

Energy Conservation through Electrical and Thermal Energy Audits at Onshore Processing Facilities West Java Province

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Abstract – Onshore Processing Facilities is one of the industries engaged in natural gas processing. The total use of natural gas over the last four years tends to increase. OPF also utilizes electrical energy as secondary energy generated from GEG. Currently the condition of installed equipment such as GEG, air compressor, HVAC, and building lighting is 8 years old, so there are indications of a decrease in efficiency. Then the GEG condition which only generates electricity around 30% of its capacity is also suspected to cause low engine efficiency. Therefore, it is necessary to conduct an energy audit to determine energy use and potential savings that can be made. Based on an audit conducted by the SEC for 2022, 0.8 GJ/TOE is still relatively efficient. The Air Compressor System has an average efficiency of 78.73%, the HVAC unit has a COP value of 3.31, the lighting level of each room in the OPF building does not meet the minimum standard, which is around 125 - 450 lux, and GEG has an efficiency value of 27.2 %, which is below the design standard. Opportunities for savings that can be made are by reducing the compressor air pressure by 0.7 bar can save Rp. 21,778,565, installing a capacitor bank of 416 micro farads in the HVAC system can increase the value of cos phi to 0.95, replacing building lights with 28 watts installed recess type 69 units to meet lighting standards, and the use of PLN electricity will save electricity costs of IDR 2,367,557,200.

Keywords: Energy Audit, Air Compressor, HVAC, Lighting System, Gas Engine Generator.

I. INTRODUCTION

Every year energy use always increases. Based on data from the Indonesia Energy Outlook study (2019), it is estimated that an average annual energy demand growth rate of 5% during the 2019-2050 period. This is inversely proportional to the availability of fossil energy reserves as the main energy which has not been able to keep pace with the growth rate of energy demand. Based on data from the

Handbook of Energy and Economic Statistics of Indonesia (2019), it is stated that energy consumption in Indonesia reached 1,007.26 million BOE, of which the amount was absorbed by the transportation sector 41.19%, the industrial sector 38.66%, the household sector 14.6%, the commercial sector was 4.36%, and other sectors were around 1.19%.

As an effort to conserve energy resources, the Government of Indonesia issued a policy through Government Regulation Number 70 of 2009 concerning Energy Conservation to maintain national energy security. One of the contents of the government regulation is to oblige users of energy sources and energy users who use energy sources and or energy greater than or equal to 6000 TOE per year to conserve energy. This Government Regulation is a derivative or elaboration of Law Number 30 of 2007 concerning Energy. Seeing this, it is important for energy users, especially industry, to always save energy.

Onshore Processing Facilities (OPF) in West Java Province is one of the industries engaged in natural gas processing, where the production process uses natural gas as its main energy source. In terms of energy use, the total use of natural gas per day is around 165 MMSCFD, of which this amount is used for blanket vessels and condensate storage tanks of 63.1%, Gas Engine Generator (GEG) of 19.3%, Triethylene Glycol (TEG) Reboiler by 14.5%, and flare by 2.9%. The total use of natural gas over the past four years has tended to increase, where in 2019 total consumption was 48.23 MMSCF, in 2020 it was 50.05 MMSCF, in 2021 it was 53.58 MMSCF, and in 2022 it was 61.01 MMSCF. On the other hand, this OPF also utilizes electrical energy as secondary energy produced from a Gas Engine Generator of around 6305 kWh every day. This electrical energy is used to supply equipment such as load banks of 48.1%, air compressors of 22.06%, Heating Ventilation and Air Conditioning (HVAC) of 17.9%, and other equipment of 11.8%. Current OPF electricity use also tends to increase where in 2019 the average generator load is around 198 kW until 2022 increases to 242 kW.

In line with these regulations and to support the company's energy saving program and reduce the emissions, this OPF as one of the processing facilities feels the need to save energy. OPF is designed to process fluids from wells so that they can produce natural gas and condensate products according to the required specifications. Currently the condition of equipment installed in OPF such as GEG, air compressor system, HVAC, and building lighting system is 8 years old, so there are indications that there has been a decrease in the efficiency of these equipment which has an impact on energy use. In addition, inefficient energy use can also occur due to modifications or changes in equipment operation. Then the condition of the power plant or GEG which only produces electricity around 30% of its capacity is also suspected to cause low and less than optimal engine efficiency. So that if it is operated continuously, it will cause waste of energy and waste of energy costs. On the other hand, natural gas and condensate production from wells has continued to decline in the last four years. Where in 2019 the amount of natural gas was 4,016,751 MMSCF, in 2020 it was 3,619,862, in 2021 it was only 3,216,237 MMSCF, and in 2022 it was 2,853,991 MMSCF. And for condensate in 2019 it was 26,002.533 BC, in 2020 it was 23,469,997 BC, in 2021 it was 20,507.357 BC, and in 2022 it was only 20,034.152 BC. So the Specific Energy Consumption (SEC) to increase from 0.5 GJ/TOE in 2019, 0.5 GJ/TOE in 2020, and 0.7 GJ/TOE in 2021, and 0.8 GJ/TOE in 2022.

Therefore, energy conservation measures need to be carried out to identify energy use, production and SEC as well as analyze energy use efficiency in GEG, air compressor systems, HVAC and building lighting systems in detail so that energy saving opportunities is obtained. Energy conservation is a systematic effort made to obtain optimal energy use without reducing the comfort level or equipment performance. In this study an energy audit will be carried out which is a method of evaluating and analyzing energy use in carrying out the production process so that it is known in detail the optimization of energy use based on existing technical standards and can determine energy savings in the equipment used.

