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Comparative Perspective of Air Pollution from Heavy Vehicle NOx Emissions and Its Impact on Environmental Sustainability in Indonesia and Other Countries

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ABSTRACT

Abstract— Heavy vehicle emissions have a significant impact on humans and the environment. The purpose of this study is to find out the best solution that can be applied in Indonesia to reduce pollutant levels in the air, especially levels of NOx gas emissions in big cities, where poor air quality emitted from transportation system vehicles that has an impact on air quality. Vehicles generally produce exhaust gas in the form of carbon but in some vehicles, especially heavy vehicles, NOx levels are also produced which is the result of the catalysis of NO2. The impact of these gases causes damage to the lungs and damage to plants. Comparative Insight method is used to get the best solution. The results of this article using NGC 0.2 technology will reduce almost 95% of NOx emissions and this solution is suitable to be applied in Indonesia.

Keywords— Comparative study, NOx emission, Heavy vehicles.

INTRODUCTION

Exhaust emissions have a long-term negative impact on the environment because exhaust emissions can cause a greenhouse gas (greenhouse gas) effect which causes an increase in the average temperature of the earth and has an impact on global warming and extreme weather (Kuncoro, 2011). In addition, other impacts caused by exhaust emissions are health problems that can have a negative impact on some people who have respiratory problems. The composition of exhaust gas emissions includes CO, CO2, NO, NO2, HC and SO2 (Octradha et al, 2017). The composition of this gas emission is not dangerous enough, but because it reacts with other gases or particles it can cause environmental damage and respiratory problems (Erqou, 2018).

Air as a natural resource that affects human life and other living creatures must be maintained and preserved for its function through controlling air pollution for the maintenance of human health and welfare as well as the protection of other living creatures. The level of air pollution is a value that states the condition of air quality at a certain place and time. Determining a substance that enters the air is at a very dangerous, dangerous, or harmless level, a quality standard is used for the content of substances that are considered still fit for life, which are still allowed to be in the air (Peraturan Pemerintah Nomor 22 Tahun 2021 tentang Penyelenggaraan Perlindungan dan Pengelolaan Lingkungan Hidup).

Nitrogen oxide (NOx) is a pollutant released from various sources, especially in the transportation sector. As an illustration, the transportation sector contributes 69% of NOx pollutants in urban areas, followed by industry and households. According to Hadiwidodo and Huboyo (2006), about 10% of air pollution every year is nitrogen oxides. Most of the nitrogen oxides produced by the combustion system are in the form of NO, but under normal conditions there is also nitrogen dioxide (NO2). NO2 levels during combustion are indeed low, but after being released NO2 levels can increase significantly (Kristi and Boedisantoso, 2015).

Looking at the current situation, there are many human activities that have the potential to cause air pollution. One of them is as a transportation route for diesel-fueled heavy vehicles that produce emissions that are quite worrying for the environment, especially in the air quality sector, from lead (Pb) to particulate dust (PM). Particulate itself is a form that is dispersed in solids and liquids with a single molecule size between 0.01 micrometers to 10 micrometers (Soedomo, 2001). Therefore, this article review aims to look at the phenomenon of an increase in air pollution because of increased human activities, especially in the field of transportation, both in Indonesia and in other countries.

METHOD

This article review begins with the preparation activities, secondary and supporting data collection, data analysis, and conclusions. Broadly speaking, this article is targeted to be able to compare the conditions in Indonesia with those in other countries. The method used in this study is a comparative analysis to find out the insights of the methods applied in Europe and several other countries as well as in Indonesia regarding the solution to the impact of NOx emissions produced from several types of heavy vehicles. Comparison of solutions from the journal base used is McCaffery (2021) which examines NOx emissions produced by several types of heavy vehicles and compared in several circumstances and for the territory of Indonesia using several comparative journals, including Sunarno (2021), Puji (2020) which examines pollution produced by NOx and how to handle it, as well as classification based on the type of vehicle that produces these emissions.

