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HYBRID SOLAR ELECTRICAL PRODUCTION SYSTEM (PLTS) CONSTRUCTION ANALYSIS at P.T. BAKRIE PIPE INDUSTRIES USING PVSyst 7.2 STANDARDS

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ABSTRACT

The data collection technique used is the observation method. Observation is done by direct observation and measurement. The data obtained is then analyzed and used as input in the design of PLTS Hybrid. The kWh meter data used in this study is BPI factory hourly consumption data for the last year from January 2021 – December 2021. The data is then used as a load reference in calculating the size of the total capacity of the solar panel and battery components. The calculation of the size of the total capacity of the components is carried out by iterating the results of the PVSyst 7.2 simulation which is then combined with the financial parameters of the PLTS development in order to obtain the optimal combination of total capacity sizes. After obtaining the optimal capacity of solar panels and batteries, a technical design for the construction of PLTS Hybrid is carried out as the output of this research. The technical design includes the design of PV mini-grid technology along with the bill of material/quantity of construction. From the design, an analysis of the impact of development is carried out from several aspects such as financial, environmental and social. For the financial aspect, the calculation and analysis of savings will be carried out. Regarding the environment, a carbon emission reduction analysis will be carried out.

Keyword: hybrid, quantity, pvsyst, iteration

1. Introduction

Indonesia's economic growth rate is projected at 5.2% in 2022, after a decline of 3.2% - 4.0% throughout 2021 [1]. This leads to an unavoidable increase in energy requirements. As a national energy management guide, the Indonesian government has issued an electricity supply business plan (RUPTL) 2021-2030. In addition to establishing regulations to preserve national energy sovereignty, these regulations are set to address the challenges and problems of energy needs by leveraging new and renewable energy sources. One sign of the government's seriousness, the President of Indonesia, Mr. Joko Widodo reaffirmed his commitment to the use of EBT by issuing Presidential Regulation No. 22 of 2017 on the National Energy General Plan (RUEN). In RUEN, it is stated that the EBT mix target by 2025 is at least 23 percent and rises to 31 percent by 2050. Based on this, then the power supply capacity of the New Renewable Energy Power Plant in 2025 should reach the range of 42.5 gigawatts and increase to 167.7 GW by 2050 [1].

Solar energy is one of the new renewable energy potential that is being developed in Indonesia with an average of 4.8 - 5.0 kWh/m2 of solar irradiation per day. Moreover, the conversion of solar energy to electricity has become more and more mature in recent years [2].

One of the properties of PLTS is intermittent. This property makes the output power of the PLTS fluctuative when sudden weather changes occur. In addition, the intermittent nature makes the absorption of output power by electrical loads not maximum due to fluctuations between the PLTS and the electrical load. So in some cases PLTS not only works on its own but starts to be combined with other output resources so it is generally referred to as PLTS Hybrid.

In some cases, such as at the P.T. Bakrie Pipe Industries plant, electric load fluctuations are quite high, especially when using large power output machines. This causes the supply of PLTS to be insignificant in reducing or saving PLN electricity consumption [4].

In this case, the battery inverter acts as a load follower with a charge-discharge operation. When shading occurs on the PV system and causes the network frequency to fall, the battery will quickly replace power to re-stabilize frequencies as long as the SoC (State of Charge) battery is still above the minimum SoC. At a time when the network frequency rises, excess energy from the PV can be stored in the battery as long as the Battery SoC is still below the maximum `SoC. If the frequency is still unstable, the PLTS supply will be reduced (curtailing) until the Frequency becomes stable. Here's an example of the operating pattern on the PLTS Hybrid [4].

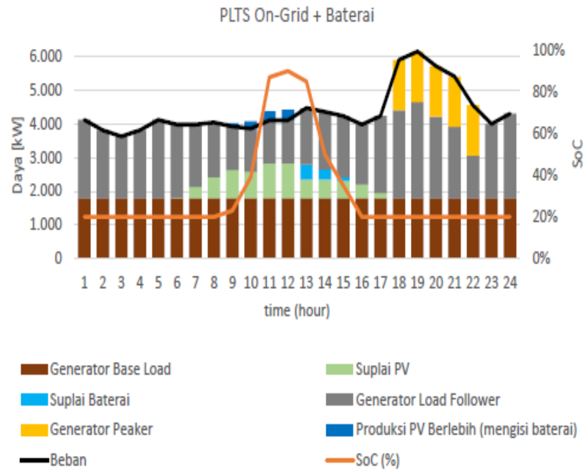

Figure 1. The PLTS Hybrid Battery

At up or down frequency conditions, the utility operates separately from the PLTS system because the battery response is faster than the power station on the utilities network. Examples of PLTS Hybrid operating patterns with batteries are shown in Figure 1. It is assumed that the utility network consists of two PLTDs that serve as base load supply and load follower. It appears that the battery is used to replace the PLTS power so that the power changes are not too extreme [5].

