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Design of Solar Power Plant Capacity for Auxiliary Load at Labuan Steam Power Plant (PLTU) PT. PLN (PERSERO)

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***Abstract* - Solar Power Plants are a form of renewable energy that harness sunlight to generate electricity through solar panels. This research designs a PLTS system for use at the Labuan Steam Power Plant (PLTU) of PT. PLN (Persero), aimed at reducing the plant's own electricity consumption. This study evaluates the design and installation of a PLTS system on a 7200 m² area at the Labuan PLTU and conducts a technical and economic comparison between On-Grid and Off-Grid PLTS systems. The research methods include field surveys, shading potential measurements, and design simulations using PVSyst software. The results show that the On-Grid PLTS installation at the Labuan PLTU Administration Building is technically and economically feasible, with a Benefit-Cost Ratio (BCR) of 1.20 and a Payback Period (PP) of 16.93 years. The implementation of this PLTS system has the potential to reduce carbon emissions by 84,187 tons of CO_2e per year, supporting PT. PLN's program to achieve the 23% renewable energy mix target by 2025.**

Keywords: Renewable Energy, PLTS, PLTU, On-Grid, Off-Grid, Energy Mix.

I. INTRODUCTION

Renewable energy plays a crucial role in meeting current and future energy needs and is essential for mitigating global climate change. By utilizing renewable energy sources, we can reduce dependence on fossil fuels, lower greenhouse gas emissions, and support environmental sustainability. Although renewable energy is increasingly utilized worldwide, the majority of energy still comes from fossil fuels (95%).

Indonesia, with a land area of 1.9 million km² and a population of 267 million, faces growing energy demands due to its stable economic growth. The heavy reliance on limited fossil fuels poses a risk of energy crises. Therefore, energy issues remain a government priority, especially considering the environmental impact of fossil fuel combustion.

According to PT. PLN (Persero)'s Electricity Supply Business Plan (RUPTL) 2021-2030 report, the development of new and renewable energy (EBT) includes the use of Solar Power Plants (PLTS) in various locations, including former mining sites and reservoirs. PLTS can reduce the use of conventional energy and is ready for deployment across different sectors.

PLTU Banten 2 Labuan, managed by PLN Indonesia Power, plans to use rooftop space for PLTS due to the significant solar exposure in Labuan Banten, which receives sunlight for 6 hours a day. With a rooftop area of 7,200 m², PLTS can provide renewable energy.

PLTS is an intermittent power source and requires backup generation to manage fluctuations in solar intensity. By 2020, the operational capacity of PLTS reached 79 MW. PLN aims to increase the share of EBT from 12.4% in 2021 to 23% by 2025, with planned development of PLTS in existing PLN facilities and a potential expansion of 112.5 MW.

II. AIM AND OBJECTIVES

This research is conducted at PLTU Banten 2 Labuan, a coal-fired power plant with a gross installed capacity of 300 MW, with the following aims:

1) To assess the potential solar energy capacity at PLTU Banten 2 Labuan as a basis for designing the capacity of a Solar Power Plant (PLTS) for the administrative building at PLTU Banten 2 Labuan.
2) To analyze the impact of PLTS as a self-consumption power supply on the stability and quality of power at PLTU Banten 2 Labuan.
3) To develop recommendations for an appropriate PLTS capacity design for self-consumption at the administrative building of PLTU Banten 2 Labuan.
4) To compare the design of Off-Grid and On-Grid PLTS for the administrative building at PLTU Banten 2 Labuan from both technical and economic perspectives.

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III. STUDY AREA AND METHODOLOGY

Study Area

At this stage, a field survey is conducted to observe and measure the parameters used for designing the rooftop Solar Power Plant, including: location coordinates, roof condition, megascopic observation of shading potential, and installed electrical capacity at the unit. Location coordinates will be collected using GPS to determine precise points for obtaining global irradiation data and calculating the rooftop area through geotagging methods. Simply put, the calculation of rooftop area can be performed using Google Earth software. Observations using Google Earth are also intended to provide a better overview. The images of several sampling locations can be seen, and the measurement of rooftop area is based on the geotagging method using Google Earth software. The rooftop area calculation also takes into account areas that are indicated to be shaded, so these shaded areas will be excluded from the rooftop area calculation. The second stage involves collecting data after the installation of the rooftop Solar Power Plant by measuring the power output of the installed rooftop.