The equipment to be analyzed in this study is a Gas Engine Generator with a capacity of 725 kW, Heating Ventilation and Air Conditioning type air cooled condenser with a capacity of 400,000 Btu/hour, a screw type air compressor with a capacity of 8.3 m³/minute, and a building lighting system. From the equipment analysis, energy saving opportunities can be determined. In addition to technical analysis, a techno economic analysis was also carried out to compare the costs of electricity production between GEGs which include energy use, maintenance costs and operational costs with PLN's electricity costs.

II. METHODOLOGY

2.1 The Scope of Research

The object of this research is the Onshore Processing Facility with the scope of an energy audit which includes energy use, the amount of natural gas and condensate production in 2019 – 2022, SEU equipment such as air compressor systems, HVAC, building lighting systems, and GEG. Actual data collection was carried out by collecting data from DCS and measuring devices installed for one week.

2.2 Data Source

The type of data taken is in the form of primary data and secondary data. Primary data was taken with the direct involvement of researchers through surveys, observations, and measurements. While secondary data is data taken as a result of existing documentation or reports.

- a) Secondary data used in this study includes consumption of gas fuel, amount of natural gas and condensate production in 2019 – 2022, specifications for air compressors, HVAC, GEG, and building lighting systems, maintenance and operating costs of gas engine generators, basic electricity rates and costs install PLN.
- b) The primary data used in this study include the electric power of the air compressor, the exhaust and suction pressure of the air compressor, the HVAC power, AHU temperature, air velocity, AHU air supply cross-sectional area, GEG fuel consumption, fuel calorie content, and room lighting intensity.

2.3 Data Collection

In general, the primary data collection method in this study was obtained from measurement results and secondary data obtained from historical data or reports.

- a) Measurement of the electric power of the air compressor uses a Schneider PM 800 power meter that is installed on the panel at intervals of every 12 hours. Measurement of discharge pressure, air compressor inlet pressure, outlet temperature, air compressor suction, and flow rate through readings on the HMI that has been installed on the unit at intervals of 12 hours.
- b) HVAC power measurement using a power meter, AHU input temperature measurement, AHU output temperature, and air supply speed using a thermometer and anemometer at intervals of every 12 hours. Measurement of the cross-sectional area of the AHU supplies air.
- c) Measurement of the intensity of lighting in each room using a lux meter.

- d) Measurement of gas engine genset fuel consumption using an installed flow meter, measuring the heat of gas fuel periodically, and measuring generator power usage at intervals of every 12 hours
- e) Collection of secondary data includes reports on natural gas consumption for the period 2019 – 2022, reports on natural gas and condensate production for 2019 – 2022, specifications for air compressors, HVAC, GEG, and lighting systems, reports on maintenance of GEG and operations and determination of basic electricity rates and costs PLN electricity installation for industry.

III. RESULTS AND DISCUSSIONS

3.1 Energy Use and Production

OPF uses gas fuel as its main energy source which is obtained from gas wells and electricity as a secondary energy source produced from the Gas Engine Generator. In the production process, the products produced from this OPF are natural gas and condensate.

1) Use of Gas Fuel

Gas fuel is all types of fuel in the form of gas, this fuel belongs to the class of fossil fuels. In actual conditions, gas fuel in OPF is used for Gas Engine Generators, pilot gas to flare, TEG, blanket vessels and condensate storage tanks. This gas fuel is obtained from OPF wells or production wells. Flow meters for fuel gas are installed on total fuel gas, pilot gas to flare, TEG and GEG. The following is the daily fuel consumption at the OPF based on the measurements taken.

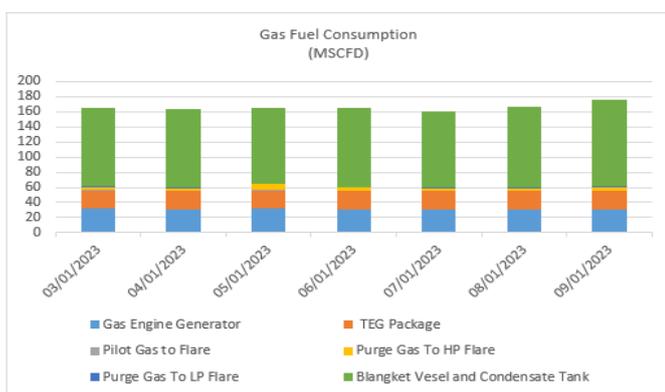


Figure 1: Chart of Daily Gas Fuel Consumption

Based on the data above, it can be seen that the total consumption of gas fuel per day on average is 166 MSCFD with the smallest being 161 MSCFD and the largest being 175 MSCFD. The largest consumption of gas fuel is used for blanket ships and condensate tanks and the smallest is pilot gas for flares.

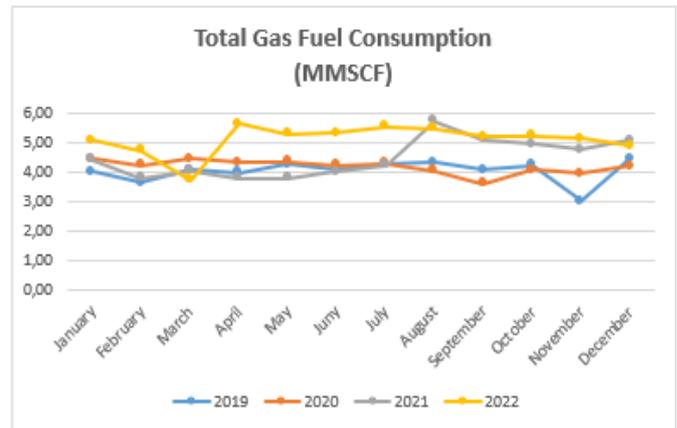


Figure 2: Chart of Total Fuel Gas Fuel Consumption 2019 – 2022

Based on historical data, the use of gas in 2019 was 48.23 MMSCF, 50.05 MSCF in 2020, 53.579 MMSCF in 2021, and 61.01 MMSCF in 2022. The graph above shows that the use of natural gas has increased from 2019 to 2022.

