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RESEARCH ARTICLE

Analysis of Liquid Fuel to Gas Fuel Conversion at Power Plant as an Effort to Reduce Greenhouse Gas Emissions and Its Economic Value (Case Study on MPP Nias and MPP Duri)

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Abstract

PT PLN actively supports the energy transition through accelerating New Renewable Energy. Global climate change is an urgent issue that requires a clean and sustainable energy transition. One strategy that has great potential is to improve the power generation performance of the mobile power plant such as the TM2500 through conversion of the fuel from liquid fuel to gas fuel. This process, which is an innovative step to support the clean and sustainable energy transition, has proven to be more environmentally friendly and efficient. This step not only increases thermal efficiency but can also reduce the main emissions, such as SO_2 , NO_x , CO, and particulate (dust) and greenhouse gas emissions. As a portable power generator, the TM2500 is designed for flexible operation, making it an ideal solution to meet the electricity needs throughout the Indonesian archipelago. Case studies in mobile power plant MPP Nias of improving the performance of the TM2500 power plant are reliable with the reduction in greenhouse gas emissions (CO_2) of around 36.705% to 37.299% and can reduce fuel costs significantly by 82.238%. While challenges such as gas infrastructure availability and initial investment costs remain, these solutions open up huge opportunities to accelerate the global energy transition to net zero emissions. It is recommended to expand fuel conversion from liquid fuel to gas fuel as an integral part of future power plant systems.

Keywords: Mobile Power Plant, Fuel Conversion, Reduce Greenhouse gas emission

1. Introduction

PT PLN is a company tasked with serving needs electrical with a vision of becoming a Top 500 global company and customer's choice for solutions energy. One of PLN's missions is to make electric power to be a driving force economic activities and carrying out environmentally sound business activities. Greenhouse gases (GHG) are gases in the atmosphere, both naturally occurring and anthropogenic, that cause global warming. The Earth Summit in Rio de Janeiro in 1992 resulted in the United Nations Framework Convention on Climate Change (UNFCCC) which aims to stabilize GHG concentrations at levels that do not endanger the climate system. Indonesia has increased its commitment to reducing GHG emissions in various ways. This was done and stated at several international meetings such as The 13th Conference of the Parties/COP-13 UNFCCC in 2007 in Bali, G-20 in Pittsburgh-USA on 25 September 2009, COP-17 in Durban, COP-21 in Paris in 2015 which to create several agreements related to long-term cooperation actions between developed and developing countries to make appropriate efforts in reducing emission levels. To support these obligations and commitments, the government has established several regulations [1].

1. PT PLN (Persero) is a state owned electricity company especially power plants with fuel, be it liquid fuel, gas fuel and LNG, coal fuel, and also biomass fuel. PT PLN is also required to do various things as an effort to reduce emissions generated from electricity generation. This is regulated in: Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 5 of 2021 concerning procedures for regulating technical approvals and operational feasibility letters in the field of environmental pollution control with KBLI codes: 35111, 35115, 35116, 35117, 35301[2].
2. Attachment IX of the Regulation of the Minister of Environment and Forestry Number P.15/MENLHK/SETJEN/KUM.1/4/2019 concerning Thermal Power Plant Emission Quality Standards (State Gazette of the Republic of Indonesia 2019 Number 455[3]).
3. Presidential Regulation of the Republic of Indonesia Number 98 of 2021 concerning the Implementation of Carbon Economic Value for Achieving Nationally Determined Contribution Targets and Controlling Greenhouse Gas Emissions in National Development, article 7 paragraph 3, article 15 paragraph 3, and also article 21 paragraph 3[4].

One way to achieve the NZE target by utilizing onshore power supply (OPS) can reduce ship operational costs related to fuel by 28% to 59% [5]. PT PLN is also trying to be very committed to supporting the net zero emission program, one of is by minimizing emissions from power plants by implementing gasification. Gasification in power plant is konversi the fuel from liquid fuel to gas fuel to optimize gas use and fulfill Paris Agreement commitments and fulfill energy mix targets in national policy. The basis for carrying out this gasification is Decree of the Minister of Energy and Mineral Resources no 249.K/MG.01/MEM.M/2022 concerning the Assignment for Implementing the Supply and development of Liquefied natural gas Infrastructure, as well as the conversion from using liquid fuel to gas fuel in the Supply of electric

power. In an effort to reduce emissions, the costs required by each technology and sector can vary. Therefore, it is very necessary to take into account its operations [6],[7], for example to achieve the emission reduction target of 2.5% and 5% against normal conditions in Java-Madura-Bali, it is necessary to reduce the capacity of coal-fired power plants by 480MW and 995MW, but this increases operational costs by IDR 18.4 billion and IDR 90.1 billion per week [8]. This cost is called the emission reduction cost (abatement cost). In figure 1, displays the marginal abatement cost curve showing technologies in order of cost decarbonization from lowest to highest (in Euro/ton CO_2). On a range of costs specific cases, the economic value of carbon is considered to be able to encourage or provide incentives for a technology to enter the market.