Method

The data collection methods used in this research are:

1) Field Data Collection: Gathering data on power consumption loads at the power plant unit.
2) Computational Simulation: Using Helioscope (non-beta) and PV Syst version 7.2 software for simulation.
3) Data Analysis: Based on the results of the simulations.
4) Economic Analysis: Assessing the economics of investing in PLTS.
5) Supplementary Data Collection: Obtaining additional data related to the research theme from books, literature, articles, and journals.

IV. RESULT AND DISCUSSION

Figure 1: Photo of PLTU Labuan 2 on Google Earth

The Solar Power Plant will be installed on the roof of the Administrative Building at PLTU Labuan, Banten, with coordinates of latitude: -6.3710° S and longitude: 105.8257° E. As shown in Figures 1, the total surface area of the PLTS is 628.57 m². The aim is for the PLTS to reduce the Self-Consumption (PS) load of PLTU Labuan, Banten. Based on the research review obtained from online sources, the solar radiation values at PLTU Labuan are as follows range 1,834 - 3,186 kWh/m^2/day

The amount of potential solar energy is obtained from calculation (1). This calculation shows that the PV area is 628.579805 m², with an average solar intensity of 2.60667 kWh/m²/day, as obtained from Table 4. Additionally, the temperature coefficient factor (TCF) can also be calculated:

TCF = 1+(Temperature Coefficient×Temperature Difference)

TCF = 1 + (-0.004 × 8) TCF = 1 - 0.032 TCF = 0,968

= 0,968%

From the energy management report for August 2024, the total auxiliary power consumption for non-generation areas in August was 251,551.06 kWh, or 1.12% of the total auxiliary power at PLTU Labuan. This amount includes the electricity consumption of the Administrative Building, which is 46,344.76 kWh.

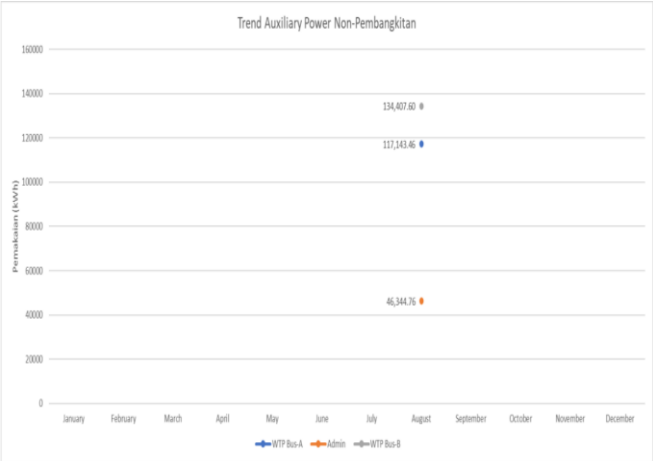

Figure 2: Auxiliary Power Consumption at PLTU Labuan

The selection of solar panel types is based on the products available in the market. The researcher chose Jinko Solar's Tiger Pro 72HL4-BDVP model, which has a power output of 545 watts and is a bifacial module with dual glass. The selected module type is JKM545M-72HL4-BDVP, chosen for its maximum power output of 545 Wp.