2) Use of Electricity

Electrical energy is obtained from the Gas Engine Generator generating system with a capacity of 725 kW. There are two GEG units, where in normal conditions only one GEG unit operates, while the other GEG units are in standby condition. For emergency needs, a Diesel Engine Generator unit with a capacity of 440 kW is available. From the results of measurements of OPF electricity usage for one week on January 3-9 2023 where the average uses of electrical energy per day is 6088.17 kWh. The use of electrical energy per day ranges from 5920.4 kWh to 6305.6 kWh per day.

Table 1: Electricity Consumption per Day

	Electricity Consumption Per Day							
	03-Jan-23	04-Jan-23	05-Jan-23	06-Jan-23	07-Jan-23	08-Jan-23	09-Jan-23	Rata-rata
Electricity per Day (MWH)	6,3056	5,9244	6,1788	6,1224	6,2152	5,9504	5,9204	6,0881714

3) OPF Production

OPF production includes gas and condensate. The table below shows the total gas and condensate production in 2019 of 4016,751 MMSCF and 26,002,533 BC. In 2020 it will be 3619,863 MMSCF and 23,469,997 BC. In 2021 it will be 3216.238 MMSCF and 20507.357 BC. And in 2022 it will be 2853,991 MMSCF and 18,934,152 BC.

Table 2: Natural Gas and Condensate Production 2019 – 2022

Month	OPF Production							
	2019		2020		2021		2022	
	Natural Gas	Condensate	Natural Gas	Condensate	Natural Gas	Condensate	Natural Gas	Condensate
	MMSCF	BC	MMSCF	BC	MMSCF	BC	MMSCF	BC
January	365,45	2508,00	335,27	2218,14	296,48	2090,98	268,17	2184,19
February	326,26	2230,00	309,05	2116,24	267,65	1845,88	230,89	1947,97
March	357,77	2431,00	291,32	1926,31	262,24	1747,53	53,00	20,70
April	341,83	2310,00	308,33	2101,03	287,47	2180,00	234,44	1965,10
May	350,19	2366,00	320,86	2105,00	212,91	1021,22	275,92	1987,76
June	336,03	2378,00	305,85	1998,64	274,65	1295,27	263,11	1490,34
July	336,70	2368,00	299,69	2055,29	281,19	2148,58	266,58	2019,96
August	345,87	2395,40	310,43	1713,53	277,31	1897,06	257,92	1162,31
September	332,33	2010,73	259,68	1137,43	264,82	1425,64	252,87	1997,43
October	324,60	1515,59	315,65	2071,95	264,32	1772,42	261,59	1973,93
November	265,92	1268,02	290,23	1913,29	261,27	1867,38	245,19	1186,95
December	333,81	2223,81	273,49	2113,16	265,91	1215,40	244,33	1797,52
Min	265,92	1268,02	259,68	1137,43	212,91	1021,22	53,00	20,70
Max	365,45	2508,00	335,27	2218,14	296,48	2180,00	275,92	2184,19
Average	334,73	2166,88	301,66	1955,83	268,02	1708,95	237,83	1577,85
Amount	4016,75	26002,53	3619,86	23470,00	3216,24	20507,36	2853,99	18934,15

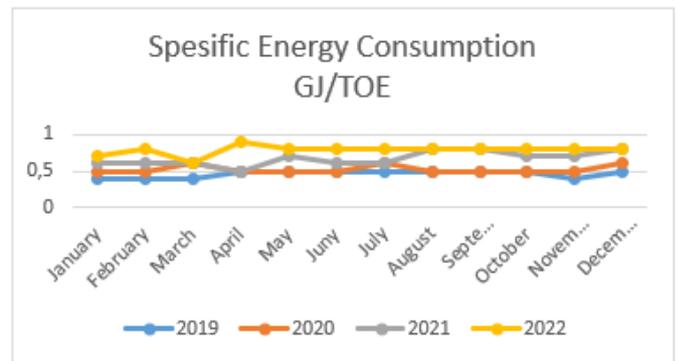


Figure 3: Chart of SEC 2019 – 2022

Based on the 2020 IOGP for the oil and gas industry, the energy intensity benchmark for Asia and Australia is around 1.5 GJ/TOE. And the average OPF intensity for 2022 is 0.8 GJ/TOE, so it is still relatively efficient because it is below the benchmark. However, the intensity increases every year.

4) Specific Energy Consumption (SEC)

To determine the energy performance used to calculate the intensity of energy use. The use of energy intensity/specific energy consumption (SEC) is one way to determine the performance of energy utilization in production output. Then the energy intensity used is the total energy/product. Total energy use intensity is calculated based on the ratio of total energy consumption to total production. The SEC value can be determined by the following calculation:

$$SEC = \frac{\text{Konsumsi Energi (GJ)}}{\text{Jumlah Produksi (TOE)}}$$

$$SEC = \frac{5364,1 \text{ (GJ)}}{6405,3 \text{ (TOE)}}$$

$$SEC = 0,8 \text{ GJ/TOE}$$

The following table shows production, energy consumption and SEC from 2019 to 2022.

