. Terminal Teluk Lamong, which has just implemented shore connection since January 2019, can accomplish fuel cost efficiency by the average of 92,72%.

Keywords:- *Shore Connection; Vessels Emissions; Cost and Environmental Benefit; Greenhouse Gas Emissions.*

I. INTRODUCTION

The Government of Indonesia has committed to reducing Greenhouse Gas (GHG) emissions by 2020 by 26% with its own efforts and is estimated to achieve an efficiency of 41% if it receives international funding assistance. This commitment has been regulated in Presidential Regulation Year 2011. The Ministry of Transportation issues a derivative of climate change mitigation policies through Govenrment Regulation of 2013 concerning the Determination of the National Action Plan for Reducing Greenhouse Gas Emissions in the Transportation Sector and Greenhouse Gas Emissions Inventory from the Transportation Sector For the Year 2010 to 2020. At the Conference of the Parties (COP) 21 meeting in Paris, France in 2015, the Government of Indonesia committed to reduce GHG emissions in 2030 by 29% through a fair scenario, using their own abilities. A minimum reduction of 41% is an ambitious scenario with international support. These commitments are then included in the Nationally Determined Contribution (NDC) document.

Meanwhile, WHO (World Health Organization) states that air pollution from ambient (outdoor) air is a major environmental health problem that affects human health, whether it occurs in low, middle or high income countries. Ambient air pollution affects both developed and developing countries, with low- and middle-income countries experiencing the highest burden, with the largest number of victims in the Western Pacific and Southeast Asia regions (WHO, 2016). Shipping activities also contribute to global air pollution, especially in coastal areas. These shipping activities contribute to 15% of NOx and 5-8% of SOx worldwide, both of which are serious threats to human health and the environment [1]. In the UK it is estimated that the total cost of air pollution could be as high as £54 billion per year. Health problems from exposure to air pollution also pose high costs to society and business. In the UK, these healthcare costs add up to £20 billion annually. The UK has been heavily criticized by the European Union, UN and WHO for failing to tackle air pollution within the air pollution limits set by the European Union [1].

The main source of greenhouse gas emissions is fossil fuels which are used in various activities in human life, including transportation activities. Since the issuance of the Decree of the Minister of Transportation of 2013, climate change mitigation actions in the sea transportation sub-sector have not been carried out optimally. This can be seen that of the seven actions until 2016, there were only two actions that could be reported and verified by the Ministry of Environment and Forestry, namely: the development of solar cell technology in the Sailing Navigation Aids Facility and ship rejuvenation.

Based on the Report published by ESPO (European Sea Ports Organization), it was known that ESPO has conducted an assessment of 90 ports in Europe from 19 ESPO member countries, which are also member countries of the European Union plus Norway. Of the 90 ports, there are 66 ports that already have internationally recognized environmental management certifications. In addition, in the assessment, there are 88% of ports that communicate their environmental policies to relevant stakeholders, and 84% of ports have published them on their website [2].

Several international ports have developed policy, procedure or planning frameworks to improve environmental management governance and manage specific environmental issues. Examples of implementing environmental management policies in several ports [3], namely: (1) Port of Los Angeles and Port of Long Beach, with the San Pedro Bay Clean Air Action Plan which designed to reduce air pollution

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and health risks associated with air pollution, by setting emission reduction targets and objectives, (2) Port of Dover, social and environmental aspects will be considered from the initial stage of the project, along with economic aspects so that the principles of environmental sustainability will guide all project decisions, (3) Port of Metro Vancouver has establish an environmental assessment procedure to review all project proposals related to physical works in the port area. The majority of ship emissions released into the air can drift a distance of 400 km inland [4]. The port area is of course also exposed to the ship's emissions, this is mainly due to the use of the ship's auxiliary engine for its energy needs. Container ships can use 6 MW of energy while operating in ports, Ro-Ro ships need 1 to 3 MW and cruise ships need up to 10 MW, while the time needed for ships to stay in port ranges from a few hours to several days [4]. Ship emissions represent 3% of global CO2 emissions, 15% of global NOx emissions and 6% of global SOx emissions [5].