The experimental approach utilized in the fundamental journal McCaffery (2021) measures each type of vehicle under examination using the Portable Emission Measurement System (PEMS), which is a measure of emissions from the combustion engine as the vehicle or equipment operated, allowing real-time world use testing. PEMS is a cutting-edge and forward-thinking partner for analyzing the environmental impact of combustion engine emissions. PEMS integrates modern gas analyzers, exhaust mass flow meters, weather stations, Global Positioning Systems (GPS), and connection to the vehicle network for emission regulating reasons. PEMS allows real-time monitoring of the pollutants released by the engine and the connected engine. In a comparative journal in Indonesia, Puji (2020) conducted research on emission inventories in Jakarta using experimental methods on data and all data were mostly obtained from relevant government agencies and Indonesian state-owned companies such as the Ministry of Energy and Mineral Resources, National Agency for Gas Companies, Ministry of Energy and Mineral Resources. Transportation, and the National Oil Company use the Business method (BAU) to calculate the resulting emissions and control technology. Then for the territory of Indonesia, it also uses research from Sunarno (2021) which examines the trend of emissions produced by vehicles and the power generation sector based on historical data from 1995-2015 and makes projections up to 2030, the projection method used is trend analysis based on an exponential approach. and polynomials.

The comparison of the journals studied in the California and Indonesia regions has a close method, so that a comparison of the results and solutions of the two journals can be made to obtain conclusions in the form of useful insights for tackling NOx emissions in the environment.

RESULT and DISCUSSION

- Transportation Emission in Indonesia

  Based on the Jakarta Environmental Management Agency (2013), as a source of air pollution, transportation activities or exhaust gas emissions, of course become a source of quite large air pollution when there is an incomplete combustion process. The most common exhaust emissions from the transportation sector to the free atmosphere by mass are carbon dioxide (CO2) and water vapor. This can happen if the combustion process can take place completely because of the excess oxygen supply. This is a very rare combustion condition to occur. While many studies measure and predict transport-based CO2 emissions, their scope can be narrow and may not consider interactions with other related sectors such as electricity, the environment or society. Ismiyati (2014) conducted research on air pollution in the capital city of Jakarta and found that the main sources of air pollution were the largest from the transportation and industrial sectors. In this case, motorized transportation vehicles contribute to the emission load of approximately 71% levels of NOx, 15% levels of SOx, and 70% levels of particulates. Gas emissions and their contents are certainly a moral burden for motorized vehicle users and industrial business actors. In Indonesia, this has become one of the problems as well as a development phenomenon, especially for developing countries like Indonesia. Although the development of the transportation sector is highly expected by the people, from the other side, the development of the transportation sector can also have an unfavorable ecological impact and can cause depression to the people. So for the citizens of Jakarta, of course, the presence of air pollution from these transportation activities can cause stress levels for humans themselves.

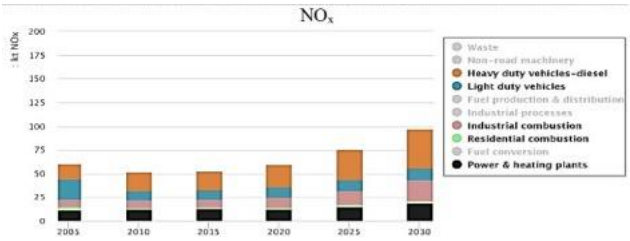
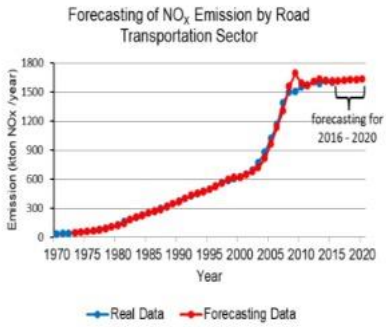


Figure 1 NOx Concentration in Jakarta

Source: Puji, 2020

Also, for NOx, the problem comes from the transportation sector which is certainly dangerous for public health. From the research "Inventory of Pollutant Emissions (CO, SO2, PM2.5, and NOx) in Jakarta Indonesia" written by Puji (2020) stated that the NOx emissions produced in Jakarta were as much as 52.9 Ktons and 57% of NOx emissions were produced by the industrial sector. transportation, heavy vehicles are the largest NOx contributor (Saikawa, 2017). If in Indonesia there is no change or standard setting for NOx gas emissions, according to the research trend of Sunarno (2021) entitled "Analysis of Trends in NOX and SO2 Emissions in Indonesia for the Period 1990-2015 Using Data Analysis Tools" the addition of NOx levels produced by the transportation sector amounted to 17.