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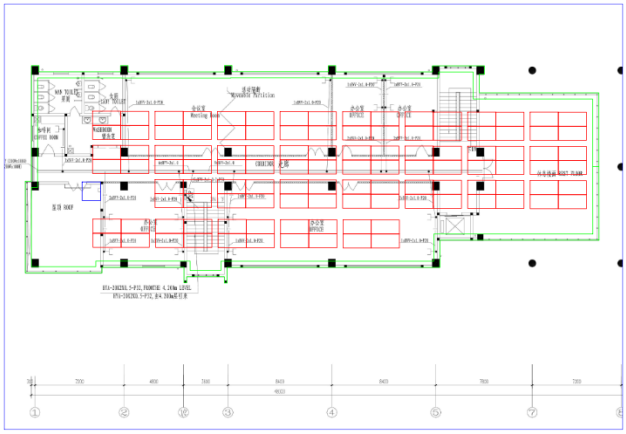

Designing solar panels on the rooftop requires detailed planning to account for structural, aesthetic, and energy efficiency factors. The roofing material used is concrete for the Administrative Building at PLTU Banten 2 Labuan. The number of panels installed is based on the available roof area and accessibility for maintenance and monitoring. The solar panel design includes 112 units

The estimated potential electrical energy that can be generated by the rooftop Solar Power Plant (PLTS) at the Administrative Building of PLTU Labuan, based on the PVsyst simulation performed by the Detail Engineering Design (DED) author, is 92,514 kWh per year, or 7,709 kWh per month, with an average of 256 kWh per day. Considering the electricity tariff for coal-based power plants, the production cost of electricity usually ranges around Rp 1,325 per kWh. If we take an average value, for example, Rp 1,000 per kWh, the calculation for 92,514 kWh would be:

Saving = 92.514 kWh × 1.325 Rp/kWh

= 125.078.928

So, for a solar power plant (PLTS) electricity production of 92,514 kWh, the estimated savings on electricity from a coal-based power plant is approximately Rp 125,078,928.00

To determine the reduction in carbon emissions achieved by the Solar Power Plant (PLTS), the following calculation can be used:

CO_2e Emissions (kg) = Energy Consumption (kWh) × Emission Factor (kg CO_2e/kWh)

CO_2e Emissions (kg) = 92,514 kWh × 0.91 kg CO_2e/kWh

CO_2e Emissions (kg) = 84,187.74 kg CO_2e = 84.187 tons CO_2e

*Coal-based power plants have an emission factor of 0.91 kg CO_2e/kWh.

The installed Solar PV serves as an alternative power source, directly contributing to the reduction of self-consumption power. The initial investment costs for the rooftop PLTS at the Administrative Building of PLTU Labuan include expenses such as: solar module costs, inverter and communication system costs, installation costs, protection and power cable costs, module support frame costs, monitoring system costs, grounding costs, as well as installation, technical, commissioning, and operation feasibility certification costs.

V. CONCLUSION

This research aims to analyze the potential implementation of a Solar Power Plant (PLTS) at PLTU Labuan. The findings are as follows:

1) Solar Energy Potential: The highest solar radiation value in Labuan occurs in August at 3.186 kWh/m²/day, due to the peak dry season. Conversely, the lowest radiation occurs in December at 1.834 kWh/m²/day, due to the rainy season. For the administrative building's rooftop with an area of 628 m² and using panels with 21.24% efficiency, the potential daily electricity generation is about 666 kWh.
2) Self-Consumption Electricity Load: The highest electricity consumption at PLTU Labuan occurred in June at 20,474.97 MWh, while the lowest was in March at 9,131.14 MWh, reflecting fluctuating power usage. The self-consumption electricity need for the Administrative Building is 251,551.06 kWh, or 1.12% of the total auxiliary power at PLTU Labuan, including 46,344.76 kWh for the building itself.
3) Electricity Generation Forecast: The estimated annual electricity generation by the rooftop PLTS at the Administrative Building is 92,514 kWh, or 7,709 kWh per month, averaging 256 kWh per day, based on PVsyst simulation.
4) System Comparison: From a technical perspective, the off-grid system offers better reliability during power outages, while the on-grid system is more economical, saving around 26.55% or Rp 440,000,000.00 due to the absence of battery costs. The NPV for the on-grid system is Rp 238,651,041.00, making it feasible, whereas the off-grid system has an NPV of -Rp 201,348,959.00, making it unfeasible. The Benefit-Cost Ratio (BCR) is 1.20, indicating that the on-grid PLTS investment is feasible. The Payback Period (PP) is 16.93 years, shorter than the project lifespan, supporting the continuation of the on-grid system.
5) Long-Term Investment Feasibility: The PLTS at the Administrative Building will reduce carbon emissions by 84.187 tons CO_2e annually and supports PT. PLN's

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commitment to achieving a 23% renewable energy mix by 2025, as outlined in the National Energy General Plan (RUEN). The abundant solar potential in Indonesia makes PLTS a key resource for reaching this target.

