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PHOTOVOLITAICS CONCEPT INTEGRATED ON THE GRID WITH THE STT-PLN BUILDING

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Abstract

Abstract: As we enter the 21st century, concerns over dwindling oil and gas reserves have become more pronounced. With energy demand on the rise, particularly in developed nations, projections indicate a 70% increase between 2000 and 2030. By the year 2017, global electricity demand is expected to reach 25.4 trillion kWh. Solar energy emerges as a promising solution, especially in regions like Indonesia, where the entire mainland covers roughly 2 million km2 and receives an average daily radiation distribution of 4.8 kWh/m2. This translates to a solar energy potential of 5.10 mW, equivalent to 112,000 GWp. Technically speaking, solar panels have shown an efficiency improvement of 17.4%. When considering components and the quality absorbed by solar power plants (PLTS) synchronized by KWH EXIM, calculations reveal a performance ratio of 81%, confirming the technical feasibility of implementing such systems.

Keyword: Solar Cell, KWH exim, Electrical energy

1. Introduction

The new energy source referred to is the integrated solar power generation system (PLTS) connected to the national electricity grid (On Grid) with a Back-Up Battery, due to the abundant potential of solar energy available with an average solar radiation intensity of around 4.8 kWh/m2 per day across Indonesia's regions (Asriyadi et al., 2016; Bachtiar, 1996; GET STT PLN, 2017). Energy (power) is a fundamental requirement for performing tasks or activities, including electricity, mechanical energy, electromagnetic energy, chemical energy, nuclear energy, and heat. As we enter the 21st century, the reserves of oil and natural gas are diminishing (Manan, 2012; Panel Surya, 2017; Ramadhan & Rangkuti, 2016; Yuwono, 2005). Meanwhile, the demand for energy is increasing, especially in industrialized countries, projected to rise by up to 70% between 2000 and 2030. By 2017, the demand for electrical energy reached 25.4 trillion kWh. However, primary energy sources (oil and natural gas) could only contribute 14.5 trillion kWh. Solar energy is a potential source of energy to be developed in Indonesia, considering Indonesia's location near the equator(Diantari et al., 2017; Anggara Trisna Nugraha, 2017; Nugraha & Agustinah, 2018a). The solar energy that can be generated for the entire land area of Indonesia, which covers approximately 2 million km2 with a radiation distribution of 4.8 kWh/m2/day, is approximately 5.10 mW or equivalent to 112,000 GWp. The purpose of this study is to assess the viability and potential benefits of integrating photovoltaic technology into the grid infrastructure, particularly with the STT-PLN building, as a means to address the growing energy demand and promote sustainable energy.Research aims to comprehensively explore the advantages of solar energy over fossil fuels, including its accessibility, environmental friendliness, suitability for diverse geographic conditions, and ease of installation, operation, and maintenance, incorporating state-of-the-art advancements in technology and methodology.

2. Material and methods

The concept of designing an on-grid PLTS system for the STT-PLN building requires several stages of completion (Nugraha & Agustinah, 2018b; Nugraha & Jamaaluddin, 2018; Rahim et al., 2018). The research stages include literature review, which involves gathering data from relevant reference books and journals related to the research topic. Then, the problem identification phase involves formulating the background of the problem in the research and outlining the objectives of the study. Lastly, the observation stage involves collecting data by directly observing the installation of the STT-PLN building connected to the PLTS (Nugraha, 2018a; Nugraha & Jamaaluddin, 2018; Nugraha et al., 2018; Pradana et al., 2022). Figure 1 is the diagram of the conceptual system or planning of the on-grid PLTS, where its assembly does not require batteries.

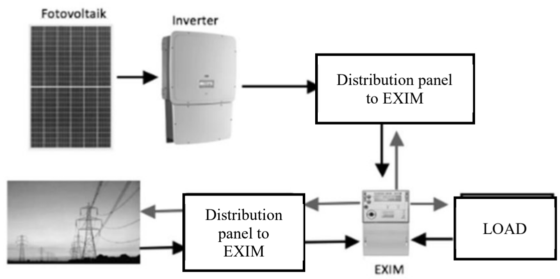

Figure 1. On-grid system

Briefly explained, according to the conceptual scheme, the energy generated by the PLTS will be converted from DC to AC by the inverter, which will then be routed through the distribution panel for adjustment. Subsequently, the output from the distribution panel will enter the EXIM metering device, which will synchronize it to both the load (consumers) and the PLN power grid.