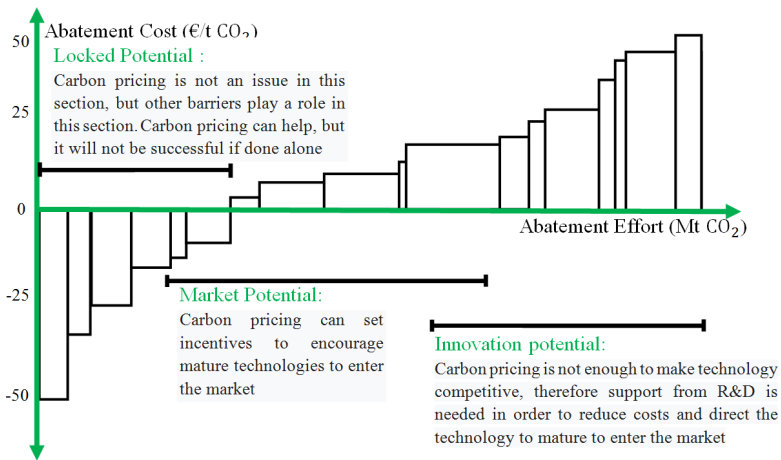


Figure 1. Marginal abatement cost-curve and the potential for implementing the economic value of carbon[9]

This is also regulated in Law No. 7 of 2021 concerning Harmonization of Tax Regulations and also in Presidential Decree No. 98 of 2021 concerning Implementation of Carbon Economic Value[4]. At present, the energy consumption data of emission sources from power plants in the carbon emission calculation model are collected manually, in the future, the calculation model can be developed through technology [10], which is now starting to use CEMS [11]. In this study, we modify the fuel system from liquid fuel to gas fuel to compare CO_2 emissions from each. As a result, we can determine the feasibility of fuel by considering the emissions produced with its operational costs [6],[7],[12].

The Relationship Between Fuel Conversion (from liquid fuel to gas fuel) and Continuous Emission Monitoring System (CEMS): The conversion of fuel in power plants from diesel-based fuels to natural gas is a critical strategy to reduce greenhouse gas emissions and other air pollutants such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), and particulate matter. Natural gas burns more cleanly than liquid fuels, resulting in lower carbon intensity per unit of energy produced. This transition supports national and global efforts to decarbonize the power sector and improve air

quality. While fuel conversion is a technological measure to reduce actual emissions, the Continuous Emission Monitoring System (CEMS) functions as a regulatory and operational tool to continuously measure and verify the emissions performance of the plant. CEMS provides real-time data on emissions released into the atmosphere, including CO₂, NO_x, SO₂, and other critical pollutants. This ensures transparency, accountability, and compliance with environmental standards. The relationship between fuel conversion and CEMS is therefore synergistic. Fuel conversion to gas acts as a proactive emission reduction measure, whereas CEMS serves as a reactive monitoring system that ensures the effectiveness of that measure. Without CEMS, it would be difficult to track the actual environmental benefits of the fuel switch. Likewise, without switching to a cleaner fuel, CEMS would merely document ongoing high emissions without meaningful mitigation. Together, fuel conversion and CEMS form an integrated approach to clean energy production: one reduces the source of emissions, while the other validates and maintains performance over time. This combination is essential in the broader pursuit of sustainable energy systems and net-zero emission targets.

2. Method

In general, emissions produced from power plants consist of primary emissions (SO₂, NO_x, CO, and PM/ Dust) and greenhouse gas emissions (CO₂).

2.1 Primary Emission

$$E = C_{av} \times Q \times 0.0036 \times t[3] \quad (1)$$

$$E_{Year} = \sum_{i=1}^n E[3] \quad (2)$$

where:

- E = emission load
- C_{av} = measured concentration
- Q = emission flow rate
- t = generator operating time
- E_{Year} = annual emission load
- n = total data

2.2 Greenhouse Gas Emissions

For greenhouse gas emissions(CO₂), it is the multiplication of activist data (fuel consumption) with the fuel emission factor.

$$E = DA_xFE[1][13] \quad (3)$$

where:

- E : GHG Emissions (tons)
- DA : Activity Data (TJ)
- FE : Emission Factor (tons/TJ)

To calculate the amount of emissions, there are several methods that can be used according to the data we obtain, as in the chart in Figure 3. CO₂ emission calculations can be carried out using one or a combination of calculations and measurements, however the level of accuracy must still be observed according to the tier system as in Figure 2. There are differences in data quality, accuracy, and uncertainty within each Tier. The higher the Tier used, the more accurate the GHG emission calculation results, but require more detailed data. However, the amount of GHG emissions resulting from a high Tier value will be lower than the calculation results using a lower Tier

Tier	Required Data		Method
	Activity	Emission factor	
Tier-1	Fuel Consumption NCV default IPCC-2006)	Default Emission Factor IPCC - 2006	Method - 1
Tier-2	Fuel Consumption (NCV national or NCV in the power plant unit)	National Emission factor	Method - 1
		Specific Emission Factor in the power plant unit (no unburned carbon data available and using national default oxidation factors)	Method - 2
Tier-3	fuel Consumption per combustion technology (NCV in the power plant unit)	Specific Emission Factor in the power plant unit (carbon content data is available and oxidation factors in the power plant unit)	Method - 2
		Specific Emission Factor in the power plant unit (unburned carbon data available)	Method - 3
	GHG emissions according to CEMS (CEMS is operated according to the equipment usage procedures (certification, calibration, and operating hours minimal 97,5%)		Method - 4

Figure 2. Tier system matrix [1]

Method-1 [1],[13]

$$E_{CO_2} = DA \times FE$$

where, activity data is consumption data for each type of fuel that has been converted into energy units.

$$DA_{BB} = F_{BB} \times NCV \times 10^{-3} \tag{4}$$

where:

DA_{BB} : Coal activity data (TJ)

F_{BB} : Coal consumption in a year (tons)

NCV : Net calorific value of coal (TJ/Gg)

$$DA_{BM} = F_{BB} \times \rho \times NCV \times 10^{-6} \tag{5}$$

where:

DA_{BB} : Liquid fuel activity data (TJ)