The system is unable to perform a blackstart because the voltage and frequency references have to be obtained from the utility network. It requires a primary control device that integrates the control device of the PV system and the energy storage system so that the operation of the entire component in this system can be controlled [6].

Determination The PLTS capacity is based on the load requirement at the hour when solar energy is still generating power. Due to its position on the equatorial line, the average sunlight in Indonesia lasts about 12 hours between 06:00 and 18:00. Based on the load requirements at the time, the PLTS capacity is as follows:

$$PV(Wattpeak) = \frac{DC/AC\ Ratio\ x\ kWh\ DL}{\%PR\ x\ PSH} \quad (1)$$

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Where :
1. PV(Wattpeak): PLTS capacity in kilograms Wattpeak
2. kWh DL: Daily Load or daily Load for a duration of 06.0 – 18.00 in kWh
3. DC/AC Ratio: Comparison of solar panel capacity to inverter
4. %PR: Performance Ratio is the ratio of output to load to input from solar energy in percentage.
5. PSH: Peak Sun Hour is the average duration of the sun with its maximum intensity in hours

The PLTS inverter capacity is determined using the DC/AC ratio comparison as follows.

$$Inverter\ kW = \frac{PV(Wattpeak)}{DC/AC\ Ratio} \quad (2)$$

The determination of the kWh battery capacity is based on the iteration that will be performed in the basic visual program excel by taking into account the SoC of the battery where it is at the value [10%, 90%] with batteries to be used are lithium-ion batteries where when the energy of the solar panel is more than the load then the solar energy will charge to the batteries.

$$PV = Battery_{charge} + Load\ kWh. \quad (3)$$

On the contrary, when the solar energy is less than the load then the battery will do the discharge to the load.

$$Load\ kWh = Battery_{discharge} + PV \quad (4)$$

The determination of battery inverter capacity is based on the maximum power discharging the battery to the load.

$$Battery\ Inverter\ kW = MAX(kW\ Discharge)$$
(5)

2. Methods

The research site is being carried out at the Bakrie Pipe Industries Factory, which is counted from the beginning of April 2022 until completion. The object is the Bakrie Pipe Industries Electricity System with land to be used as a PLTS Hybrid land.

Figure 2. Location Pabrik Bakrie Pipe Industries

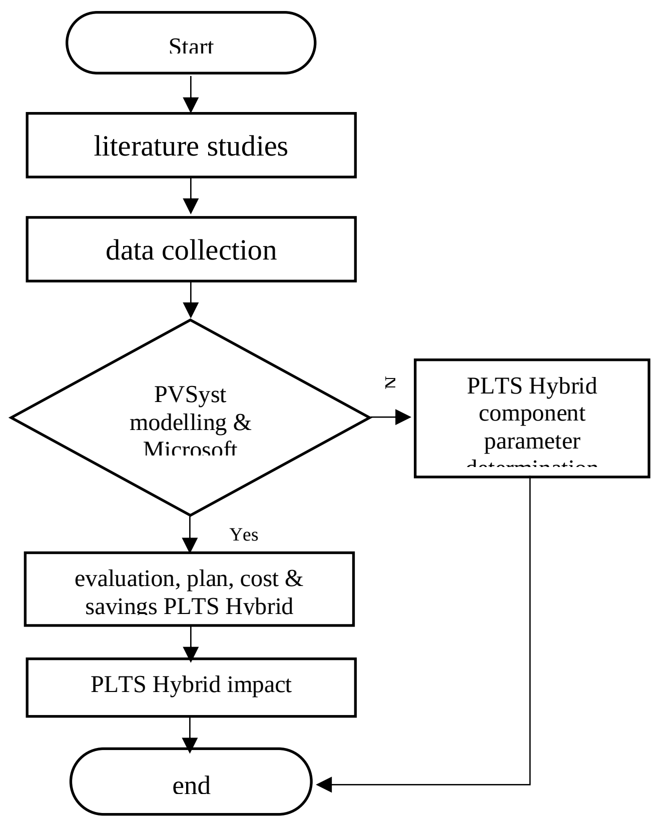

Figure 3 Research Flow Diagram

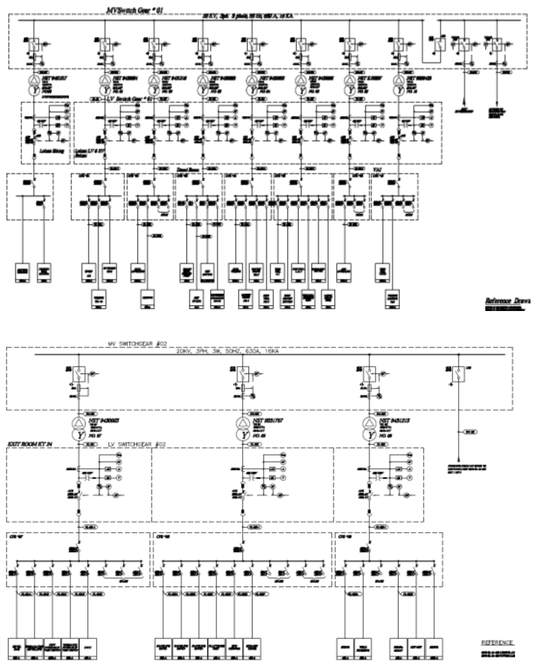

Figure 4. Single Line Diagram BPI

Bakrie Pipe Industries' electrical system is divided into two MV Switchgear, the MV Swichgear 01 and the MV switchgear 02. Total installed capacity of 20 MVA. Load types on BPI electrical systems include induction motors, arc furnaces, lighting and other loads such as PCs, etc. On the MV Switchgear 01 there are 8 trafo step downs and on the MV and the MV switchgear 02 there are 3 trafo steps downs.