Table 3: Production, Energy Consumption, and SEC 2019 – 2022

Month	2019			2020			2021			2022		
	Production (TOE)	Fuel Gas (GJ)	SEC (GJ/TOE)	Production (TOE)	Fuel Gas (GJ)	SEC (GJ/TOE)	Production (TOE)	Fuel Gas (GJ)	SEC (GJ/TOE)	Production (TOE)	Fuel Gas (GJ)	SEC (GJ/TOE)
January	9833,8	4209,7	0,4	9009,8	4684,4	0,5	7986,1	4661,2	0,6	7266,2	5350,2	0,7
February	8777,9	3829,9	0,4	8315,6	4452,3	0,5	7203,6	3999,7	0,6	6207,8	4972,5	0,8
March	9623,7	4294,1	0,4	7828,4	4673,9	0,6	7049,1	4241,3	0,6	1536,3	3924,8	2,6
April	9193,0	4178,0	0,5	8294,5	4557,8	0,5	7765,7	3977,6	0,5	6302,2	5927,3	0,9
May	9417,9	4484,0	0,5	8619,9	4578,9	0,5	5665,3	3998,7	0,7	7438,3	5558,0	0,7
June	9052,6	4283,5	0,5	8215,5	4452,3	0,5	7304,8	4220,2	0,6	7034,1	5590,7	0,8
July	9068,6	4473,4	0,5	8064,2	4505,1	0,6	7598,5	4462,9	0,6	7201,0	5813,4	0,8
August	9309,8	4536,7	0,5	8292,7	4262,4	0,5	7461,2	6024,4	0,8	6851,8	5761,7	0,8
September	8903,4	4294,1	0,5	6893,9	3777,1	0,5	7068,9	5380,8	0,8	6842,5	5450,4	0,8
October	8631,1	4441,8	0,5	8480,2	4294,1	0,5	7106,5	5212,0	0,7	7065,2	5492,6	0,8
November	7074,4	3165,2	0,4	7798,4	4156,9	0,5	7041,4	5001,0	0,7	6525,6	5385,0	0,8
December	8972,7	4695,0	0,5	7393,8	4410,1	0,6	7066,8	5349,1	0,8	6592,3	5142,3	0,8
Min	7074,4	3165,2	0,4	6893,9	3777,1	0,5	5665,3	3977,6	0,7	1536,3	3924,8	2,6
Max	9833,8	4695,0	0,5	9009,8	4684,4	0,5	7986,1	6024,4	0,8	7466,9	5927,3	0,8
Average	8988,3	4240,4	0,5	8100,6	4400,5	0,5	7193,2	4710,7	0,7	6405,3	5364,1	0,8

3.2 Air Compressor System

The compressed air system consists of a compressor, an air dryer and a receiving tank. The compressed air from the receiving tank is divided into two, namely for utility air and instrument air. Compressed air is obtained from two compressor units which operate continuously and alternately. Based on utility design the air pressure is 125 Psig and for instrument air it is 110 Psig. The results showed that the air pressure coming out of the receiving tank for instrument air was around 112 Psig and utility air was around 125.1 Psig.

1) Air Compressor Performance Analysis

An overview of the performance of the compressed air system at OPF is known by measuring several operational parameters of the compressed air system to determine its efficiency value. Measurements are made by taking sample data directly. Calculation of compressor air efficiency can be done with the following steps:

$$Efficiency = \frac{\text{Isentropik Power}}{\text{Actual Power}} \times 100\%$$

$$\text{Isentropic Power} = \frac{\gamma}{\gamma - 1} \times \frac{P1Q1}{36} \times ((r^{\frac{\gamma-1}{\gamma}}) - 1)$$

$$= \frac{1,4}{1,4 - 1} \times \frac{1,001 \times 486}{36} \times ((\frac{9,354}{1,001})^{1,4-1} - 1)$$

$$= 42,23 \text{ kW}$$

$$Efficiency = \frac{42,23}{53,64} \times 100\%$$

$$= 78,73 \%$$

Note:

- Q_1 : Free Air Delivery (m^3/jam)
- P_1 : Suction Pressure (Bar)
- $r : P_2/P_1$
- γ : Heat Capacity (1,4 for air)

Based on the calculation results above, it is known that the average efficiency of air compressors is 78.73%. When compared to the air compressor design efficiency standards according to CAGI 2021 it is in the average category.

2) Air Compressor Energy Saving Opportunities

Opportunities for air compressor energy savings can be made by reducing operating pressure so that the use of electric power will be reduced. A decrease of 1 Bar can save energy by 6 - 7%. It is recommended to lower the pressure from 140 psig to 130 psig or about 0.7 bar. This is based on the fact that utility equipment requires a pressure of approximately 125 psig and instrument equipment 110 psig. The following is a graph of the relationship between compressor pressure and motor input power based on the measurement results.

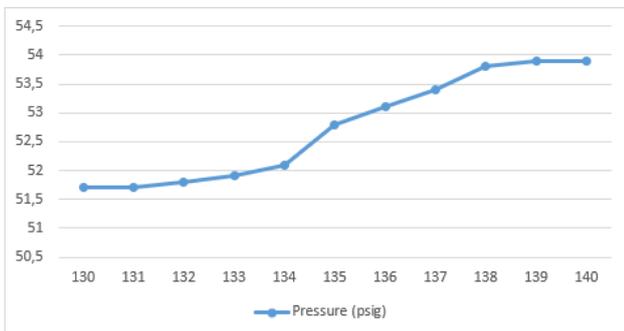


Figure 4: Chart of Air Compressor Pressure and Electrical Power

From the graph above it can be seen that at a pressure of 140 psig the electric power of the compressor motor is 53.9 kW and at a pressure of 130 psig the electric power of the motor is 51.7 kW so that a pressure drop of 10 psig can reduce the motor power by 2.2 kW or 4.1 %. Calculation of energy savings by lowering operating pressure is as follows:

Energy Consumption

$$= \left(\frac{\text{Power (kW)}}{\text{Motor Eff (\%)}} \right) \times \% \text{Full Load} \times \text{Operasional (H)}$$

$$= \frac{55}{0,93} \times \frac{53,74}{55} \times 8760$$

$$= 513.221,74 \text{ kWh/y}$$

$$\% \text{Saving} = \frac{P \text{ in } 140 \text{ Psig} - P \text{ in } 130 \text{ Psig}}{P \text{ in } 130 \text{ Psig}} \times 100\%$$

$$= \frac{53,9 - 51,7}{53,9} \times 100\%$$

$$= 4,1\%$$

Annual Energy Saving

$$= \text{Annual Energy Consumption} \times \% \text{Saving}$$

$$= 555783,91 \times 4,1 \%$$

$$= 21.042,09 \text{ kWh/y}$$

Annual Cost Saving

$$= \text{Annual Energy Saving} \times \text{Electricity Cost}$$

$$= 21042,09 \times Rp 1035$$

$$= Rp 21.778.565$$

3.3 HVAC

Heating Ventilation and Air Conditioning (HVAC) yang digunakan pada gedung CCR menggunakan jenis *air cooled condenser*. Unit HVAC terdiri dari 2 unit AHU dan 8 unit condensing unit. Pada operasi normal menggunakan 1 unit AHU dan 4 condensing unit.

1) HVAC Performance Analysis

To get an overview of the HVAC system performance, in this energy audit process several HVAC system operational parameters are measured to determine the value of system performance efficiency. Measurements are made by taking data samples directly. Following are the HVAC operating parameters. Based on the parameters measured, the COP of the installed HVAC system can be determined through the following calculations:

$$m = A \times V \times \rho$$

$$m = 2,73 \text{ m}^2 \times 5,84 \frac{\text{m}}{\text{s}} \times 1,205 \text{ kg/m}^3$$

$$m = 19,22 \text{ kg/s}$$

$$Q = m \times (H_{in} - H_{out})$$

$$Q = 19,22 \frac{\text{kg}}{\text{s}} \times (57 - 51)$$

$$Q = 115,266 \text{ kW}$$

$$\text{COP} = \frac{Q}{P}$$

$$\text{COP} = \frac{115,266}{34,77}$$

$$COP = 3,31$$

Note:

COP: Coefficient of Performance

Q : Cooling Capacity (kW)

M : Air Masses Out (kg/s)

A : Ducting Supply (m²)

V : Air Speed (m/s)

P : Air Density (kg/m³)

H_{in} : Entalphi in (kj/kg)

H_{out} : Enthalpi out (kj/kg)

P : Power Consumption (kW)

Based on the calculation results, this HVAC system has an average COP of 3.31, which when compared with the minimum standard for efficiency of air conditioning equipment for Air Cooled Chillers < 150 TR (screws) is 2, it can be said that currently the installed HVAC system is efficient.

2) Improved HVAC Power Factor

Based on the measurement results, the power factor value in the HVAC system is classified as low, namely 0.73. It is necessary to add capacitors to increase the HVAC power factor in order to maximize the use of electric power. Here's the calculation:

$$\text{Data : } P = 34,77 \text{ kW}$$

$$I = 69,49 \text{ A}$$

$$PF = 0,73 \text{ atau } 43,11^\circ$$

$$V = 397 \text{ V}$$

Then the QL or reactive power is as follow:

$$QL = \sqrt{3} \times 397 \times 69,49 \times \sin 43,11$$

$$= 32654,96 \text{ VAR}$$

Furthermore, if the expected power factor is 0.95 or 18.19° then I on HVAC:

$$I = \frac{P}{\sqrt{3} \times V \times \cos \Phi}$$

$$I = \frac{34770}{\sqrt{3} \times 397 \times 0,95}$$

$$= 53,28 \text{ A}$$

Then Q_k or reactive power correction is as follows:

$$Q_k = \sqrt{3} \times V \times I \times \tan 18,19$$

$$= \sqrt{3} \times 397 \times 53,28 \times \tan 18,19$$

$$= 12038,42 \text{ VAR}$$

$$Q_{cap} = Q_L - Q_k$$

$$= 32654,96 - 12038,42$$

$$= 20616,54 \text{ VAR}$$

Next to determine the value of the capacitor is as follows:

$$C = \frac{Q_{cap}}{-V^2 \times \omega}$$

$$= \frac{20616,54}{-397^2 \times 2\pi f}$$

$$= \frac{20616,54}{-397^2 \times 2 \times 3,14 \times 50}$$

$$= \frac{20616,54}{49489226}$$

$$= 4,16 \times 10^{-4} \text{ Farad or } 416 \text{ Mikro Farad}$$

3.4 Building Lighting System

Light intensity or illumination is the amount of light in a lighting system that falls perpendicular to a work area. The amount of strong light in a room is influenced by the lamp used as a source of lighting.

Table 4: Lamp Tipe

No	Lamp Tipe	Power	Amount
1	Recess Mounted 2240 Lm	30 W	76
2	Pendant Mounted 3500 Lm	42 W	9
3	Down Light 614 Lm	11 W	15

In the current conditions the OPF building lighting system uses LED lights as shown above. The OPF building is 32 meters long, 10 meters wide and 3.5 meters high. Based on the results of field surveys and documents, the OPF building uses several types of lights.

To get an idea of the quality of lighting in the OPF, during the energy audit process, lighting levels were measured using a lux meter. Measurements are made by taking samples of lighting strength data at each point in the room. Measurement of room light intensity is carried out independently using a lux meter.

Table 5: Light Intensity

No	Room	Light Intensity (Lux)	
		08.00	20.00
1	CCR Room	280	278
2	Substation Room	303	300
3	Instrument Panel Room	310	305
4	Battery Room	260	262
5	HVAC Room	270	268
6	Telecommunication Room	300	296
7	Administration & File	450	311
8	Toilet	125	124
9	Corridor	254	182

Table 5 shows that the range of lighting levels in each room in the building is different, ranging from 125 – 450 Lux in the morning and 124 – 311 Lux at night. Where the lowest lighting level is in the toilet and the highest lighting level is in the administration room and archive room. The data shows that the lighting level is still not good and does not meet the SNI 03-65752001 standard. The minimum standard for workspace lighting is 350 lux.