F_{BB} : Fuel oil consumption in a year (kiloliters)

ρ : Fuel specific gravity(kg/m³)
 NCV : Net calorific value of liquid fuel (TJ/Gg)

$$DA_{BBG} = F_{BB} \times K \tag{6}$$

where:

DA_{BBG} : Gas fuel activity data(TJ)
 F_{BBG} :Gas fuel consumption in a year (MMBTU)
 K :Conversion (0.001055TJ/MMBTU)

$$DA_{BM} = F_{BB} \times NCV \tag{7}$$

where:

DA_{Bm} :Biomass-based fuel activity data(TJ)
 F_{Bm} : :Biomass-based fuel consumption in a year (biomass unit)
 NCV : Net calorific value of biomass-based fuel (TJ/unit mass of Biomass)

Metode-2 [1],[13]

1. Coal fuel

$$E_{CO_2} = F_{BB} \times C_{ar} \times FO \times 44/12 \tag{8}$$

2. Fuel Oil (BBM)

$$E_{CO_2} = F_{BBm} \times \rho \times C_{ar} \times FO \times 44/12 \times 10^{-3} \tag{9}$$

3. Natural gas dan LNG fuel

$$E_{CO_2} = F_{Gas} \times 0,001015 \times C / NCV \times FO \times 44/12 \times 10^{-3} \tag{10}$$

where:

F = amount of fuel consumption
 C = Carbon content
 FO = Oxidation Factor
 NCV = Net Calorific Value

For the oxidation factor, we can use the values as in the table 1.

Table 1. Oxidation Factor Value[1]

Fuel	Oxidation Factor
Coal	0,98
Liquid Fuel	0,99
Gas Fuel	0,995
Rated voltage	72 V
Rated capacity	50 Ah
Rated energy	3.6 kWh
Maximum charge voltage	84 V

Table 2. NCV and Emission Factors National for liquid fuel and gas fuel[1]

Fuel Type	Kg/TJ			Net Calorific Value (NCV)	Carbon Content
	CO ₂	CH ₄	N ₂ O	TJ/Gg	%
High Speed Diesel (HSD)/ ADO	74300	N/A	N/A	42.66	86
Industrial Diesel Oil (IDO)	73900	N/A	N/A	42.12	85
Marine Fuel Oil (MFO) Heavy Fuel Oil (HFO)	75200	N/A	N/A	41.31	85
Natural Gas (Pipe)	57640	N/A	N/A	45.2	71
LNG	57270	N/A	N/A	47.1	74

For the Net Calarific Value (NCV) and Emission Factor National, we can use the values as in the table 2.

For the price of liquid fuel, each type is different depending on the type of liquid oil. For the MPP Nias power plant, using the liquid fuel type High Speed Diesel (HSD) with 0% biodiesel, and called HSD B-0. For the price of liquid fuel, we can see in the table 3 which is colored yellow, namely Industrial Biodiesel (B-0).

Table 3. Price of Industrial Fuel HSD B40[14]

Produc	Regional 1	Regional 2	Regional 3	Regional 4
	Rp/KL	Rp/KL	Rp/KL	Rp/KL
Pertamax Turbo	16,150,000	16,250,000	16,350,000	16,500,000
Pertamax	15,050,000	14,150,000	15,250,000	15,400,000
Pertalite	14,250,000	14,350,000	14,450,000	14,600,000
Kerosene	12,950,000	13,050,000	13,250,000	13,450,000
Dex 10 ppm	21,450,000	21,450,000	21,550,000	21,700,000
Dex 50 ppm	21,300,000	21,300,000	21,400,000	22,150,000
Bio Pertamina Dex	21,300,000	21,300,000	21,400,000	22,150,000
Dexlite	21,100,000	21,100,000	21,200,000	21,350,000
Industrial Biodiesel (B-0)	17,600,000	17,600,000	17,700,000	17,850,000
Industrial Biodiesel	20,950,000	20,950,000	21,050,000	21,200,000
Diesel Oil	16,150,000	16,150,000	16,250,000	16,400,000
MFO Low Sulphur *	16,700,000	16,700,000	16,700,000	16,700,000
MFO High Sulphur 180 Cst	14,650,000	14,750,000	14,850,000	15,000,000

*) in units Rp/MT

2.3 Flowchart

2.4 Continuous Emission Monitoring System (CEMS)

To obtain more accurate data, CEMS was installed on the power plant. The data communication flow can also be described in topological form as in figure 6.

