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SIMULATION OF ON GRID SOLAR POWER PLANT POTENTIAL AT PT. HALMAHERA JAYA FERONIKEL EMPLOYEES HOUSING

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ABSTRACT

Simulation of On Grid Solar Power Plant Potential at PT. Halmahera Jaya Feronikel Employee Housing, Ilham Adam. In today's era of globalization, the need for electrical energy sources is a major factor in life. Various routine activities carried out by humans every day are not far from electronic goods, making electricity a basic need. The need for electricity also plays a very important role in industry and mining such as at the PT. Halmahera Jaya Feronikel mess which consumes quite high electrical energy, which is around 255 kWh/day, besides that in the PT. Halmahera Jaya Feronikel employee mess area has a mess roof that can be used to make solar power generators and the location of the employee mess is quite strategic because it is free from tall buildings that can cause shadows or shading. The results of the on-grid solar power plant simulation using 98 solar panels with a capacity of 550 Wp and 7 inverters with a capacity of 10 kW, the effective energy that can be generated in this solar power plant based on PVsyst software is 82303 kWh/year with an initial investment value of Rp. 792,040,000 and operational and maintenance costs for 20 years which is the project life of Rp. 438,408,000, with a payback period of 7.9 years and a net present value of Rp. 1,205,963,279 and can be said to be feasible because the NPV value is more than 0 which means that this solar power plant does not experience losses, and the Benefit cost ratio value obtained is 2.57 and can be said to be feasible because the results of the BCR are more than 1 which are obtained from the results obtained with the costs incurred.

Keywords: PLTS; Solar Panels; Inverters

1. Introduction

In the current era of globalization, the need for electrical energy sources is a major factor in life. Various routine activities carried out by humans every day are not far from electronic goods, making electricity a basic need. With the increasing demand for electricity, the continuity of electricity supply is getting higher, making the performance of the generators increasingly difficult and petroleum as a fuel for the generators is getting thinner. Indonesia's electricity consumption continues to increase every year in line with the increase in national economic growth. The increase in electricity demand is estimated to grow by an average of 6.5% per year until 2020 [1].

The need for electricity also plays a very important role in industry and mining, for example PT. Halmahera Jaya Feronikel (HJF) which is currently under construction in the Eastern region of Indonesia, precisely in Kawasi Village, South Halmahera Regency, North Maluku Province.

In the employee of PT. Halmahera Jaya Feronikel, it consumes quite a lot of electrical energy, which is around 255 kWh/day, from the use of electrical energy using a steam power plant as the main source of electricity generation, in addition, in the employee mess area of PT. Halmahera Jaya Feronikel has a mess roof that can be used to make PLTS and reduce the electrical load of the steam power plant used to supply electricity in the employee mess, and the location of the employee mess is quite strategic because it is free from tall buildings that can cause shadows (shading).

Based on previous research by [2]"Planning of Hybrid Power Plant (solar power plant-state electricity company) on the Roof of PT PLN (Persero) UIP Sulawesi Office Building for Third Floor Lighting Electricity Supply" which is the reference for this research, in this research there is a development, namely supplying electrical energy to the entire electrical load while in the reference research it only supplies for building lighting.

Then in the previous study by [3] entitled "Design of Homer-Based Solar Power Plants in Surakarta State 6 high school as an Energy-Saving and Environmentally Friendly School". In this study there is a development, namely using the more complete PVsyst 7.4.0 software, while in the reference study using homer software, then in the reference study only supplies for lighting while in this study supplies for the entire electrical load of the employee mess. Therefore, this basic idea is what

underlies the author to submit a final assignment entitled "Simulation of On Grid Solar Power Plant Planning at the Employee Housing Mess of PT. Halmahera Jaya Feronikel".

2. Materials and Methods

In this study, certain tools and materials are needed to conduct analysis that supports the smooth running of the research. The tools and materials used in this study include:

a. Materials

The supporting tools used are divided into 2, namely hardware and software, including:

1) Computer or laptop is the hardware in this study that functions as a tool for designing solar power plants as well as writing this research
2) PVsyst software in this study functions as a solar power plant design to create an optimal system from the solar power plant design. The PVsyst software used in this study uses version 7.4.0
3) SketchUp Pro software is used to create a construction model of the solar power plant to be designed
4) Microsoft Office Excel is used to process data related to the economics and feasibility of the PLTS system and to create tables.
5) Microsoft Word software is used in compiling the thesis report.

b. Methods

Data collection aims to obtain the data needed to complete this research. The data in question is in the form of determining the intensity of sunlight (irradiation). The data collection methods used in this study are:

1) Observation
   Observation is an activity carried out to directly observe a particular object with the aim of obtaining a number of data and information related to the object

2) Documentation Study
   Documentation study is carried out to find sources of written data, images or secondary data in the field related to the design to be carried out such as climate data

3) Load Study
   Collection of load study data, namely collecting the amount of electrical load used in the employee mess of PT. Halmahera Jaya Feronikel.