Yustiano, (2014) explained that there are several technologies to mitigate environmental impacts in the port area, one of which is shore side electricity, in the context of this study called shore connection. This is a technology that allows ships to be connected to a power source originating from the mainland. A study conducted at the Port of Aberdeen showed that the shore connection system could reduce annual emissions of 108 tonnes NO_x, 2.7 tonnes PM and 4,767 tonnes CO_2 which is equivalent to £1.3 million or €1.4 million [1]. The biggest operational costs for operating a ship are ship fuel costs which can reach up to 47%, then port costs 46% and D.O (Delivery Order) 7% [6]. A very influential factor in the ship's fuel consumption is the workload of the ship's engine itself. Research on the ship's fuel consumption during berth and fuel costs and external costs, was conducted at the Port of Mombasa, Kenya. Furthermore, an investment assessment for shore connection is carried out as a follow-up to the provision of alternative energy for ships [7].

Mitigation has the potential to reduce greenhouse gas emissions from the sea transportation sub-sector, especially in the fourth mitigation action, namely the efficiency of port operational management where one of the target indicators is the prevention of air pollution through a program to turn off the ship's auxiliary engine when docking and replace it with electricity provided by the port. In this case, the electricity network at the port is termed the Shore connection. In Indonesia, shore connection or OPS (Onshore Power Supply) facilities operated at public ports are still few in number, including at Berlian Terminal (BJTI Port) and Terminal Teluk Lamong. This shore connection is a facility at the port to provide energy supply in the form of electrical energy to ships that are docking and carrying out loading and unloading activities. In general, berthing ships still turns on the auxiliary engine to turn on the onboard electrical system and air conditioning system.

With the shore connection, the auxiliary machine does not need to be turned on again and is replaced with electricity provided by the pier. This of course can save the use of ship fuel so that the Greenhouse Gas emissions generated from the ship when it is docked can be reduced. Naturally, Greenhouse Gases are part of the Earth's atmosphere. Facts show that the ice sheet on the Arctic Continent is currently decreasing by about 2.7% per decade [8]. Research at two Ports, Winoujğcie and Ystad, in Poland also concluded that the operating costs of producing electricity on board (using auxiliary engines) show a much higher value than those supplied from land, where the energy costs for ships when still using auxiliary engines when docked was $2,483 [9]. Research by [10], at the Port of Charleston, USA shows the potential for reducing emissions by using shore connections on cruise ships. Comparison of fiscal benefits and environmental emissions (NO_x and CO_2) when introducing coastal power needs to be calculated quantitatively for the future [11].

Terminal Teluk Lamong, located in the border area between Surabaya City and Gresik Regency, in East Java province, is a multipurpose terminal flanked by two ports owned by PT. Pelabuhan Indonesia III (Persero), namely Gresik Port in the west and Tanjung Perak Main Port in the east. Several shortcomings appeared along with the research are; (1) There is no method of calculating greenhouse gas emission reductions for several mitigation actions in the sea transportation sub-sector, (2) No new mitigation actions that have the potential to reduce emissions in the sea transportation sub-sector have yet been identified, (3) Activity data has not been collected properly, (4) The lack of human resource capacity in the sea transportation sub-sector regarding the issue of climate change, especially the calculation of the Greenhouse Gas inventory and the reduction of Greenhouse Gas emissions, and (5) Lack of attention from stakeholders so that the issue of climate change has not become the mainstream in transportation policy.

While the objectives of this research are; (1) to obtain the results of an inventory/profile of GHG (green house gas) emissions and air pollution generated from ships docked at Terminal Teluk Lamong in 2018, (2) to obtain results of potential reductions in GHG emissions and air pollution from the use of shore connections at Terminal Teluk Lamong, and 3) to analyze the potential for ship fuel cost efficiency from shore connection facilities. In order to optimize the achievement of GHG emission reduction in the sea transportation sub-sector, it is necessary to find a method for calculating the mitigation action or find new potentials for mitigation action. The selection of this research location is based on the realization of shore connection facilities which have been implemented at Terminal Teluk Lamong since early 2019.

II. LITERATURE REVIEW

Today, environmentally friendly ports have been implemented in many countries, especially in many developed countries. An environmentally friendly port or commonly referred to as a green port / eco port is a port that is developed in a sustainable and environmentally friendly manner, which meets all environmental requirements [12]. In Europe, environmental concerns in ports are reflected in many ways, green initiatives from individual ports or in coordinated activities by the wider port community. Sustainable development is Development that meets the needs of the present without compromising the ability of future generations to meet their own needs [13].