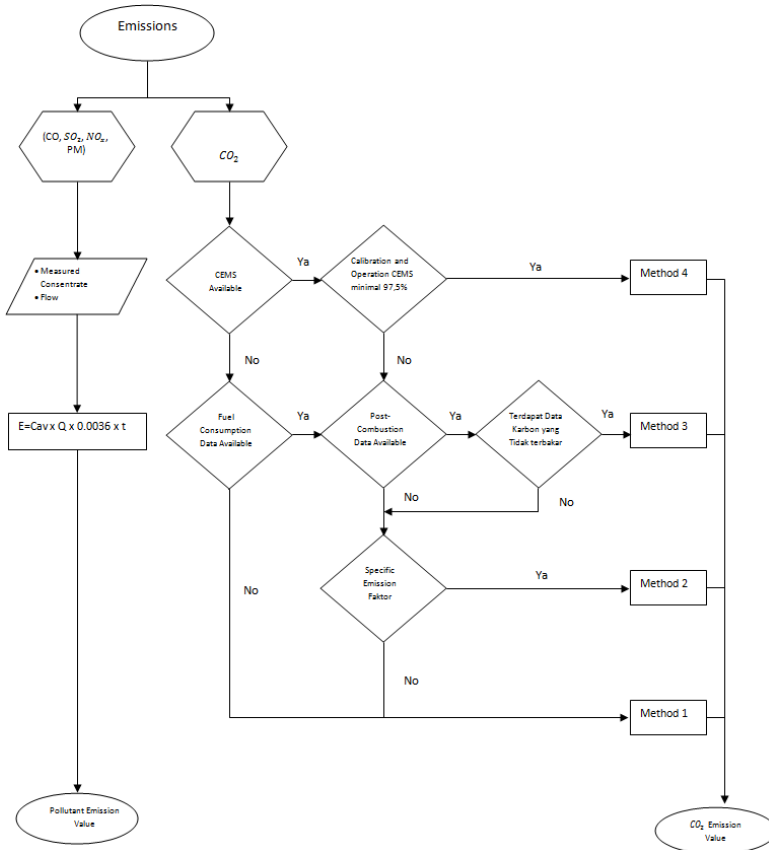


Figure 3. Flowchart

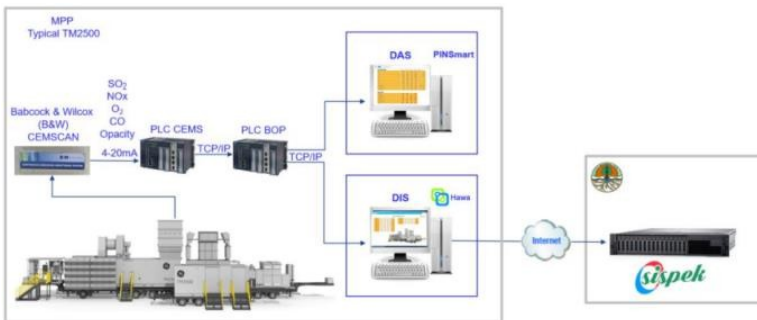


Figure 4. Equipment topology and CEMS data communication PLTG MPP TM2500 Gunungsitoli-Nias[15]

In figure 4, CEMS measures the emission of SO_2 , NO_x , CO, Opacity dan measures O_2 and produces a -20 mA analog signal. Then, $4\text{--}20\text{ mA}$ signal received by the PLC CEMS which is then sent to the PLC BOP via TCI/IP. Data from the BOP PLC is

then sent to the Data Acquisition System(DAS) and Data Interfacing System(DIS). The data from DIS is then sent to Continuous Industrial Emission Monitoring Information System (SISPEK) server belongs Ministry of Environment and Forestry (KLHK). And here is the data from CEMS displayed on the screen.

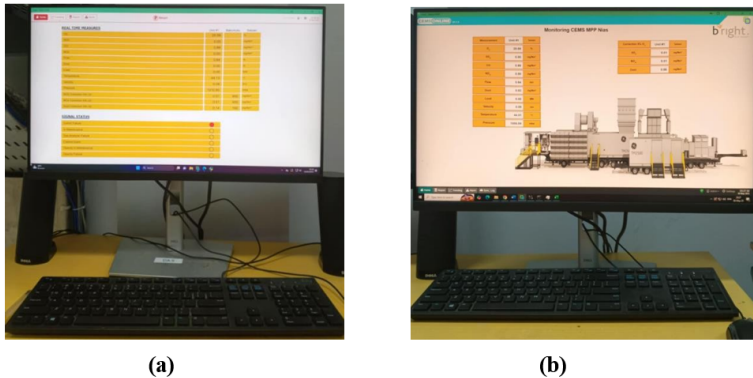


Figure 5. a. Data Acquisition System (DAS) and b. Data Interfacing System (DIS)

CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) REPORT																		
Corporate Identity		Identitas Tesis Pengukuran Emisi																
Corporate Name		Company Name																
Corporate Address		Company Coordinates																
		Company Height																
		Company Diameter																
TANGGAL	JAM	SO ₂	NO _x	CO	PM ₁₀	PM _{2.5}	Flow	Temp	Temp	SO ₂	NO _x	CO	PM ₁₀	PM _{2.5}				
31	01-01-2024	1700	15.80	589.59	26.57	117.76	21.17	3098.64	19.71	3.39	127.19	0.30	1.36	140	8.67	11.89	8.11	0.11
34	01-01-2024	2000	16.30	76.14	94.32	201.48	36.36	3098.99	16.75	19.96	129.76	0.99	4.12	967	23.02	111.76	12.17	1.64
35	01-01-2024	2100	15.72	104.52	42.28	184.97	35.36	1052.46	18.45	4.75	194.54	0.43	1.85	211	28.10	28.10	21.56	0.28
38	01-01-2024	1100	20.28	146.79	13.46	151.21	16.97	2095.15	23.69	7.54	40.95	1.54	6.06	88	5.84	2.86	4.71	0.61
39	01-01-2024	1100	15.28	184.67	39.43	174.44	16.12	1011.64	18.57	4.49	179.09	0.48	1.74	224	12.41	25.42	23.77	0.24
79	01-01-2024	1700	15.70	111.46	26.77	116.89	23.26	3098.46	19.17	3.47	129.17	0.31	1.42	160	6.91	12.11	10.16	0.14
82	01-01-2024	2000	16.20	76.61	82.33	204.42	31.87	1012.21	24.84	19.60	124.89	0.96	3.96	990	20.52	111.11	13.64	1.61
83	01-01-2024	2100	16.41	114.56	64.58	212.76	38.48	1008.47	17.41	7.41	200.48	0.48	2.38	119	17.26	60.56	17.02	0.44
100	04-01-2024	1700	12.35	146.76	31.71	168.69	27.12	1006.46	16.69	4.61	161.69	1.43	1.99	200	11.16	22.56	15.99	0.25
101	04-01-2024	2000	16.54	107.17	100.17	144.23	16.42	1015.30	17.87	5.39	241.42	0.44	1.92	237	16.46	47.75	16.42	0.71
102	04-01-2024	2000	6.40	6.00	90.16	109.80	6.82	1009.48	17.70	16.43	121.09	0.54	1.39	366	6.00	164.15	0.15	1.89
111	01-01-2024	2100	20.17	479.90	20.98	126.36	16.46	1012.47	19.09	3.44	129.77	0.11	1.79	109	12.46	9.84	6.76	0.12
115	08-01-2024	1700	194.79	213.56	277.06	147.49	213.89	1009.56	5.84	0.54	36.74	0.05	0.27	48	25.76	36.64	29.61	0.61
116	08-01-2024	1800	6.74	26.51	148.59	126.69	6.46	1017.66	14.54	14.54	111.64	1.52	4.76	479	10.74	171.59	8.78	1.59
118	08-01-2024	2000	7.15	13.75	82.74	104.97	17.76	1005.52	16.34	6.13	201.45	0.44	1.67	256	2.76	95.12	17.12	0.51
119	04-01-2024	1800	9.01	393.89	6.00	6.00	18.17	1013.17	20.42	6.00	52.11	0.00	0.00	59	6.00	6.00	6.00	0.00
171	07-01-2024	1700	6.00	7.01	91.53	147.17	16.41	1009.05	19.11	3.49	126.44	0.44	1.68	117	6.00	16.25	6.04	0.12
176	07-01-2024	2000	6.22	6.92	96.43	113.61	7.91	1009.49	18.42	10.55	130.54	0.55	4.08	363	6.00	111.44	1.14	1.10
199	08-01-2024	1700	6.00	6.00	25.44	104.51	16.76	1008.60	19.28	1.58	111.40	0.46	1.50	163	6.00	101.20	6.44	0.70
202	08-01-2024	2000	1.26	1.49	46.71	119.19	8.19	1005.70	16.48	19.00	154.83	1.00	6.74	201	1.42	94.74	9.70	2.27
203	08-01-2024	2100	1.17	12.30	53.36	119.81	15.58	1011.90	17.90	6.34	227.34	1.27	3.50	200	6.00	434.67	27.48	1.04
212	09-01-2024	1600	6.00	6.23	91.56	116.28	16.40	1006.17	17.01	9.17	101.22	1.87	6.29	195	6.00	161.44	70.64	1.61

Figure 6. CEMS Data for PLTG MPP Nias after recap

3. Result and Discussion

3.1 Consumption Fuel.

This study aims to calculate the amount of emission reduction from gasification in power plants from power plants with liquid fuel to gas fuel. From the power plant operation data for a year, it is known that:

From the data in table 4, it is obtained that the SFC of liquid fuel is 0.4196 Liters/kWh and from the data in table 4, it is obtained that the SFC of gas fuel is 0.011485 MMBTU so that if the PLTG NIAS uses gas fuel to produce the same load,

Table 4. SFC Data for MPP TM2500 Gunungsitoli-Nias Gas Power Plant in 2024

SFC Data(kWh) PLTG 1 X 25 MW GUNUNGSITOLI NIAS 2024			
Month	Produce	Liquid Fuel Consumption	SFC
	kWh	Liter	Liter/kWh
Januari	459,909.37	208,590.00	0.4535
Februari	1,802,833.05	754,435.00	0.4185
Maret	2,100,718.16	798,979.00	0.3803
April	1,065,813.85	472,880.00	0.4437
Mei	1,195,466.51	496,064.00	0.4150
Juni	1,752,607.13	743,997.00	0.4245
Juli	1,362,191.27	574,628.00	0.4218
Agustus	1,029,262.04	452,616.00	0.4397
September	662,712.89	290,642.00	0.4386
Oktober	477,968.16	204,363.00	0.4276
November	592,797.63	251,248.00	0.4238
Desember	551,318.03	228,996.00	0.4154
TOTAL	13,053,598.09	5,477,438.00	0.4196

Table 5. SFC Data for MPP 2 x 25 MW Balai Pungut Duri in 2024

SFC Data (kWh) PLTG 2 X 25 MW BALAI PUNGUT DURI 2024			
Month	Produce	Gas Fuel Consumption	SFC
	kWh	MMBTU	MMBTU/kWh
Januari	1,718,678.41	20,123.00	0.011708
Februari	1,357,917.79	16,060.00	0.011827
Maret	1,442,326.46	17,639.00	0.012230
April	1,245,013.91	15,183.00	0.012195
Mei	1,829,707.67	22,035.00	0.012043
Juni	8,510,473.19	96,983.00	0.011396
Juli	7,921,383.22	90,812.00	0.011464
Agustus	5,197,539.88	59,114.00	0.011373
September	8,955,434.49	100,055.00	0.011173
Oktober	5,237,543.00	59,477.00	0.011356
November	2,993,938.00	34,507.00	0.011526
Desember	2,610,962.00	31,012.00	0.011878
TOTAL	49,020,918.02	563,000.00	0.011485

or if the PLTG Balai Pungut uses liquid fuel to produce the same load, it will require fuel, as in table 6.

$$\text{Fuel consumption} = \text{kWh production} \times \text{SFC}$$

Table 6. Fuel consumption for the same load by changing liquid fuel to gas fuel or vice versa

Power Plant	Produce kWh	Fuel	Fuel Consumption
MPP NIAS	13,053,598.09	Liquid Fuel	5,477,290 KiloLiter
		Gas Fuel	149,920,574 MMBTU
MPP DURI	48,999,550.64	Gas Fuel	562,759,839 MMBTU
		Liquid Fuel	20,560,211 KiloLiter

3.2 Total Emissions

3.2.1 Primary Emissions

Total amount of primary emissions (SO₂, NO_x, CO, dan PM/Dust) can be calculated using equation 1 and equation 2. For comparison, samples were taken every month from each power plant, both from the PLTG MPP NIAS and from the PLTG MPP DURI, where the larger load in the same month, the load is adjusted to the lower load and can be seen in table 7 and table 8 below.

