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Microgrid Design in Electricity Supply in Paper Factories

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ABSTRACT
Renewable energy is growing, one of which is by controlling solar energy. A solar power plant (PLTS) is a power generation system that utilizes solar energy to become electrical energy through photovoltaic modules, which are included in environmentally friendly energy so that it becomes a renewable, effective, more efficient, and reliable plant. The research designing the modeling of PLTS on a grid was carried out on the roof of a gas power plant (PLTG) which generated 164.47 MWh / year. Analyzing modeling in the addition of the Rooftop Solar System that enters the network can reduce exhaust emissions from the use of other equipment for four years with an average of PLN by 99.29%, PLTG #1 by 99.06 and PLTG #2 by 99.11%. The impact of the addition of the PLTS Rooftop on the quality of power entering the 3.3 kV network system is seen that the feeder 2-panel bus has improved to 97.82% of the voltage drop of 72.67% in line with the PLN 3 panel, the improvement is made by providing capacitors of 3x4Mvar. Feeder 3 improved to 97.61% of the voltage drop of 78.87%, in line with the PLN 4 panel. The improvement was carried out by providing a capacitor of 2x4Mvar. Panel feeder four was seen to have improved to 99.21% from an excess voltage of 109.23% in line with the generating equipment, and the improvement was made by reducing capacitors by 0.1 Mvar from the used 5x0.1 Mvar.

INTRODUCTION

The geographical location is in the territory of Indonesia stretching from Sabang to Merauke (Purwanto & Mangku, 2016)(Ibrahim et al., 2019)(Mbete et al., 2023)(Metrahultikultura & Setiawan, 2023)(Faradiba, 2021)(Nofrizal et al., 2021). It is located at 6008' N to 11015' LS and 94045' BT to 141005' BT, which is on the equator with a relatively high solar radiation intensity averaging around 4.8 kWh / m^2 per day throughout Indonesia. Based on solar intensity data in Indonesia is a potential that should be utilized to produce electrical energy optimally (Syahputra & Soesanti, 2020)(Syahputra & Soesanti, 2021)(Suyono et al., 2018)(Zulkarnain & Zambak, 2021)(Fitriaty & Shen, 2018)(Susan & Wardhani, 2020)(Revy et al., 2022)(Edward & Dewi, 2019).

New renewable energy is a concern or spotlight as an environmentally friendly alternative crop compared to conventional plants. Based on Law No. 30 of 2007, Energy is the ability to do work in the form of heat, light, mechanics, chemistry, and electromagnetics. Furthermore, to clarify energy, the term energy will be classified into primary energy, sec, secondary, non-renewableble energy. (ESDM, 2007) In Indonesia, it is estimated to have considerable solar energy potential considering Indonesia's geographical location in the tropics, based on solar irradiation data in Indonesia, which has the potential to produce electricity of 207.9 GWp. Under these conditions, solar power development for electricity is projected to have been utilized around 6.5 GWp in 2025 and 45, Gwpwill ben uused45 GWp in 2050 or ,22% of what is expected.

The condition of the national energy general plan for the use of solar energy has been utilized is 78MW from the 0.04% utilized. Based on the regulation of Permen-LH Law No. 27 of 1999 concerning environmental impact analysis, forcing power plants to design to reduce exhaust emissions from the use of raw materials for making steam boilers, namely gas and coal, limited fossil energy sources, high fuel prices, and an abundance of new renewable energy resources, plant owners need to develop new and renewable energy to meet the electrical energy needs of paper mills and Environmentally friendly. (CANDY on Environmental Impact Analysis Number 27, 1999) The current condition of paper mill consumption is supplied with gas fuel power plants with a capacity of 2x4.2 MW, diesel fuel plants with a total of 5x 4.2MW an,d PLN adjusting the needs between 2MW to 8MW. Electricity production data uses data forfour4 years from 2019 to 2022 which the average production of both fuel gas supply plants is ±2.,7MW and the average use of PLN is > 4.5M. Thediesel generation is only used as a backup when there is a voltage drop. Based onfoufoursars, electricity consumption data is averaged for all supplies, namely 4MW – 5 MW.