1) Lighting System Analysis

The average lighting level of a building is calculated using the following equation. In actual conditions, it is known that the number of lamps used was 120 with 76 units of 2240 lm recess mount type, 9 units of 3500 lm pendant mount, and 15 units of 614 lm downlighting. The coefficient values of kp and kd are assumed to be 0.5 and 0.8 respectively so that:

$$E_{average} = \frac{F_{total} \times Kp \times Kd}{A}$$

$$= \frac{((76 \times 2240) + (9 \times 3500) + (12 \times 614)) \times 0,5 \times 0,8}{320}$$

$$= 261 \text{ Lux}$$

Note:

- E average: Iluminte (lux)
- F total: Fluks luminous (lumen)
- A: Room Area (m²)
- kp: Usage coefficient 0,5
- kd: Depreciation coefficient 0,8

Based on the calculation results, the lighting level in the building is 261 lux. So that these results are still below the lighting level set by SNI for work spaces, namely 350 Lux. Then by utilizing natural lighting that comes from light that enters through windows and doors as well as actual lighting,

then the lighting levels are simulated into the DIALux software assuming sunny weather conditions during the day.

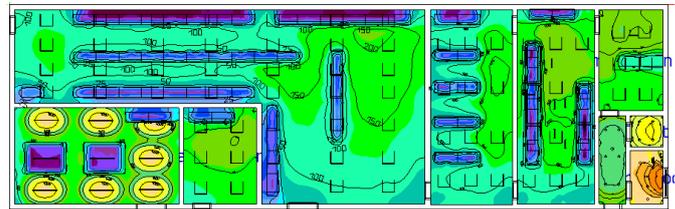


Figure 5: Actual Lighting System

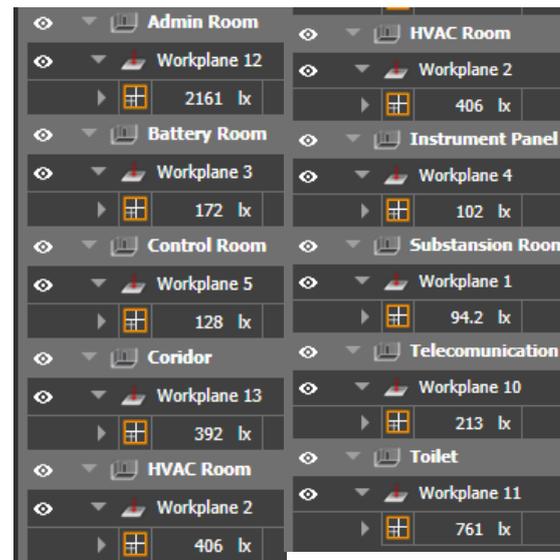


Figure 6: Simulation of Lighting Levels for Each

The picture above shows that the average lighting level in buildings is green. The figure also shows that the lighting level in each room is between 102 - 2161 lux. So it can be concluded that the lighting in the building is not good and uncomfortable for workers in carrying out activities because some rooms still have a poor lighting level of 350 Lux.

2) Optimization of the Lighting System

Next, the calculation of the lighting level of the building is carried out. At this stage optimization was carried out by replacing the Reces Mounted 28 Watt 4043 lumen type light bulb. Optimization is done by calculating the value of the total flux and the number of armatures to be used using the following equation. The main room area of the building is 320 m², the lighting level of the building is 350 lux assuming a kp value of 0.5 and a kd value of 0.8, the total flux value can be calculated:

$$F_{Total} = \frac{350 \times 320}{0,5 \times 0,8} \text{ lumen}$$

$$F_{Total} = 280.000 \text{ lumen}$$

After obtaining the total flux value, the number of lamp armatures suitable for application to buildings can be calculated by:

$$N_{Total} = \frac{280.000}{4043 \times 1}$$

$$N_{Total} = 69,25 \text{ unit}$$

Based on the above calculation results, it is known that the number of lamp armatures suitable for a building with an area of 320 m² is 69 units. To find out the level of lighting after optimization, a simulation was carried out using the DIALux software. The steps for the lighting system simulation after the repairs were carried out were to change the type of lamp to a Recess Mounted 28 Watt and 4043 lumens with the number of lamps according to the calculations.

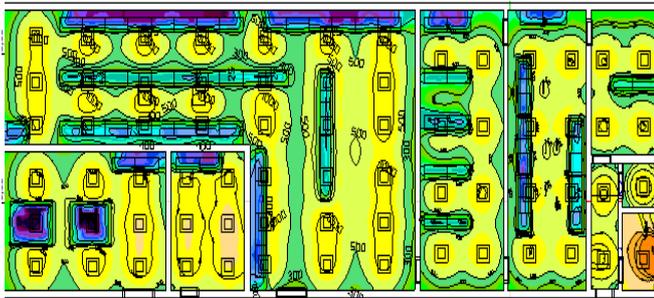


Figure 7: 2D Simulation after Optimization

Furthermore, from the optimization results, the lighting level in the building can also be displayed in 3D.