Table 7. Emission load produced by PLTG MPP Nias in 2024

Month	Operation Hours	LOAD MW	Emission			
			SO ₂ Kg	NO _x Kg	CO Kg	Dust Kg
January	96	444.38	813.42	7,811.17	1,936.64	268.99
February	175	1,337.22	3,470.27	20,492.47	3,622.61	255.81
March	108	1,410.11	1,527.76	31,232.21	947.03	375.64
April	166	989.59	695.62	7,443.66	3,188.23	218.23
May	185	1,012.05	776.38	7,361.02	3,853.22	303.95
June	266	1,700.34	836.04	13,305.80	5,301.00	511.11
July	220	1,277.74	1.50	5,542.82	3,167.13	311.13
Agust	190	955.27	31.40	7,596.62	3,744.27	185.94
September	128	446.00	0.02	4,906.49	2,457.18	124.23
October	79	433.86	87.72	2,905.67	1,398.08	87.06
November	106	570.52	29.70	4,128.85	1,803.84	107.29
December	113	500.82	29.75	3,561.86	2,983.74	89.24
TOTAL	1832 Hours	11,077.90 MW	8,299.57 Kg/Year	116,288.64 Kg/Year	34,402.96 Kg/Year	2,838.64 Kg/Year

Table 8. Emission load produced by PLTG MPP Duri in 2024

Month	Operation Hours	LOAD MW	Emission			
			SO ₂ Kg	NO _x Kg	CO Kg	Dust Kg
January	76	445.51	351.08	3,590.57	892.57	71.00
February	124	1,337.04	25.79	10,935.64	744.10	344.27
March	138	1,410.10	59.86	5,924.83	846.29	347.40
April	74	989.22	79.80	4,125.88	418.35	250.60
May	52	1,009.36	59.92	5,485.60	191.31	285.97
June	190	1,701.73	135.86	4,034.57	1,249.06	371.55
July	132	1,278.38	98.44	2,928.54	1,081.33	283.63
Agust	52	955.64	64.50	2,467.02	1,178.27	202.89
September	32	449.39	15.96	2,443.81	278.87	186.17
October	71	435.23	20.13	910.86	843.40	80.15
November	89	570.39	25.91	288.07	1,044.72	100.07
December	86	501.82	38.26	1,965.34	989.86	160.71
TOTAL	1,116 Hours	11,083.80 MW	975.51 Kg/Year	45,100.72 Kg/Year	9,758.12 Kg/Year	2,684.41 Kg/Year

Figure 7 and 8 are graphs showing the total emissions from each power plant during 2024. Figure 7 shows the total emissions of the Nias MPP in 2024 and figure 8 shows the total emissions of the DURIE MPP in 2024.

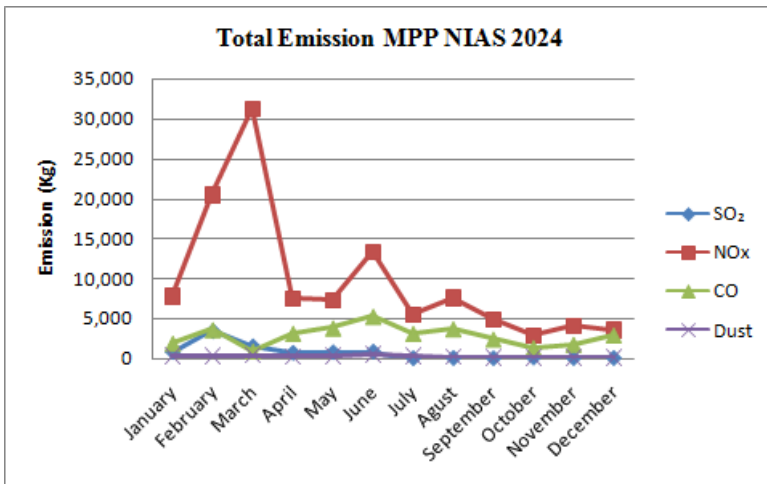


Figure 7. Total emissions from the MPP Nias Power Plant every month in 2024

From the two figure above, it shows that almost every month, the higher emissions

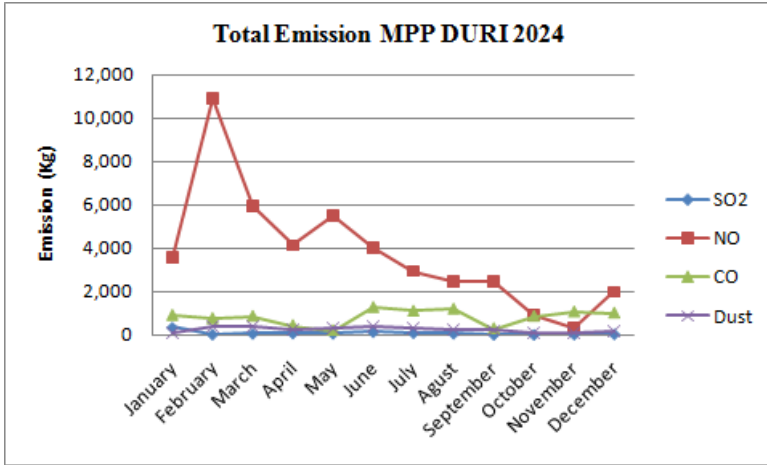


Figure 8. Total emissions from theMPP Duri Power Plant every month in 2024

are NO_x emissions except in November 2024 at MPP DURI. However, overall the highest emissions are NO_x emissions followed by CO emissions.