Year	Emission (kton/year)
2016	1615.70
2017	1620.06
2018	1624.43
2019	1628.79
2020	1633.16

Figure 2 NOx Emission Prediction in Jakarta

Source: Sunarno, 2021

Minister of Environment Regulation No. 20 of 2017 regulates vehicle exhaust emission standards with EURO 4 standards which impact on exhaust regulations for vehicles not based on type but based on exhaust emission levels, but its implementation was originally scheduled to take effect on April 8, 2021, for engines. Diesel fuel was postponed until 2022, the delay was stated in a letter issued by the Minister of LHK Number S786/MENLHK-PPKL/SET/PKL.3/5/2020 dated 20 May 2020, this delay occurred due to the unpreparedness of human resources and facilities provided to support the standard.

- Transportation Emission in China

Cai et al. quantify emissions in the transportation sector in China from a national and regional viewpoint by calculating and applying a new fuel consumption data set from the transportation sector. Zhang and Nian used provincial panel data and stochastic impacts with regression on population, affluence, and technology models to analyze emissions in China's transportation industry.

Zhou et al. used a data analysis methodology oriented on undesirable outputs with different

returns to scale to investigate the transportation sector's emission performance across 30 Chinese administrative regions. Yan and Crookes examine future developments in energy demand and greenhouse emissions in China's road transport industry and assess potential abatement methods from the standpoint of a specific mode of transportation. Wang et al. analyze emissions and passenger car pollutants in China from 2000 to 2005 and forecast future trends based on three different scenarios. Emissions increase greater in places with less public transportation, according to Hao et al. Tian et al. evaluate regional greenhouse gas emissions from different means of goods transport and examine the turnover of commodities and energy consumption in different regions with different modes of transport. Gang et al. analyze the cost- effectiveness and environmental benefits of various vehicles to investigate the co-benefits of the metropolitan public transportation sector.

NOx emissions in China are expected to rise substantially from 11.0 Mt in 1995 to 26.1 Mt in 2010, owing to strong expansion in energy consumption. In 2010, power generation, industry, and transportation were the primary sources of NOx emissions, accounting for 28.4%, 34.0%, and 25.4 percent of total NOx emissions, respectively.

In general, existing literature solely considers fossil fuels in emission estimations, while some studies include electricity as a source of carbon accounting. From an environmental standpoint, the use of electricity to replace fossil fuels in transportation is becoming increasingly widespread. This study is unique in that it calculates emissions from two sources: fuel usage and electricity consumption. To put it another way, assessing emissions from a fuel entails calculating the product of total fuel consumption and appropriate emission coefficients. While accounting for electricity is required because the electric car business had a surge after 2014, when the government supported and financed the industry, it is unclear whether electricity generated by battery- powered vehicles is clean. According to the China Electricity Power Yearbook (2018), thermal (fossil fuel) power generates 60% of China's national electricity, followed by hydraulic (19%), solar (9%), wind (9%), and nuclear (2%). As a result, electricity produces sufficient emissions indirectly. Furthermore, the official energy and electricity statistics yearbook is used to produce and estimate data on power use.

- Transportation Emission in European Union

In the European Union the long-term goal is to achieve zero emissions by 2050. This requires greenhouse gas emissions (GHG) reduction in all sectors of the economy to the point where zero- emissions can occur through natural and technological processes, as outlined in the European Green Deal, the EU's commitment to the Paris Agreement, and the 2050 long-term Climate Strategy. Except for transportation, almost every industry has showed progress toward this aim. While total GHG emissions in Europe fell by 22.5 percent between 1990 and 2018, total transport emissions rose by more than 23 percent.