3. Results and discussion

3.1. Planning an On-Grid System

Solar radiation potential is the primary source of energy for solar power generation. The potential solar radiation of a city can be determined through various methods, such as using luxmeters, thermometers, and applications like Meteonorm, or by accessing solar radiation potential data on NASA's official website. In this study, to ascertain the solar radiation potential, Tabel 1 are data obtained from NASA's official website was utilized.

Table 1. Sun Radiation

No.	Month	**Sun Radiation (kWh/m2 /hari)**	**No.**	**Month**	**Sun Radiation (kWh/m2 /hari)**
1.	January	3.67	7.	July	4.03
2.	February	4.00	8.	Agustus	4.33
3.	March	3.97	9.	September	4.31
4.	April	4.22	10.	Oktober	4.17
5.	May	3.81	11.	November	3.78
6.	June	3.61	12.	December	3.89
Average					3.98

In addition to considering the issue of solar radiation potential, designing a PLTS in a particular area also requires taking into account its temperature. Table 2 are the temperature data:

Table 2. Temperature

Month	**Averege .temp° C**	**Month**	**Averege .temp° C**
January	26.7	July	27,2
February	26.7	Agustus	27,2
March	27.2	September	27.8
April	27.8	Oktober	28.3
May	27.8	November	27.8
June	27.8	December	27.2
Average			27.5

According to the table provided, the average temperature is 27.5°C. The highest temperature occurs in October, reaching 28.3°C, while the lowest temperatures are recorded in January and February at 26.7°C.

3.2. Determining the Solar Power Generation System

The solar power generation system to be designed is an on-grid solar power generation system. The energy generated by the solar power generation system will be connected to the PLN electricity grid and will also be used to supply power to other electrical appliances.

a. Solar Panels

In this design, commercially available solar panels that are certified are utilized to facilitate equipment selection. The data from the specifications of these solar panels will be used to determine the series and parallel connections in the circuit. The solar panels used are RECxxxTP2S 72 350Wp. These solar panels are of the Polycrystalline type with an efficiency value of 17.4%. Given the condition of the area with an average temperature of 27.5°C and frequent cloud cover, it is advisable to use polycrystalline solar panels.

b. Inverter

In this design, an inverter that is readily available and certified is utilized to facilitate equipment selection. The inverter chosen for this purpose is the ABB TRIO-20.0-TL-OUTD with a capacity of 20 kW.

c. Determining the Capacity of Solar PV Systems

Referring to PERMEN ESDM No. 12 of 2017, Chapter V Article 5 paragraph 3 stipulates that "If the BPP Generation in the local electricity system exceeds the national average BPP Generation, the purchase price of electricity from photovoltaic solar power plants as mentioned in paragraph (2) shall not exceed 85% of the BPP Generation in the local electricity system."

According to the conducted survey, the electrical power in group R3 amounts to 33,000 VA. Once the installed KVA is known, the capacity of the solar PV system to be installed can be determined. To establish the maximum capacity of the on-grid solar PV system that can be installed:

$$Cap.PLTS = 33.000VA \times 85\%$$
$$= 28.050VA$$

Based on the customer's request, only 60% of the load is supplied by the solar PV system. Therefore, the installed capacity of the solar PV system is:

$$Cap.PLTS = 33.000VA \times 60\%$$
$$= 19.800VA = 20kWp$$

d. Calculating the Number of Modules

To determine the appropriate number of modules for the design, considering the load capacity being used, it is necessary to first determine the capacity of the modules to be used. In this planning, Polycrystalline modules with a capacity of 350 Wp will be utilized.

e. Determining the Distance Between Each String

Once the number of solar modules to be installed is known, for the solar panel installation planning, it is necessary to consider the distance between each panel string.