Table 1. Data on electricity production during 2019 - 2022

Equipment Producty	Year			
	2019	2020	2021	2022
	KW			
GT #A	3.295	1.984	2.398	3.138
GT #B	3.265	2.864	1.554	3.099
DG #1	193	259	97	-
DG #2	184	54	172	-
DG #3	-	-	292	57
DG #4	239	276	377	49
DG #5	-	-	-	-
PLN	2.089	4.202	7.933	2.667

Referring to this, the production of electricity produced from plants with capacities has different values; this is due to a decrease in performance in generation in electricity production and in reducing CO2 exhaust emissions released by plants. To overcome the need for electrical energy production in factories, reliable alternative energy sources must be considered to build an effective system to reduce CO2 exhaust emissions. Judging from the condition of the plant in the middle of the city, design the use of a Solar Rooftop. The use of Solar Rooftop has several advantages, namely solar panels that are very environmentally friendly, do not use fossil fuels, do not emit harmful greenhouse gas emissions such as carbon dioxide, solar panels are easy to install or maintain, solar panels greatly contribute to reducing noise pollution or solar panels work very quietly, and a very long service life of 20-30 years.

For the reliability of the electric power system, it is also necessary to pay attention to such as the standard voltage profile of the network area, which is 3.3kV, in order to create no harm in the electricity supply to the factory to design the use of Solar Rooftop. On this basis, research was conducted on the use of PLTS in reducing exhaust emissions produced by plants. The research was conducted in the approach of exhaust emissions and the need for electricity supply, a design was carried out if PLTS Rooftop was used to supply the needs of the paper mill by simulating with software. Therefore, the author made the idea of discussing "Microgrid Design in Providing Electricity to Paper Mills"

METHODS

This chapter will present the electrical modeling system in the factory area power plant, previously the electricity supply in the factory area using PLTG, PLN, and PLTD power plants. The existence of the Paris Agreement, whereby least developed countries and small island developing countries can prepare and deliver strategies, plans, and actions for development that are low in greenhouse gas emissions according to their specific situations.

Base on the Minister of Energy and Mineral Resources No. 16 of 2020 concerning the National Action Planned for Reducing Greenhouse Gas Emissions (RAN GRK) is a work plan document for the implementation of various activities that directly and indirectly reduce GHG emissions in accordance with the national development target as outlined in Presidential Regulation Number 61 - 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions (RAN GRK) which is a planning guideline, implementation, monitoring and evaluation of GHG emission reduction.

In this Presidential Regulation, there is a description of GHG emission reduction targets and strategies in five main sectors, which include agriculture; forestry and peatlands; energy and transportation; industry; and waste management.

Based on these two guidelines, PLTS modeling will be carried out planned using rooftop facilities; modeling here will show the potential that can be generated with a limited area, offer the benefits obtained if installing rooftop PLTS in terms of exhaust emissions, and at the end, it is displayed showing the modeling of the Rooftop PLTS system when entering the network.

RESULTS AND DISCUSSION

In this chapter, we will discuss the condition of electricity generated by PT. Alpha5 by looking at the monthly energy profile in 2019 – 2020, planning the potential of modeling that can be developed in the area of PT. Alpha5 by looking at the possibility of sunlight that can cause photovoltaic, calculating the potential for electrical energy that can be generated, determining the number of modules used, and see the potential for exhaust emissions to be blocked using PLTS; Data simulation to know the stability of the PLTS Rooftop modeling system that is interconnected to the generation network using ETAP 12.6 software.

A. Electrical condition generated by PT. Alpha5

Based on the results of data collection taken from the producers and fuel consumption needed for electricity generation produced for three consecutive years. The conditions in the table below in 2019, total fuel usage in both engines is 21,050,830 m^3 equivalent to 765,485 MMBTU / Year, and actual diesel use is 67,157 liters, equivalent to 2,177 MMBTU / Year. In 2020, the total fuel use in both engines was 12,849,538 m^3, equal to 467,256 MMBTU / Year, and the actual use of diesel was 43,577 liters, equivalent to 1,413 MMBTU / Year. In 2021, the total use of fuel in both engines was 15,871,337 m^3, equal to 577,140 MMBTU/Year, and the actual use of diesel is 1,081,355 liters, equivalent to 35,052 MMBTU/Year.