A number of tools have been developed internationally to help ports develop an Environmental Management System (EMS), including; International standard ISO 14001, European Union Eco-Management and Audit Scheme (EMAS), EcoPorts and Port Environmental Review System (PERS) [3] ESPO has conducted an assessment of the priority of environmental issues that are considered important by port operators, which shows that the highest priority is the issue of air quality. Air quality is an important concern for residents in port cities and also in urban areas in general. Every year, air pollution causes about 400,000 premature deaths in the EU and health costs in the hundreds of billions of Euros [2].

Research on CO_2 emissions per ton-km (in grams per year) for container feeder vessels (with capacities up to 500 TEU) is 31.6, three times higher than emissions for container ships, with capacities greater than 4,400 TEU [14]. This difference is even greater for dry bulk carriers, with a difference of more than a factor of 10 between the smallest vessels (up to 5,000 dwt) and capsized vessels (> 120,000 DWT) [15]. The (main) passenger port in Piraeus, Greece according to [16] is eligible for the ship emission and externality study based on its dominant presence in Mediterranean waters, making it the most frequented port by coastal passenger ships and cruise ships.

On-shore Power Supply (OPS) is a tool to improve air quality in ports and port cities, to reduce emissions of air pollutants and reduce noise. OPS can also reduce the carbon dioxide produced by ships when docked at the dock by replacing the electricity on the ship which is usually powered from the ship's auxiliary engine with electricity supplied from the dock [17]. On-shore Power Supply (OPS) technology is commonly known by various names, namely: Alternative Maritime Power (AMP), Cold Ironing, Shore Side Electricity, Shore to Ship System and Shore Connection. Shore connection is an electrical system to connect ships that are docked at the dock with the electricity network on land so as to allow the ship to still get electricity supply to turn on the cooling, heating, lighting, and other equipment and turn off the ship's auxiliary engines during the loading and unloading process at the port.

According to [1], Cold ironing (Onshore Power Supply (OPS) or shore-side electricity (SSE) is "The process of connecting ships with electricity from land rather than having to turn on an auxiliary generator with the aim of providing energy for the hotelling process. The definition of shore connection according to [18] is An electrical connection between ships anchored at the port and the pier, which is designed to reduce fuel consumption and emissions. Based on research conducted by [5] in the shore power connection at the Port of Hamburg, the definition of shore connection is The process that allows a ship to turn off its engine when docked and connect it to a source of energy originating from land.

From those definitions, shore connection can be defined as an electrical system to connect ships that are anchored at the dock with the electricity network on land so as to allow the ship to continue to get electricity supply to turn on cooling, heating, lighting, and other equipment and turn off the ship's auxiliary engine during the loading and unloading process at the port.

III.RESEARCH METHODS

Data analysis was carried out using a mixed method, where the quantitative method in this study is used to calculate the ships emissions as the emissions inventory resulting from the ships anchored at Terminal Teluk Lamong during 2018 when there was no shore connection facilities. Moreover, the quantitative method is also used to calculate the potential of GHG emissions reduction from the ships anchored using shore connection facilities as the energy supply on ships. Then qualitative methods were used to complete the quantitative data. In-depth interviews were conducted with informants from the port management, namely PT. Terminal Teluk Lamong and from the relevant regulators, namely the Ministry of Transportation and the Ministry of Environment and Forestry. The samples in this study were ships that used shore connection facilities when they docked at Terminal Teluk Lamong from January to April 2019. The sampling technique in this study was purposive sampling, i.e the selected sample was a sample based on various considerations according to research needs. The number of samples in this study were five ships at Terminal Teluk Lamong.

The quantitative method in this study is used to calculate the emissions produced by the ship when the ship docked in the port and shore connection emissions that occur in the power generation sector so that the potential for emission reductions and also the emission profile or emission inventory can be obtained. Quantitative data is obtained from ship visit data at Terminal Teluk Lamong, which is needed for the ship emission calculation, shore connection emission calculation, GHG emission and air pollution reduction. The approach to calculating emission reductions from shore connection would include inputs such as; Vessel inputs, Activity inputs, and Shore power inputs.