In figure 9, shows the comparison of SO_2 emissions and figure 10 shows the comparison of NO_x emissions.

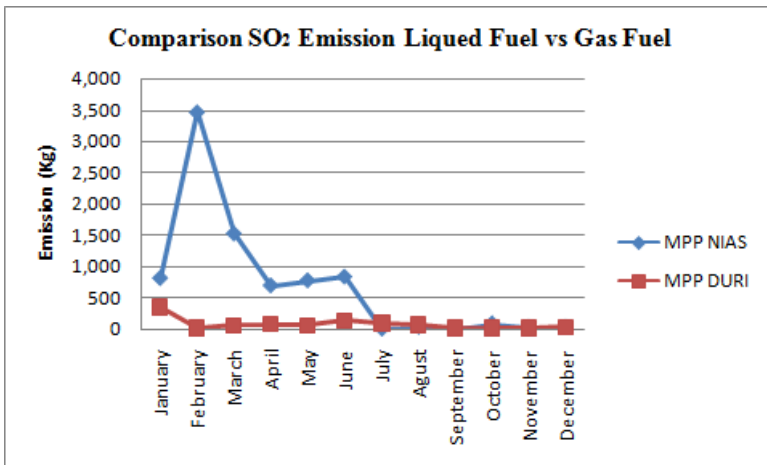


Figure 9. Comparison SO_2 Emission Liqueed Fuel vs Gas Fuel

From the two figure above, it shows that the emissions produced in the Nias MPP (in this case using liquid fuel), always have higher emission values compared to the emission values in the Duri MPP that uses gas fuel, except in July, September and December for SO_2 emission values. However, if the overall value is taken, both SO_2 and NO_x emissions, are always higher in power plants using liquid fuel compared to gas fuel, (with almost the same load).

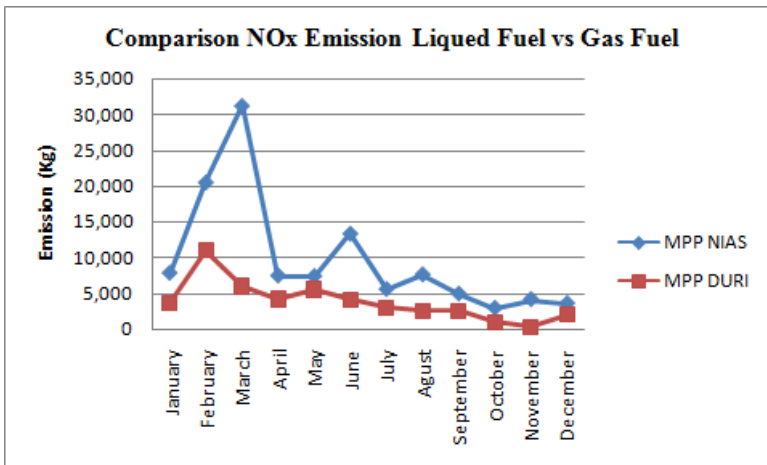


Figure 10. Comparison NO_x Emission Liquid Fuel vs Gas Fuel

Figure 11, is a comparison of CO emissions and figure 12 is a comparison of dust emissions, between power plants with liquid fuel and power plants with gas fuel.

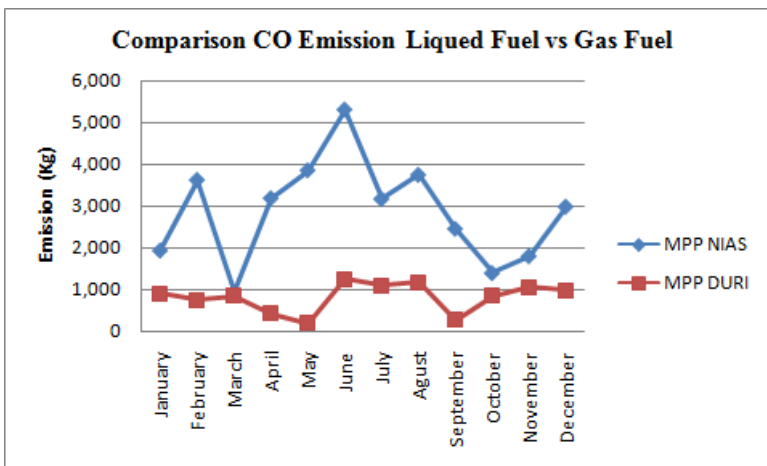


Figure 11. Comparison CO Emission Liquid Fuel vs Gas Fuel

From the data, the CO emission value at the power plant in MPP Nias (in this case using liquid fuel), is always higher every month compared to the emission value at the power plant in MPP Duri (in this case using fuel gas). However, the dust emission value is not certain. For the overall emission value, it can be seen in figure 13.

From the figure 13, show that the emission reduction in annual is significant there are SO₂ emissions by 88.246%, NO_x, emissions by 61.27%, CO emissions 71.636% and also includes particulates emissions (dust) by 5.433%.