Table 2. Fuel Use

Month	Feul Consumption														
	2019					2020					2021				
	Gas Consumption			Solar Consuption		Gas Consumption			Solar Consuption		Gas Consumption			Solar Consuption	
	Total	PGN	Total	Total	Total	Total	PGN	Total	Total	Total	Total	PGN	Total	Total	Total
	M3	M3	MMBTU	Liter	MMBTU	M3	M3	MMBTU	Liter	MMBTU	M3	M3	MMBTU	Liter	MMBTU
January	1.828.971	2.011.868	73.159	-	-	-	-	-	-	-	1.870.174	2.057.191	74.807	-	-
Febuary	1.646.152	1.810.767	65.846	-	-	-	-	-	-	-	1.708.514	1.879.365	68.341	-	-
March	1.814.764	1.996.240	72.591	-	-	1.127.183	1.239.901	45.087	2.417	78	2.971.542	3.268.696	118.862	2.147	70
April	918.047	1.009.852	36.722	-	-	838.775	922.653	33.551	29.563	958	805.936	886.530	32.237	-	-
May	1.821.011	2.003.112	72.840	-	-	815.601	897.161	32.624	-	-	807.957	888.753	32.318	-	-
June	1.816.893	1.998.582	72.676	2.403	78	833.449	916.794	33.338	-	-	769.324	846.256	30.773	-	-
July	935.340	1.028.874	37.414	-	-	815.783	897.361	32.631	120	4	921.530	1.013.683	36.861	116.698	3.783
August	1.886.371	2.075.008	75.455	-	-	1.005.004	1.105.504	40.200	7.512	244	-	-	-	542.218	17.576
September	1.808.873	1.989.760	72.355	-	-	1.690.521	1.859.573	67.621	2.695	87	-	-	-	413.310	13.397
October	1.860.102	2.046.112	74.404	-	-	1.795.592	1.975.151	71.824	1.270	41	927.930	1.020.723	37.117	3.915	127
November	1.782.998	1.961.298	71.320	-	-	1.836.734	2.020.407	73.469	-	-	1.774.470	1.951.917	70.979	3.067	99
December	1.017.596	1.119.356	40.704	64.754	2.099	922.756	1.015.032	36.910	-	-	1.871.112	2.058.223	74.844	-	-
Total	19.137.118	21.050.830	765.485	67.157	2.177	11.681.398	12.849.538	467.256	43.577	1.413	14.428.489	15.871.337	577.140	1.081.355	35.052
Averange	1.594.760	1.754.236	63.790	5.596	181	973.450	1.070.795	38.938	3.631	118	1.202.374	1.322.611	48.095	90.113	2.921

B. Energy potential that can be generated by PLTS Rooftop

The potential energy that PLTS Rooftop can produce can be seen from systematic calculations and simulations through PVSyst. Systematically generated energy potential

Table 3. InInsolation per month

Bulan	Insolation (kWh/M²/Days)	Bulan	Insolation (kWh/M²/Days)
Januari	4,33	Juli	4,77
Febuari	5,00	Agustus	4,96
Maret	5,00	September	5,16
April	4,86	Oktober	5,54
Mei	4,67	November	4,86
Juni	4,72	Desember	4,54
Rata - Rata Tahunan = 4,87			
Insulasi Tertinggi = 5,54			
Insulasi Terendah = 4,33			

From the data it can be seen that the average solar insulation is 6.38 kWh / m2. Therefore ESH can be calculated:

ESH = Annual Average Insulation/Standard Insulation
= 4,87 x 1000/1000
= 4.87 Jam

Based on the calculation above, the amount of potential energy generated from the PLTS system can be estimated. The planned solar system is 0.132 MWp, but for the suitability of design needs, the capacity of PLTS becomes 132 kWp. In the design of this PLTS system, it is planned to use solar modules with the power of each module 440 Wp, so that the number of solar modules is:

Total of modules = Solar Capacity/Module Capacity
= 132.000 Wp/440 Wp
= 300 solar panel

Next, calculate the potential energy produced by the PLTS system using the formula:

Potential PV Energy = Solar Capacity x ESH
= 132.000 x 4,87
= 642.840 Wh/day

From the calculation of generated energy above, some will be lost due to various losses in the system. So the energy that can really be utilized is:

PV Energy Potential Utilized = PV Energy Potential / Potential Loss
= 642.840 Wh/1,21
= 531.273 Wh/hari
= 531.273 Wh x 365/tahun
= 193.915 kWh/tahun

C. Potential energy generated by simulation

To find out how much potential energy is generated can also be done using the help of simulation software. In this study, the calculation of generated energy was carried out using PVSYST Software.