3. Results

a. Electrical Energy Load Profile

The use of energy load in this study is based on the estimation of electrical energy needs for 24 hours, with the aim that the use of electrical load in the employee mess can be met throughout the day. The estimation of the use of lighting load in the employee mess of PT. Halmahera Jaya Feronikel can be seen in the following table.

Table 1. Estimated Electricity Requirements for 24 Hours

No	Equipment Name	Amount	(kWh)/day
1	Air conditioner	20	240
2	Bathroom lights	20	1,8
3	Room lights	20	2,16
4	Tube light	20	8,64
5	Standby power	80	2,4
	Total usage	**160**	**255**

The equipment that uses the most power is the air conditioner at 240 kWh and the smallest is the bathroom light at 1.8 kWh so that the total daily electricity consumption is 255 kWh.

b. Climate Data

1) Solar Radiation Data

Solar radiation research data was obtained from the Meteonorm 8.1 data source (2016-2021) by selecting the coordinates of the research object around the PT. Halmahera Jaya Feronikel Company. The average solar radiation obtained per day and per month in a year can be seen in the following table.

Table 2. Monthly Solar Radiation

No.	Month	Amount
1	January	165,0
2	February	130,4
3	March	151,6
4	April	144,3
5	May	146,3
6	June	130,8
7	July	148,6
8	August	161,2
9	September	154,5
10	October	137,1
11	November	176,0
12	December	153,1
Average		**149,9**

2) Temperature

The temperature research data was obtained from the Meteonorm 8.1 data source (2016-2021) by selecting the coordinates of the research object in the industrial area of PT. Feronikel Halmahera Jaya. The average temperature values obtained per month in a year can be seen in the following table.

Table 3. Temperature

No.	Month	Temperatur (°C)
1	January	27,8
2	February	27,7
3	March	27,7
4	April	27,1
5	May	27,2
6	June	26,0
7	July	26,0
8	August	26,1
9	September	26,1
10	October	27,2
11	November	27,3
12	December	27,9
Average		**27,0**

c. PVsyst Software Simulation Results

Testing the results of the production of electrical energy from solar power plants was carried out using PVsyst software to determine the productivity of the PLTS system. For more details, see the table of solar power plant productivity at the PT. Halmahera Jaya Feronikel Employee Mess below.

Based on the table, it can be seen that globhor or global horizontal irradiance is the total amount of solar radiation received by solar panels from above by a horizontal surface, which is 1799.0 kW/h/m2 /year, then the temperature with an average of 27.01 oC /year, then EArray or effective energy at the output array is the amount of effective electrical energy produced during a year of 82303 kWh/year. then E_user or energy supplied to users is the amount of energy supplied to users during a year of 93382 kWh/year. Then E_solar or energy from the sun is the energy supplied by solar panels to users, which is 51369 kWh/year, then EFrgrid or energy from the grid is the energy supplied from the main network is 42013 kWh/year, then E_grid or energy injected into the electricity grid is the energy injected into the main network is 29466 kWh/year,

Table 4. Electricity Production of PLTS at the Employee Mess of PT. Halmahera Jaya Feronikel Based on PVsyst Software

No.	Month	GlobHor kWh/m²	T_Amb °C	EArray kWh	E_User kWh	E_Solar kWh	EFGrid kWh	E_Grid kWh
1	January	165,0	27,82	6868	7931	4413	3518	2330
2	February	130,4	27,68	5686	7164	3710	3453	1867
3	March	151,6	27,70	6875	7931	4262	3669	2488
4	April	144,3	27,12	6831	7675	4283	3392	2437
5	May	146,3	27,18	7193	7931	4390	3541	2680
6	June	130,8	26,01	6608	7675	4114	3561	2378
7	July	146,6	25,99	7438	7931	4553	3378	2760
8	August	161,2	26,09	7852	7931	4586	3366	3157
9	September	154,5	26,15	7176	7675	4408	3267	2644
10	October	137,1	27,22	6096	7931	4039	3893	1938
11	November	176,0	27,31	7309	7675	4401	3275	2778
12	December	153,1	27,87	6364	7931	4232	3699	2011
	Years	**1799,0**	**27,01**	**82303**	**93382**	**51369**	**42013**	**29466**

d. Feasibility Analysis Based on PVsyst Software

The feasibility analysis is determined based on the results of the PVsyst software simulation, the results obtained are the total installation cost of Rp. 792,040,000, then the depreciable assets are Rp. 483,000,000, then the operational costs are Rp. 21,920,400, then the Net Present Value is Rp. 1,205,963,279, then the Payback Period is 7.9 years, then the Return of Investment is 152.3%. For more details, see the following table.