Conclusion: Implementing rooftop PLTS at PLTU Labuan shows significant potential for generating renewable energy and reducing carbon emissions. The research provides a basis for optimizing solar energy use in conventional power plants, contributing to energy diversification and environmental impact mitigation. Further potential can be explored by installing PLTS on available land at PLTU Labuan.

REFERENCES

[1] Bayu, H. (2021). Tinjauan Kebijakan dan Regulasi Pengembangan PLTS di Indonesia . Jurnal Energi Baru dan Terbarukan, 124-132.

[2] Berwal, A. K., Kumar, S., Kumari, N., Kumar, V., & Haleem, A. (2017). Design and analysis of rooftop grid tied 50 kW capacity Solar Photovoltaic (SPV) power plant. Renewable and Sustainable Energy Reviews, 1288-1299.

[3] BPPT. (2021). Perspektif Teknologi Energi Indonesia. Jakarta: Badan Pengkajian dan Penerapan Teknologi (BPPT).

[4] BPS. (2022). Jumlah Penduduk Pertengahan Tahun (Ribu Jiwa), 2021-2023. Jakarta: Badan Pusat Statistik.

[5] Dewan Energi Nasional. (2022). Outlook Energi Indonesia. Jakarta: Dewan Energi Nasional.

[6] Global Solar Atlas. (2024, Maret 28). Diambil kembali dari Global Solar Atlas: https://globalsolaratlas.info/

[7] Irfan, M. (2017). Perencanaan Teknis dan Ekonomis Pembangkit Listrik Tenaga Surya Sistem On-Grid. UIN Sultan Syarif Kasim, 430-436.

[8] Irfani, K. N. (2021). Studi Perancangan Pembangkit Listrik Tenaga Surya Pada UMKM Coffee Shop Di Kota Semarang Ditinjau Dari Analisis Kelayakan Teknis Menggunakan Software Pvsyst. Jurnal Ilmiah Teknik Elektro, 643-651.

[9] Kacaribu, R. (2022). Analisis Tekno Ekonomi Model PLTS Rooftop Sistim On Grid Skala Rumah Tangga di Kota Semarang. Semarang: UNDIP.

[10] Megawati, E. (2021). Analisis Potensi Dan Unjuk Kerja Perencanaan Pembangkit Listrik Tenaga Surya Sistem Hybrid Pada Atap Kandang Ayam Closed House Di Tualang Kabupaten Serdang Bedagai. Transient Journal Ilmiah Teknik Elektro, 384-388.

[11] Nagel, A. A. (2022). Pengembangan PLTS Atap Dengan Sistem ON Grid Kapasitas Kecil Untuk Sektor UMKM (Studi Kasus: UMKM Sentra Rotan, Desa Trangsan, Kecamatan Gatak, Kabupatan Sukoharjo). Semarang: UNDIP.

[12] Nike Sartika, A. N. (2023). Perancangan Dan Simulasi Sistem Pembangkit Listrik Tenaga Surya (PLTS) Atap Pada Masjid Jami' Al-Muhajirin Bekasi. Transmisi Jurnal Imiah Teknik Elektro, 1-9.

[13] Pertamina, P. (2023, 08 10). Energi Baru Terbarukan. Retrieved from Pertamina Power Indonesia: https://pertaminapower.com/energi-baru-terbarukan

[14] PLN. (2021). Rencana Usaha Penyediaan Tenaga Listrik (RUPTL) 2021 - 2023. Jakarta: PT. PLN (Persero).

[15] USAID. (2020). Panduan Perencaaan dan Pemanfaatan PLTS Atap Di Indonesia. Jakarta: Direktorat Jendral Energi Baru Terbarukan dan Konservasi Energi.

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