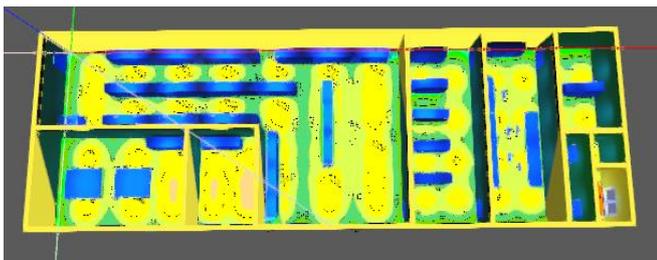


Figure 8: 3D Simulation after Optimization

From the picture it can also be seen that the lighting level is very good and evenly distributed to every corner of the room without being affected by the presence of existing furniture. So that the average lighting level from the simulation results shows that the OPF building is very good, safe and comfortable for workers in carrying out their activities.

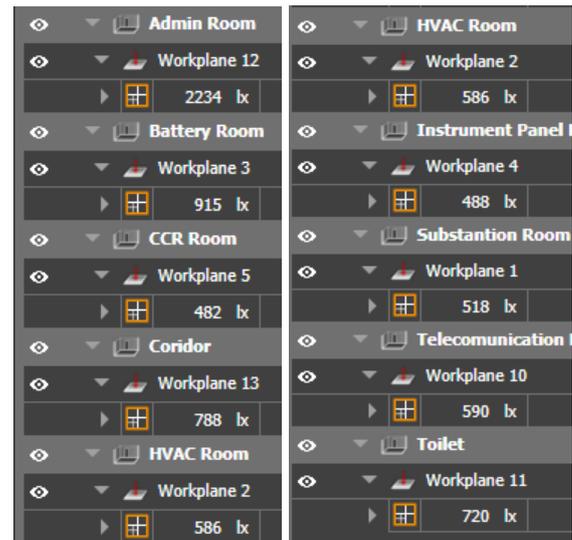


Figure 9: Simulation of Lighting Levels for Each Room

The picture above shows that the building's lighting level is more optimal with an indication of a yellow display and the average lighting level ranges from 482 – 2234 lux.

3.5 Gas Engine Generator

Gas Engine Generator is a generator system that uses the main propulsion system of a gas engine, where the fuel used for this gas engine is gas produced by production that has gone through a processing process at the production process facility.

Table 5: Specifications of Gas Engine Generator

Spesification	Gas Engine Generator A	Gas Engine Generator B
Manufactur	Carterpillar	Carterpillar
Engine Type	G3512	G3512
Rated Voltage	400 V	400 V
Rated Power	725 kW	725 kW
Phasa	3	3
Frequensi	50 Hz	50 Hz
Power Factor	0,8	0,8
Generator Type	SR 4	SR 4

This Gas Engine Generator works at a voltage of 400 Volts 50 Hz and has a capacity of 725 kW. Currently the Gas Engine Generator is used as the main generating system. Under normal operating conditions, only one Gas Engine Generator unit is working and the other units are in standby condition.

1) GEG Performance Analysis

To determine the performance of the Gas Engine Generator, several parameter measurements were carried out.

Following are the results of the GEG parameter measurements that have been carried out. Then the following calculations are carried out to determine the efficiency of the GEG with the direct method.

$$\eta = \frac{\text{Parameter Generate, } kCal/h}{\text{Heat of Fuel Gas, } kCal/h}$$

$$\eta = \frac{106334,2 \text{ } kCal/h}{1247,1 \times 1248,6 \text{ } \frac{scf}{h} \cdot Btu/cf}$$

$$\eta = \frac{106334,2 \text{ } kCal/h}{1557208,1 \times 0,251 \text{ } ,kCal/h}$$

$$\eta = \frac{106334,2 \text{ } kCal/h}{390859,2 \text{ } kCal/h} \times 100$$

$$\eta = 27,2 \%$$

Based on the calculation above, the GEG efficiency value is 27.2%.

2) Electricity Cost Analysis

Seeing the use of GEG with a small workload, it can be said that the use of GEG for electricity generation is not efficient so that it has the opportunity to use PLN electricity. So to find out the difference in these costs, a calculation and analysis of the cost of using electricity from GEG and PLN is carried out as follows:

Table 6: Cost of Using GEG and PLN Electricity

Cost of Gas Engine Generator				
Component	Quantity	Unit	Price/Unit (Rp)	Total Price (Rp)
Lube Oil	1216	Liter	85650	Rp104.150.400
Fuel Gas GEG 725 kW	11355,15	MMBTU	120000	Rp1.362.618.000
Maintenance and Service for 2000 hours	4	Time	233595000	Rp934.380.000
Personil For Operating	1	ls	1072500000	Rp1.072.500.000
Total Price				Rp3.473.648.400
Cost of PLN				
Component	Quantity	Unit	Price/kWh	Total Price
Electricity (kWh) per year	1068687	kWh	1035	Rp1.106.091.200
Savings				Rp2.367.557.200

The cost of electricity needed when using GEG is IDR 3,473,648,400 while the cost of electricity needed when using PLN electricity is IDR 1,106,091,200. So that the savings that will be obtained if you use PLN electricity are IDR 2,367,557,200.

3) PLN Electricity Investment

Investment in electricity costs required if using PLN electricity includes the cost of connecting PLN electricity, the cost of procuring and installing a 20kV transformer and

substation, as well as the cost of building a house for the placement of MV substations and transformers. The PLN electricity connection cost simulation can be seen through the Mobile PLN application. Based on the simulation results, the cost components include a connection fee of IDR 775 per VA, a customer guarantee fee of IDR 154 per VA, a stamp duty fee of IDR 10,000, and an SLO fee of IDR 15 per VA. So that for the connection of electricity with a capacity of 345 kVA the follow-up fee is IDR 325,960,000.

In addition to electricity connection costs, investment costs for medium voltage electrical equipment are also required to support the availability of the PLN electricity network in OPF. The electricity investment costs include the cost of procuring 20 kV 400 kV transformers, 20 kV booths, and cables including installation costs.