Transportation emissions contributed significantly to this growth, increasing by approximately 27% during the period and accounting for nearly 95% of all transport emissions in 2018. The contribution of road transport to overall emissions increased from less than 13% in 1990 to about 21% in 2018. Passenger automobiles and light vehicles are the primary contributors to these emissions, accounting for roughly 70% of total transport emissions and 15.1 percent of total GHG emissions in the EU in 2018. As a result, these vehicles have been identified as a major contributor to the EU's considerable increase in overall transportation emissions.

Given the necessity of reducing road transport emissions, all EU member states have enacted comprehensive plans based on policies from other nations and regions facing similar issues, including the United States, China, and the G20. These measures are mostly aimed at supply-side players (car manufacturers and fuel suppliers). This strategy is based on strong justifications for regulatory capacity or economic efficiency, with a small number of suppliers thought to be more managed than a vast number of demand sides.

Analyzing demand policies, according to a survey of the literature and available scientific studies, may be a solution. Cap & Surrender (C&S) systems can fill up the holes in current rules. However, given the time it takes to build up such a system and the current political climate, now may not be the best moment to start implementing it. However, in the long run, given the 2050 target and beyond, it may have the potential to supplement existing steps and boost broad acceptance of recall measures done to reassure consumers of the need for more sustainable transportation patterns.

Experts in Europe are very positive about the environmental success of this policy template, but they are more skeptical about some economic and social implications. Europe must reach net zero emissions by 2050, according to the European Commission. It may be claimed that all European societies and states will need to adjust their conduct in order to achieve this. As a result, confronting people with the need to change their behavior by proposing immediate action, such as C&S, may appear to be a viable option. Long-term, such a system is likely to generate a high degree of awareness, paving the way for more, probably more radical, acts and actions to reach ground zero in the remaining time.

- Transportation Emission in United States

The research journal "Real-world Nox emissions from heavy-duty diesel, natural gas, and diesel hybrid electric vehicles of different vocations on California roadways" written by McCaffery, C. (2021) covers 50 different heavy- duty vehicles, issues raised in This research is because most of the heavy vehicles operating on the California Roadway use diesel engines and do not meet the standards of the Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) because in 2010 there was an increase in standards to reduce NOx levels to 90% of the standard. . Previously, according to data released by the California Air Resources Board (CARB) (2021), the maximum limit for NOx gas in the air was 0.02 g/bhp-hour. Based on research data, it is known that the rate of NOx gas release in heavy vehicles increases when the vehicle starts to move due to high engine torque rotation so that it has an impact on combustion temperature, most diesel engines have a combustion rate above 200 Celsius, that is what causes the catalyst from NO2 gas. The resulting vehicle exhaust gas reacts with NO in the air to produce high levels of NOx gas (Jiang et al., 2018).

Transportation-related emissions, primarily from heavy vehicles, account for the majority of emissions in the United States. Between 1960 and 2008, the number of travels (measured in kilometers per passenger) nearly tripled, while freight climbed nearly thrice. While vehicles and private light trucks or SUVs still dominate travel, accounting for 90% of trips in 1960, air travel is expanding at a quicker rate, accounting for more than 12% of all trips in 2008. From little over 7% in 1960 to roughly 4% in 2008, rail and buses have lost ground. Similarly, in terms of freight, trucks accounted for about 32% of tonnes/km in 2008, while rail accounted for 33% of products, down from 36% in 1960. Water transport's percentage of total freight travel has decreased dramatically, whereas air transport's share has increased tenfold during a 48-year period, although accounting for less than 1% of total freight travel

in 2008. The modes of travel and transportation that use the most energy per unit of service, in particular, are growing faster than the modes that use the least.

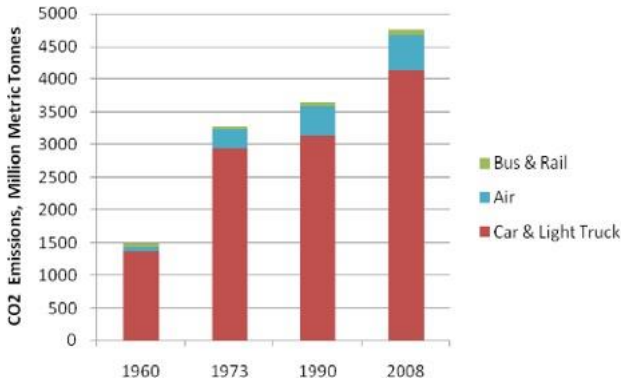


Figure 3 Passenger Vehicle Carbon Emission

Source: Schipper, 2011

The graph above depicts the total Carbon emissions by mode in the same four reference years. Car and air travel, as well as trucking, account for most carbon emissions, both because these modes dominate transportation activity and because they produce the most emissions per passenger or tonne/kilometer.