IV.RESULTS AND DISCUSSION

4.1. Inventory of GHG Emissions and Air Pollution Emissions

An inventory of GHG emissions and air pollution is required from ships that dock at Terminal Teluk Lamong in 2018. In 2018, there were 1,030 ship visits at Terminal Teluk Lamong where none of these ship visits had used shore connection, because the facility was implemented starting from January 2019. The results of the inventory of 1,030 ship visits can be seen in Table 1.

No	Ship Type	International Ship Emissions (tons)						
		NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	CO_2 default EPA	CO_2 with National EF
1.	Container	75,4	2,09	1,92	11,5	6,04	3.788,59	1.468,66
2.	General Cargo	2,73	0,07	0,07	0,41	0,22	135,91	52,68
3.	Bulk Carrier	26,1	0,85	0,78	4,67	2,45	1.536,00	595,43
	TOTAL	104,26	3,01	2,77	16,62	8,71	5.460,5	2.116,77

Table 1:-International Ship Emissions at Terminal Teluk Lamong in 2018

Table 1 shows that the largest amount of emissions is CO_2, and this CO_2 when calculated using the National emission factor produces smaller emissions when compared to using the USEPA default emission factor.

No	Ship Type	Domestic Ship Emissions (tons)						
		NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO	CO_2 default EPA	CO_2 FE National
1.	Container	50,8	1,46	1,35	8,07	4,23	2.653,1	1.028,5
2.	General Cargo	6,32	0,18	0,16	0,99	0,52	323,75	125,5
	TOTAL	57,1	1,64	1,51	9,06	4,75	2.976,9	1.154

Table 2:-Domestic Ship Emissions at Terminal Teluk Lamong in 2018

Based on Table 2, the emissions generated from domestic ships docked at Terminal Teluk Lamong during 2018 with the USEPA default emission factor is 2,976.9 tons of CO_2 and 1,154 tons of CO2 using the national emission factor.

4.2. Potential for Reducing GHG Emissions and Air Pollution Emissions

The shore connection facility was implemented starting January 2019 at Terminal Teluk Lamong, with data up to April 2019 only five ships were using it. Emissions are calculated using a formula developed by the California Air Resources Board (CARB) where CARB has established the At-Berth Regulation in December 2007. This At-Berth Regulation is designed to reduce emissions generated by ship auxiliary engines and is applied to container ships, passenger ships and refrigerated cargo vessels. Ship operators are required to choose between two options, namely: turning off the ship's auxiliary engine and connecting it to a shore connection or using technology to control emissions so as to achieve emission reductions. The formula from CARB is combined with the recommendation formula from the USEPA (2017). For potential emission reductions, it is calculated by first calculating the emissions of ships that have used a shore connection using the fuel emission factor while still using the auxiliary engine (baseline emissions) and then calculating the emissions of the same ship using the electrical emission factor (mitigation action emissions).

In calculating the potential for reducing GHG emissions, especially CO_2 gas from the five ships, the generator efficiency level is also used (Table 3).

Genset Efficiency	Baseline Emission CO_2 (tons)	Mitigation Emission CO_2 (tons)	Potential Emission Reduction (tons)
20%	2,45	1,85	0,60
21%	2,33	1,85	0,48
22%	2,23	1,85	0,38
23%	2,13	1,85	0,28
24%	2,04	1,85	0,19
25%	1,96	1,85	0,11
26%	1,88	1,85	0,04
27%	1,81	1,85	-0,03
28%	1,75	1,85	-0,10
29%	1,69	1,85	-0,16
30%	1,63	1,85	-0,22

Table 3:-Potential Reduction of GHG (CO_2) Emissions Based on Ship Generator Efficiency at Terminal Teluk Lamong in 2019 (January-April)

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Table 3 shows that at the generator efficiency level of 27% to 30%, there is no reduction in GHG emissions because when the efficiency of the generator set on the Auxiliary Engine is already high, it can save fuel for ships. On the other hand, the emission factor of the power plant in the Jamali (Java, Madura, Bali) region is high because there are still many power plants that use fossil fuels.

Then to estimate the potential for reducing air pollutant emissions, especially in the form of SO_2, calculations are carried out according to the efficiency level of the generator. For air pollutants, SO_2 gas is calculated using the USEPA default emission factor for the Auxiliary Engine genset emission factor when the ship is still using the generator and then compared with the ship's emissions when using a shore connection, using the power generation emission factor for SO_2 gas, which is the national approach of SO_2 emission factor is 0.066 gr/KWh.