Furthermore, the investment cost needed to support the availability of PLN electricity is the construction cost of making a building for the placement of transformers and medium voltage cubes with a size of 70m². The overall cost breakdown is as follows:

Table 7: Investment in Supply of Electricity PLN

Total Investment in Supply of Electricity PLN				
Component	Quantity	Unit	Price/Unit (Rp)	Total Price (Rp)
I. PLN connection fee 345 kVA				
Connection Fee	345000	VA	775	Rp267.375.000
Customer Guarantee	345000	VA	154	Rp53.130.000
Duty stamp	1	ea	10000	Rp10.000
SLO	345000	VA	15	Rp5.175.000
Total I				Rp325.690.000
II. Electrical Work				
Procurement and Installation Transformer & Cubicle 20kV	1	unit		Rp787.230.315
Total II				Rp787.230.315
III. Construction Work				
Building 7m x 10m	1	unit		Rp1.376.793.866
Total III				Rp1.376.793.866
Total I + II + III				Rp2.489.714.181
Pay Back Periode (Year)				1,051596211

Based on the cost breakdown above, the overall investment cost required for the supply of PLN electricity is a connection fee of Rp. 325,690,000, the investment cost for electrical equipment is Rp. 787,230,315, and the investment cost for building construction is Rp. 1,376,793,866. So the total investment cost is IDR 2,489,714,181.

So the period of return on investment value or payback period is 1.05 years.

$$\begin{aligned} \text{Payback Periode} &= \frac{\text{Investment}}{\text{annual saving cost}} \\ &= \frac{2.489.714.181}{2.367.557.200} \\ &= 1,05 \text{ year} \end{aligned}$$

The design of the electric power system network with electricity supply from PLN is described according to the design below. The 20kV medium voltage network from PLN electricity will enter the MV switchgear and then pass through the transformer so that the electric voltage drops to 400 V. Then the electricity supplied by PLN enters the low voltage switchgear. Gas Engine Generator (GEG) and Diesel Engine Generator (DEG) are in stand-by condition as long as electricity is supplied by the PLN network. GEG and DEG will be used if the electricity supply from PLN is cut off.

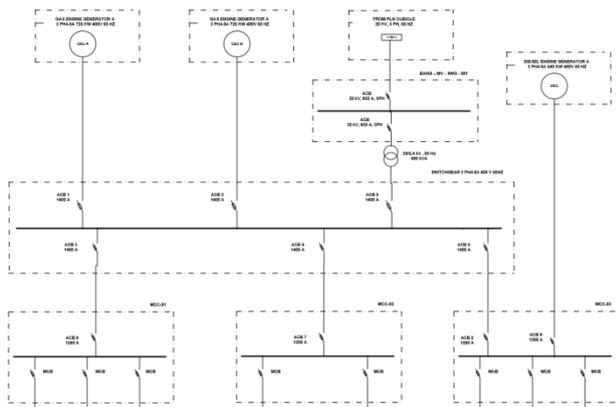


Figure 10: Deasin One Line Diagram

IV. CONCLUSION

- 1) Onshore Processing Facilities in West Java Province uses natural gas as the primary energy source and electricity as the secondary energy.
 - a) Gas fuel used is 61.01 MMSCF in 2022. During this period OPF produced 2853.991 MMSCF of gas and 18934.152 BC of condensate. The OPF energy use intensity for 2022 is 0.8 GJ/TOE so it is still relatively efficient because it is below the benchmark of 1.5 GJ/TOE.
 - b) OPF's electricity consumption is 6088.17 kWh per day which is supplied by the Gas Engine Generator.
- 2) Significant energy consuming equipment has the following efficiencies:
 - a) Air Compressor System in OPF has an average efficiency of 78.73%. Based on the 2021 CAGI standard it is in the average category.
 - b) The HVAC unit has a COP value of 3.31 which, when compared with the minimum standard for efficiency of Aircooled Chiller <150 TR (screw) equipment, is 2.9, it can be said that the currently installed HVAC system is efficient.
 - c) The lighting level of each room in the OPF building is different, ranging from 125 - 450 Lux in the morning and 124 - 311 Lux at night. Where the lowest level of

lighting is in the toilet and the highest level of lighting is in the administrative and file rooms. The data shows that the lighting level is still not good and does not meet the SNI 03-65752001 standard. According to SNI, the minimum standard for workspace lighting is 350 lux.

- d) Gas Engine Generator OPF has an efficiency value of 27.2% with a supplied load of 123 kW.
- 3) Efforts to improve equipment performance and energy savings can be made through several efforts, namely:
 - a) Lowering the pressure from 140 Psig to 130 –Psig or around 0.7 Bar. It is based on utility equipment requiring approximately 125 psig pressure and 110 psig instrument equipment. Where it can save energy of IDR 21,042.09 kWh/y so it can save energy costs of IDR 21,778,565.
 - b) The HVAC system has a low cos phi value of 0.73 so it needs to be increased to 0.95 by adding a capacitor of 416 micro farads.
 - c) Optimization of the lighting system is carried out by replacing light bulbs with the type of Recess Mounted 28 Watt 4043 lumens in a total of 69 units which can produce room lighting between 482 – 2234 lux so that it is in accordance with what is needed.
- 4) The energy cost needed to operate the Gas Engine Generator for one year is IDR 3,473,648,400 while the cost of electrical energy when using PLN electricity is IDR 1,106,091,200. So there is a potential savings of IDR 2,367,557,200 if you use PLN electricity. The total investment costs needed to provide PLN's electricity are connection costs of Rp. 325,690,000, investment costs for electrical equipment of Rp. 787,230,315, and investment costs for building construction of Rp. 1,376,793,866. The total investment cost is IDR 2,489,714,181. So the pay back period is 1.05 years.

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