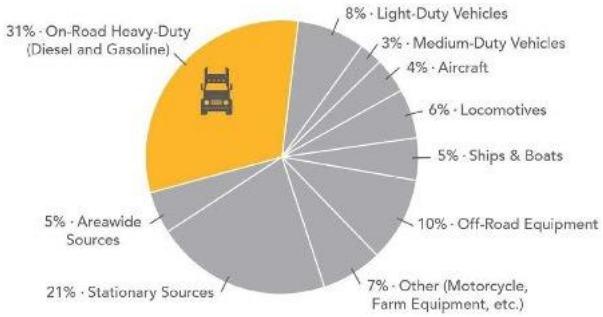


Figure 4 NOx Emission Sources

Source: CARB, 2021

Research conducted by McCaffery (2021) compared 50 types of heavy vehicles based on the emission of NOx gas produced, and this study focuses on the division of each type of engine used compared to the number of emissions released. For the study site in California, USA, according to data from CARB 2021 in Figure 1, the data show that heavy-duty trucks are the largest source of NOx in the state, accounting for nearly a third of all statewide NOx emissions and more than a quarter of total emissions. diesel particulate matter (PM) statewide. If California is to meet health-based ambient air quality standards, we need to reduce NOx emission levels from heavy-duty trucks on the road by 85 percent. This will help us reach the 2008 ozone standard of 75 ppb required by 2031 on the South Coast (CARB, 2021).

Research that has been carried out in several countries and in Indonesia has the same goal, namely reducing levels of NOx emissions in the air, to protect the environment from NOx pollution. The solution offered in McCaffery's research (2021) is to replace the vehicle engine technology with NCG 0.2 and set the EURO 4 standard as a regulation. From this study, it was concluded that at least 95% of the level of NOx emissions produced by diesel

engines could be reduced if they were replaced with 0.2 NCG engines, so when viewed in Indonesia, the same problem is experienced with NOx gas levels. emissions that will continue to increase are around 17.46 Kton/year and this figure is very high when compared to the EURO 4 standard that will be tried to be applied in Indonesia.

CONCLUSION

The insight that can be drawn from this comparative journal is that a possible solution in other countries is an update from the fleet side for the transportation sector using NCG 0.02 engine technology so that it is more environmentally friendly. However, from an economical point of view, there is nothing wrong with implementing this solution by replacing some of the old fleets (still using diesel engines without SCR) with new ones because the effect will be felt in the long run, although at the beginning it will cost money to renew the fleet (especially logistics transportation). So that in this study the solution offered can be applied in Indonesia, and will have a major impact on NOx emissions because it can reduce at least 95% of the transportation sector for NOx emissions,

This can be used as a first step to support the implementation of the EURO 4 policy which will be implemented in 2022, so that by 2030 Indonesia will reduce at least 40% of the level of NOx gas emissions from the predicted result of around 900 Kton/year. or 102,672 Kg/hour, although the therapeutic effect of this reduction is still visible, it will be even more drastic if the EURO 4 policy is implemented continuously. In addition, Indonesia as a developing country needs to learn from several other countries in adapting to existing conditions in terms of fighting for the ecological aspect. One of them is related to permit restrictions for public transportation that are not too large, empowerment of better public transportation facilities, and control of the number of private vehicles. It can also be done to limit the age of vehicles and periodically test emissions for vehicles that have aged to pay attention to the emission cleanliness aspect. In line with that, efforts can be made to build the Monorail Train network, and better traffic management. The problem of air from transportation emissions has become a global issue that needs to be controlled continuously so that the environment can always be maintained.

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Facts about the Low NOx Heavy-Duty