f. Area Array

This area has a spacious rooftop that can be used for installing the PLTS, measuring 12.5 m x 12.6 m, or approximately 157.5 m2 in total area. The PV array area is approximately 120.42 m2. The rooftop available for the solar power generation is as follows:

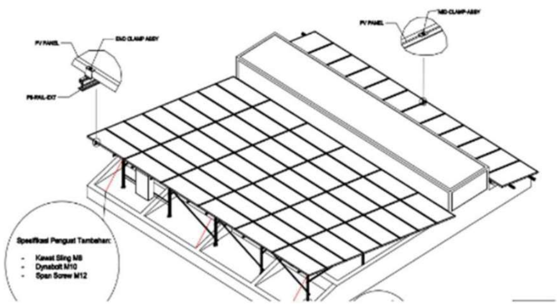

Figure 2. Applied area

g. Calculating Solar Module Energy

Based on the area, it can be calculated using the equation (1);(2);(3):

$$EI=PVarray \times npv \times TCF \times nout \times Gav \quad (1)$$

$$P\ high\ temperature\ 0.8\ C = 0{,}45\% / Celcius \times PMPP \times Rise\ Temperature \quad (2)$$

$$PMPP = Maksimum\ power\ of\ solar\ panel \quad (3)$$

h. Calculating Inverter Capacity

The selection of the inverter can be adjusted to the power capacity. The calculation of the inverter capacity is based on the energy kWh obtained from the calculation results. The designed capacity of the solar power system (PLTS) is 20 kW, so the inverter used is also a 20 kW capacity inverter.

3.3. Calculating Solar Module Output Energy

The power input received by the solar modules from sunlight radiation does not entirely enter the inverter, as it is influenced by losses in components and the system. Table 3 are the calculation of power to the energy produced:

Tabel 3. power to the energy produced

Power PV	350 Wp	
Losses type	Losses value	Power
Losses Manufacture (Power Tolerance)	3% (0,97)	339,5 W
*Losses dirt/*kotoran (debu, kotoran burung, dll)	5% (0,95)	322,52 W
Losses temperature module	5,7% (0,943)	304,14 W
Losses kabel	5% (0,95)	288,93 W
Total losses	61,07 W	
Total power output PV	**350 W – 61,07 W**	**288,93 W**

3.4. Calculating Performance Ratio (PR)

Performance Ratio (PR) is a measure of the quality of a system based on the annual energy produced. If the PR value of a system ranges from 70-90%, then the system can be considered feasible. To calculate the performance ratio, it can be done as follows (4);(5):

$$PR = system/Ideal$$

$$Eideal = P\ array\ STCx\ Htilt \quad (4)$$

$$Htilt = PSH \times 365 \quad (5)$$

$$Htilt = 3{,}95 \times 1000x\ 365 = 1441{,}7\ kWh/m2$$

Htilt represents the average solar radiation, thus the average solar radiation over one year is 1441.7 kWh/m2, therefore (4):

$$E\ ideal = 350\ Wp \times 60\ modul \times 1441{,}7\ h/tahun$$

$$Eideal = 30{,}275{,}7\ kWh/tahun$$

Ratio performance is :

$$PR = 24.695\ kWh/tahun / 30.275{,}7\ kWh/tahun = 0{,}81 = 81\ \%$$

From this planning, a performance ratio of 81% is obtained, indicating that the system is feasible for realization.

4. Conclusion

The report's findings suggest that, technically, the operation of the solar panel system is viable. With a 17.4% efficiency rate and a performance ratio calculation of 81%, it is deemed technically feasible to implement the system. Regarding recommendations for PLTS implementation, real-world regulations do not currently favor communities looking to adopt renewable energy sources.

Credit authorship contribution statement

Dimas Bayu Dwi Saputra: Conceptualization, Writing – review & editing. **Rama Arya Sobhita**: Supervision, Writing – review & editing. **Anggara Trisna Nugraha**: Conceptualization, Supervision, Writing – review & editing. **Muhammad Bilhaq Ashlah** Conceptualization, Supervision, Writing – review & editing.

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