The potential for reducing SO_2 emissions based on the efficiency level of the generator is shown in Table 4.

Genset Efficiency	Baseline Emission SO_2 (tons)	Mitigation Emission SO_2 (tons)	Potential Emission Reduction (tons)
20%	19,23	0,000135	19,23
21%	18,31	0,000135	18,31
22%	17,48	0,000135	17,48
23%	16,72	0,000135	16,72
24%	16,02	0,000135	16,02
25%	15,38	0,000135	15,38
26%	14,79	0,000135	14,79
27%	14,24	0,000135	14,24
28%	13,73	0,000135	13,73
29%	13,26	0,000135	13,26
30%	12,82	0,000135	12,82

Table 4:-Potential SO_2 Emission Reduction Based on Ship Generator Efficiency at Terminal Teluk Lamong in 2019 (January-April)

4.3. *Fuel Cost Saving Potential*

The potential cost efficiency of shore connection facilities needs to be taken into account. So, it is necessary to estimate the costs that must be incurred by the ship if it continues to use fuel and the costs paid by the ship to the port for the use of shore connection. The data was obtained from PT. Lamong Energi Indonesia as the energy manager company for Terminal Teluk Lamong. Based on these data, there is a fuel cost saving from each ship that leans by utilizing shore connection facilities.

For five ships that have used shore connection facilities at Terminal Teluk Lamong in January-April 2019 period, there is a potential for ship fuel cost efficiency of 92.72% (Table 5).

Number of Ships using Shore Connection	5 ships
Fuel Costs If the Ship Continues to Use Auxiliary Engine	IDR 28.213.941
Costs incurred by the ship to pay for the shore connection	IDR 2.053.792
Cost Difference	Rp 26.160.150
Cost Efficiency	(Rp 26.160.150 / Rp. 28.213.941) x 100 %
	= **92,72 %**

Table 5:-Recapitulation of Ship Fuel Cost Efficiency by Utilizing Shore Connection at Terminal Teluk Lamong in 2019 (January-April)

4.4. *Projected Emission Reduction in Other Cities and 2025 Projection*

In accordance with previous calculations, it can be concluded that the greater the efficiency level of the ship's generator engine, the lower the value of GHG emissions reduction and air pollution will be. This happens because if the efficiency of the ship's generator is high, the fuel used will also be more efficient. In addition, the electricity emission factor in the Jamali network is also high due to the large number of fossil fuel in the power plants. At the generator efficiency level of 20% to 26%, there is still a decrease in emissions, while starting at the generator efficiency level of 27% to 30% there is no mitigation or in other words there is no emission reduction. Then the author makes a simulation at the efficiency level of 27% to 30% to be applied in other cities, especially cities that have ports and the GHG emission factor for the electricity grid in that city is lower than the Jamali emission factor. Based on the author's previous research in calculating GHG emissions reduction from the use of shore connection at BJTI Port, Surabaya City, which the number of vessels using shore connection on 2018 is 70 vessels, then with that data the author made a projection if the shore connection is also implemented in other ports especially outside Java and Bali Island.

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Cities outside Java and Bali Island (Padang, Batam, Tarakan, Makassar, Mataram, Kupang, Tual, Jayapura and Manokwari) on average have a higher emission reduction potential value than cities in Java and Bali (Jamali electricity grid). Only Medan City actually has a lower emission reduction potential value than Jamali, because Medan City has higher losses in the transmission and distribution of its electricity network compared to losses in Jamali. For information, losses in the city of Medan are 17.35% and in the Jamali network 10.8% and the emission factor for the electricity system in the two areas is almost the same, namely Medan at 0.88 tons CO_2/MWh and Jamali at 0.9 tons CO_2/MWh.

Whereas in other cities, the emission factor of the electricity grid is lower than the emission factor in Jamali and especially on the island of Lombok (Mataram City), has an emission factor of 0.47 tons CO_2/MWh and the transmission and distribution losses are only 7.61% so that Mataram has the highest potential emission reduction value compared to other cities. As a recapitulation, table 6 shows the CO_2 emission factors of the electricity system and the losses of the transmission and distribution network in 10 cities that are used as simulations by comparison using the Jamali area.