Conclusion

The research that has been conducted on microgrid design in providing electricity to paper mills can be concluded as follows : (1) The old potential of energy that the PLTS Rooftop can produce can be seen from systematic calculations and simulations through PVSyst, which is 4.87 hours. (2) Based on the potential electricity that can be generated, which is 132 kW with a design using a 440wp solar panel capacity with the number of modules used as much as 300 pc per module and assembled 75 strings assembled in series as much as 4. (3) Systematic calculation of the capacity of 132 kWp obtained a PV energy potential of 642,840 Wh / day and a PV energy potential utilized for 193,915 kWh / year. (4) A simulated calculation of the capacity of 132 kWp obtained the potential of PV energy utilized for 164,470kWh / year or 164.47 MWh / year with a capacity factor of 14.22%. (4) The estimated cost of $52,019 is operational and maintenance costs of 1% of the estimated price of $520.19 and for 30 years with an interest rate of 4.5% with an estimated cost of $8,473.32. (5) The life cycle cost (LCC) incurred during the project until during the generation life of 30 years spent $60,492.32 with a recovery factor value (CRF) of 0.0614. (6) Solar energy costs are determined by various factors, including life cycle cost (S) and kWh of annual production. The feasibility cost of planning the use of PLTS (COE) is $ 19.87 / MWh. (7) Simulation 1 ETAP shows that PLTG and PLN enter the network, and there is a lot of voltage drop starting from the distribution transformer and the components below it. Judging from the bus, the most voltage drop is 72.67% in the PLN 4 panel, and the overvoltage is 109.23% in the F4 panel. The F2 panel shows that some buses have experienced voltage drops where they have not reached the tolerance limit, which is the bus limit tolerated at 95%. The total active power value is 13748.31kW, and the real reactive power is 11272.44 kvar. 1. The F3 panel shows that some buses have experienced voltage drops where they have not reached the tolerance limit; namely, the bus limit is tolerated 95%. The total active power value is 9998.7kW, and the real reactive power is 8198.14 kvar. The total on all buses shows that some buses have experienced voltage drops where they have not reached the tolerance limit; namely, the bus limit is tolerated at a minimum of 95%, and toleration is a maximum limit of 105%. It can be seen that the feeder two-panel bus experienced a voltage drop of 72.67% in line with the PLN 3 panel, and feeder 3 experienced a voltage drop of 78.87% in line with the PLN 4 panel. Panel feeder 4 looks 109.23% overvoltage in line with the generating equipment. (8) Simulation 2 ETAP shows that PLTS has replaced PLTG into an incoming network supply, with PLN still experiencing voltage drops starting from the distribution to the components below it. Judging from the bus, the most voltage drop is 72.67% in the PLN 4 panel, and the overvoltage is 109.23% in the F4 panel. The F2 panel shows that some buses have experienced voltage drops where they have not reached the tolerance limit, which is the bus limit tolerated at 95%. The total active power value is 13748.31kW, and the real reactive power is 11272.44 kvar. The F3 panel shows that some buses have experienced voltage drops where they have not reached the tolerance limit, which is the bus limit tolerated at 95%. The total active power value is 9998.7kW, and the real reactive power is 8198.14 kvar. The total on all buses shows that some buses have experienced voltage drops where they have not reached the tolerance limit; namely, the bus limit is tolerated at a minimum of 95%, and the maximum limit is 105%. It can be seen that the feeder two-panel bus experienced a voltage drop of 72.67% in line with the PLN 3 panel, and feeder 3 experienced a voltage drop of 78.87% in line with the PLN 4 panel. Panel feeder 4 looks 109.23% overvoltage in line with the generating equipment. (9) Simulation 3: Giving the capacitor shows that some buses that have experienced voltage drops and excess voltage have undergone repair. It can be seen that the feeder panel two buses have improved to 97.82% from a voltage drop of 72.67% in line with the PLN 3 panel; the improvement is made by providing a capacitor of 3x4Mvar. Feeder 3 improved to 97.61% of the voltage drop of 78.87% in line with the PLN 4 panel; the improvement is done by giving a capacitor of 2x4Mvar. Panel feeder four was seen to have improved to 99.21% from an excess voltage of 109.23% in line with the generating equipment; the improvement was made by reducing capacitors by 0.1 Mvar from the used 5x0.1 Mvar.

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