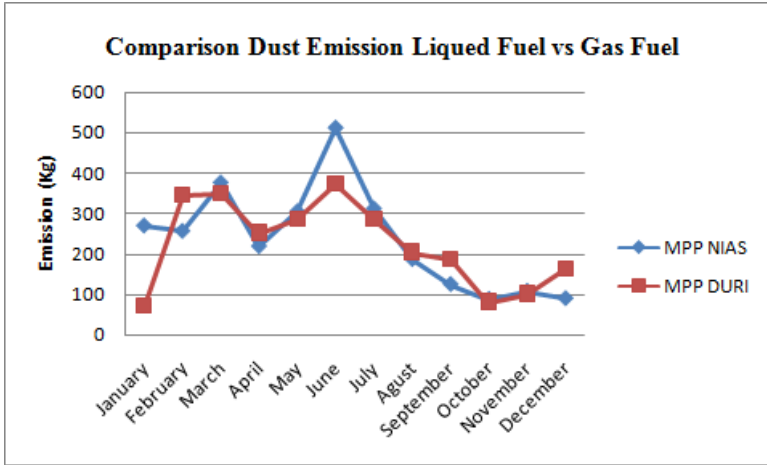


Figure 12. Comparison Dust Emission Liquid Fuel vs Gas Fuel

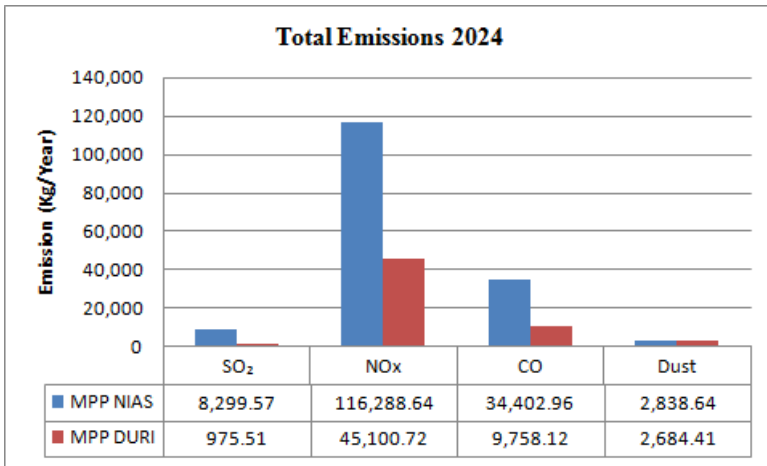


Figure 13. Total Pollutant Emissions in 2024

3.2.2 Carbon Dioxide Emissions

- Amount of emissions with method 1
 Amount of emissions CO₂, we can calculate using equations 1, 5, and 6.

Table 9. Amount of emissions CO₂, Calculated with Method-1

Power Plant	Produce kWh	Fuel	Emission CO ₂ (Ton)
MPP NIAS	13,053,598.09	Liquid Fuel	14,539.8591
		Gas Fuel	9,116.7001
MPP DURI	48,999,550.64	Gas Fuel	34,221.5384
		Liquid Fuel	54,578.5580

- Amount of emissions with method 2
Amount of emissions CO_2 , we can calculate using equations 9 and 10.

Table 10. Amount of emissions CO_2 , Calculated with Method-2

Power Plant	Produce kWh	Fuel	Emission CO_2 (Ton)
MPP NIAS	13,053,598.09	Liquid Fuel	14,320.4152
		Gas Fuel	9,064.1716
MPP DURI	48,999,550.64	Gas Fuel	34,024.3613
		Liquid Fuel	53,754.8270

- Emission Reduction

From the calculation results above, it was found that by changing the fuel from liquid fuel to gas fuel, there was a reduction in CO_2 emissions,

$$Emission\ Reduction = E_{CO_2\ Liquid\ Fuel} - E_{CO_2\ Gas\ Fuel}$$

Table 11. Emission Reduction of CO_2

METHOD	Produce kWh	Emission CO_2 Reduction	
		Ton	(%)
METHOD-1	13,053,598.09	5,423.1590	37.299%
	48,999,550.64	20,357.0197	37.299%
METHOD-2	13,053,598.09	5,256.2435	36.705%
	48,999,550.64	19,730.4657	36.705%

From the table 11, we can get that the emission reduction of CO_2 is 37,299% with method-1 and 36,705% with method-2.

3.3 Cost Comparison

For the price of liquid fuel with the HSD type, we can see it in table 3, and for the price of Gas fuel of USD 7 per MMBTU[16] or around Rp. 114,163 (with an exchange rate of Rp. 16,309)[17]. From the data above, it is obtained that for the production of 13,053,598.09 kWh (Production kWh PLTG MPP TM2500 Gunungsitoli-Nias), the fuel cost is Rp. 96.4029 billion and if using gas fuel, it only requires fuel costs of Rp. 17.1228 billion. In this case, we can conclude that with gasification in this case by changing liquid fuel to gas fuel, we can reduce fuel costs for production by 82.238%. However, to realize this, we need to calculate the initial costs in modifying the fuel system and consider the availability of the fuel.

4. Conclusion

The fuel consumption of the power plant using liquid fuel is around 0.4226 liters and around 0.011485 MMBTU to produced 1 kWh. It means, to a fuel cost of around six thousand three hundred thirty-nine Rupiah pe kWh whe using liquid fuel, and eight hundred point nine five Rupiah per kWh when using gas fuel. In this case, with

changing the fuel from liquid fuel to gas fuel, it can reduced the emissions and fuel costs significantly. CO_2 emissions can be reduced around 36.705% to 37.299% and fuel costs can be reduced by 82,238%.

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