Region	**CO_2 Emission Factor of Electricity System (ton/MWh)**	**Losses T/D (%)**
JAMALI	0,9	10,8
Padang	0,88	6,88
Medan	0,88	17,35
Batam	0,62	20,58
Tarakan	0,72	7,39
Makassar	0,80	11,25
Mataram	0,47	7,61
Kupang	0,68	6,71
Tual	0,58	12,97
Jayapura	0,73	9,18
Manokwari	0,70	9,18

Source: CO_2 Emission Factor of Electricity Grid [19], losses T/D [20].

Table 6:-Emission Factors and The Electricity Transmission/Distribution Losses In Various Cities

The recapitulation of the potential results of CO_2 emission reductions in these cities is based on generator efficiency of 27% to 30% (Table 7).

Region	**CO2 Mitigation (tons) with 27% Genset Efficiency**	**CO2 Mitigation (tons) with 28% Genset Efficiency**	**CO2 Mitigation (tons) with 29% Genset Efficiency**	**CO2 Mitigation (tons) with 30% Genset Efficiency**
Jamali	-0.93	-2.73	-4.40	-5.96
Padang	2.31	0.52	-1.16	-2.72
Medan	-3.77	-5.56	-7.24	-8.80
Batam	10.66	8.87	7.19	5.63
Tarakan	10.83	9.03	7.36	5.79
Makassar	4.53	2.73	1.06	-0.50
Mataram	24.47	22.68	21.00	19.44
Kupang	13.29	11.49	9.82	8.26
Tual	16.46	14.67	12.99	11.43
Jayapura	9.49	7.69	6.02	4.46
Manokwari	11.17	9.37	7.70	6.13

Table 7:-Potential Reduction of GHG (CO_2) Emissions in Several Cities with Generator Efficiency 27%-30%

In Table 7 it can be seen that the higher the efficiency value of the ship's generator, the smaller the potential for CO_2 emission reduction. Among the 10 cities outside Java, it can be seen that the 3 cities with the greatest potential for reducing CO2 emissions are Mataram, Tual and Kupang because the emission factors in these three cities are among the smallest of the 10 cities used for comparison. The emission factors for the three cities are Mataram 0.47 ton/MWh, Tual 0.58 ton/MWh and Kupang 0.68 ton/MWh.

In addition, the simulation estimates the emission factor of Jamali's electricity for 2025, by looking at the projected energy mix demand for power plants in Jamali, for coal, biodiesel/diesel, gas and fuel. These data can be seen in the 2019-2028 RUPTL (General Plan for Electricity Supply) PT. PLN (State Electricity Company). Then in the RUPTL, it can be seen that the projection data for Jamali's electricity production needs is 295,710.8 GWh. Furthermore, from the energy mix demand for power plants in 2025: 90 million tons

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of coal, 48,000 KL of biodiesel, 461 TBTU of gas and 194,000 KL of fuel, will produce CO_2 emissions of power plants of 166,875,516.35 tons. This amount of CO2 emissions is divided by the total projected electricity production needs of Jamali which is 295,710.8 GWh and will produce an electricity emission factor of 564.32 tons CO_2/GWh or 0.56 tons/MWh.

With a projected emission factor of 0.56 tons/MWh in the Jamali electricity system in 2025, it can be obtained a projected reduction in CO_2 emissions in the utilization of shore connections in 2025 if the number of vessel data follows the existing number of vessels that already using shore connection facility (70 vessels on 2018 based on previous research at BJTI Port) and the value of the electricity losses transmission and distribution in 2025 assumption of 10%. The comparison between realization of CO_2 emission reduction potential with data on 70 vessels connected to shore connection with projected CO_2 emission reduction in 2025 with the same number of ships (Table 8).

Table 8 shows the projection for 2025, the value of potential GHG emission reductions from the use of shore connections at ports will be higher compared to the realization in 2018, this is due to the emission factor of the electricity interconnection system in the Jamali area in 2025 will be smaller than the emission factor of 2018. Where in 2018 it is 0.9 tons CO_2/MWh and the projection for 2025 is 0.56 tons CO_2/MWh. This lower emission factor value is due to the demand for energy mix at the Jamali power plant which will experience a decrease by 75.3% in the type of biodiesel, and a decrease by 75.1% in the type of fuel, while gas fuel will increase by 28.8% and coal will also experience a 20% increase in 2025 compared to the energy mix demand for power plants in 2019 (PLN, 2019).