Table 5. Feasibility Analysis Results Based on PVsyst Software

Financial Results	
Total Installation Cost	Rp. 792.040.000 IDR
Depreciable asset	Rp. 483.000.000 IDR
Operating Cost	Rp.21.920.400 IDR/year
Net Present Value	Rp.1.205.963.279 IDR
Payback Periode	7,9 years
Return of Investment (ROI)	152,3 %

e. Investment Feasibility Analysis

Annual net income is obtained by multiplying the quantity of electricity generated by the selling price of renewable energy. This selling price of renewable electricity is based on theoretical calculations so that the selling price of renewable energy obtained is Rp. 1.507.02 / kWh. Then calculate the annual expenditure by calculating all operational and maintenance costs of the power generation system. Then net income is obtained by subtracting income from costs, as shown in the following calculation:

Cash Inflow = Energy Quantity × Electricity Selling Price
= 82303 kW × Rp. 1.507,02/kWh
= 124.032.267,06/year
Cash Outflow = Cash Outflow (O&M)
= Rp. 21.920.400
Net income = Cash Inflow – Cash Outflow
= Rp124.032.267,06 – Rp. 21.920.400
= Rp.102.111.867,06/year

After knowing the net profit obtained year, then calculate the net profit obtained during the project life of 20 years by multiplying the net income per year by 20 years of project life, so the result obtained is Rp. 2,042,237,341.

To determine the feasibility of investment, a comparison is made between Net Present Value and profit or benefit cost ratio. Benefit Cost Ratio is a measure that shows how much cost is incurred by the company to generate income. This ratio is calculated by dividing total costs by total income with the following formula

$$\text{Benefit of ratio} = \frac{\text{Benefit}}{\text{Cost}}$$
$$= \frac{\text{Rp. } 2.042.237.341}{\text{Rp. } 792.040.000}$$
$$= 2{,}57$$

Table 6. Investment Feasibility Analysis

Feasibility Analysis	Eligibility Criteria	Investment Analysis Results	Conclusion
Net Present Value (NPV)	Eligibility (NPV > 0)	Rp. 1.205.963.279	investment is considered feasible
Benefit Cost Ratio (BCR)	Eligible (BCR > 1) Not Eligible (BCR < 1)	2,57	investment is considered feasible

The feasibility of this PLTS which will be designed in the employee mess of PT. Halmahera Jaya Feronikel is determined based on the results of the net present value and Benefit cost ratio, when calculated using the net present value the result is Rp. 1,205,963,279 and can be said to be feasible because the value is more than 0 which means that this solar power plant does not experience losses, then the benefit cost ratio result is 2.57 and can be said to be feasible because the result of the BCR is more than 1 which is obtained from the results obtained with the costs incurred.

4. Discussion

This study shows that by designing a solar power plant with a capacity of 54 kWp connected to the main network, namely a steam power plant, it can save electricity consumption from the main network by 51,369 kWh/year with a profit obtained each year of Rp. 102,111,867.06/year. This shows that the designed solar power plant can save costs and is more efficient and especially more environmentally friendly.

Compared to the previous study [4], this research has an investment value of IDR 792,040,000 with a total profit over 20 years of IDR 2,042,237,341. In contrast, the previous study had an investment value of IDR 642,714,960.00 and a profit of IDR 216,680,041. This comparison shows that higher investment costs result in greater profits, particularly with a more optimal system. Similarly, in the study [5], the connection of PLTS and PLTU allowed for a savings of 133 kWh/year. Comparatively, this study demonstrates that the designed PLTS can save up to 51,369 kWh/year due to its larger capacity and better system efficiency.

This study is also more cost-effective compared to designs using batteries, such as in the study [6]. The exclusion of batteries in this system reduces investment costs and increases cost efficiency, although it sacrifices the flexibility of energy storage. Moreover, the use of PVsyst 7.4.0 software provides significant advantages compared to RETScreen, as seen in studies like [7], as PVsyst is capable of simulating more complex conditions with more accurate results.

Finally, unlike the study [8], which focuses solely on network security, this study emphasizes component specifications and project feasibility analysis. This approach offers a more comprehensive view of PLTS system implementation, covering both technical and economic aspects.

5. Conclusions

From the results of the research conducted to design the on grid PLTS in the housing mess of PT. Halmahera Jaya Feronikel employees, it can be concluded that:

1) In the planning of the PLTS using 98 solar panels and 7 inverter units to supply the mess load and the designed PLTS capacity is 54 kWp.
2) The estimated cost results obtained are the initial investment cost of IDR 792,040,000 and the operational and maintenance costs are IDR 21,920,400 and the net present value obtained is IDR 1,205,963,279 so that this design can be said to be feasible because the NVP value is greater than 0 which means that this PLTS does not experience losses.
3) The layout results are designed using the Sketchup application and the solar panels installed on the mess roof face north with a slope angle of 13.49 degrees.

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