4.5. Informant Response

The survey was addressed to shipping operators operating at Terminal Teluk Lamong, at six shipping companies, namely: PT. Salam Pacific Indonesia Lines, PT. Samudera Agencies Indonesia (KMTV Division) Surabaya, PT. PPN Panurjwan, PT. Meratus Line, PT. Lintas Kumala Abadi, and PT. Pelayaran Tempuran Emas. Of the six companies, only three companies have routinely used shore connection facilities, namely PT. Salam Pacific Indonesia Lines, PT. Meratus Line and PT. Pelayaran Tempuran Emas.

Based on the survey results of the six shipping companies, the obstacle faced by ships or shipping companies so far is the lack of shore connection facilities at the port, so that when ships dock, they are not necessarily able to use shore connections because at the dock there are still other ships using it. In 2018, PT. Lamong Energi Indonesia as the energy manager company has conducted a survey regarding the statement of interest in ship electricity cooperation, in this case they want to capture the interest of shipping companies to use shore connection facilities. A total of four shipping companies that expressed interest in cooperation using shore connection facilities, namely: PT. Pelayaran Tempuran Emas, PT. Meratus Line, PT. Salam Pacific Indonesia Lines and PT. PPN Panurjwan.

Based on the results of interviews with relevant stakeholders, in principle the Ministry of Environment and Forestry (MOEF) as the national focal point for climate change control is very supportive if the Ministry of Transportation has additional mitigation actions in addition to what has been reported so far. This is in order to increase the achievement of reducing GHG emissions in the transportation sector, so that it can contribute to the achievements of the energy sector. Especially in the sea transportation sub-sector, where so far there have only been two mitigation actions, it is hoped that this can be added because according to officials at the Directorate of GHG Inventory and MRV (MOEF), there are still other potentials that can be calculated and monitored for mitigation actions.

Meanwhile, according to the coordinator of the achievement of the National Action Plan in Reducing GHG Emissions target at the Ministry of Transportation, the Center for Sustainable Transportation Management has coordinated intensively with each sub-sector in the context of reporting on the achievement of GHG emission reductions, in particular, it requires activity data support from the sub-sectors so that mitigation actions can be monitored properly. In addition, they are also conducting an evaluation of the calculation methodology, accompanied by the MOEF and the GHG methodology panel team, so that the mitigation actions that have been reported can be more accurate and avoid assumptions. Thus, it is in accordance with the principles set by the UNFCCC (United Nations Framework Convention on Climate Change).

In addition, it is hoped that shore connection facilities can be applied to all ports in Indonesia, because the outcome of this facility is in the form of energy efficiency, reduction of air pollution and GHG emissions at the port. This study supports several previous studies, such as the use of shore connections at BJTI Port, Indonesia which can reduce CO_2 by 24.55%, air pollution by 99.3% of SO_2, and fuel cost efficiency by 79.82% [21]. Several other studies at the ports of Kenya, Hamburg and Surabaya also discussed the potential use of this shore connection [4], [5], [7]. This study is also in line with other studies, which confirm that a coast-to-ship converter system will save energy and reduce emissions [22].

V. CONCLUSION

Inventory of ship emissions during 2018 at Terminal Teluk Lamong showed the highest emissions were in CO_2 gas and then NO_x, SO_2, CO, and then PM_{10} and $PM_{2.5}$. However, there is a significant difference in CO_2 when calculated using national emission factors, which results in 61% lower CO_2 emission values than those calculated using international reference emission factors.

The potential for reducing GHG emissions from the use of shore connections will result in a higher value per vessel, especially for ships with engines with low efficiency levels, because under normal conditions they will consume more fuel than ships with high generator efficiency. The potential for reducing GHG emissions from the use of shore connections will be higher if the energy mix used in power plants no longer uses fossil fuels, but instead replaces them with more environmentally friendly energy such as gas and even renewable energy such as solar and wind energy. Shore connection is a facility that is proven to be able to save on the use of ship fuel so that shipping companies can save on fuel costs. When the ship is connected to the shore connection at the port, the ship can perform engine maintenance.

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