From the loading data of Bakrie Pipe Industries above it shows that the majority of loads are nonlinear loads such as motors and furnaces. About 45% is furnace load, 40% is motor load, and the rest is office load and lighting. That means about 85% of the load in the BPI plant is nonlinear.

The Bakrie Pipe Industries factory enters the I3 or PLN industry customers. The tariffs imposed by PLN on BPI are currently Rs. 1,035/kWh for Peak Load Outtime (LWBP) and Rs. 1,449/kwh for Peaking Load Time (WBPs) and a kVARh fine of Rs. 1,000/kVARH.

As an I3 customer, PLN charges the minimum electricity purchase fee stipulated in the Electricity Purchase Agreement (PJBL) between PLN and BPI. Such minimum accounts are represented by the formula:

$$Account\ Minimum = \\ 40\ hour\ x\ Capacity\ KVA\ Installed \quad (6)$$

3. Results and Discussions

The picture below shows the load per hour profile of Bakrie Pipe Industries.

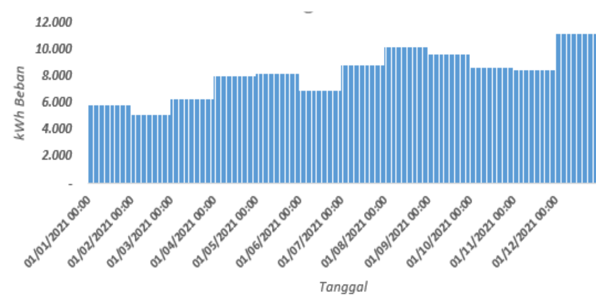

Figure 5. BPI Load Profile

The image above is an hourly record of data for the year 2021. The data is obtained from the PLN kWh meter data. It can be seen that electricity consumption continues to rise until the end of the year. From the installed BPI capacity of 20 MVA with equation (3.1) then can be determined the minimum kWh consumption of:

$$Account\ Minimum = \\ 12\ x\ 40\ hour\ x\ 20{,}000\ kVA\ x\ Rp1{,}035/kWh \\ Account\ Minimum = IDR\ \ 9{,}936 \text{ juta} \quad (7)$$

That figure is still quite far, with annual electricity payments from Bakrie Pipe Industries amounting to IDR 50,958 million with a total consumption of 44,428 MWh per year. So about 80% of the BPI's needs can be supplied from other sources.

Maximum installed capacity is determined by measurement using google earth. Perimeter obtained through google earth is then detailed using Sketchup Pro software as shown below.

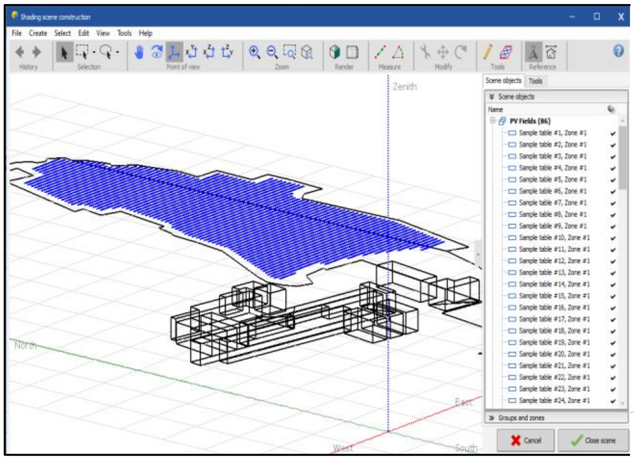

Figure 6. Maximum Installed Capacity Analysis

The result is a maximum solar panel capacity of 27,272 solar panels (capacity per solar panel 550Wp) with 15 MWp capacity. The capacity will be used as a reference capacity when iterating the battery capacity.

Table 1. Simulation Outcome PVSyst 7.2

	GlobHor	DiffHor	T_Amb	GlobInc	GlobEff	EArray	E_Grid	PR
	kWh/m²	kWh/m²	°C	kWh/m²	kWh/m²	MWh	MWh	ratio
January	124.2	81.49	25.74	114.8	108.1	1475	1394	0.809
February	139.6	79.53	25.60	132.3	125.5	1703	1606	0.810
March	145.0	80.00	26.07	144.3	137.3	1850	1744	0.806
April	145.2	78.94	26.12	150.8	143.9	1939	1828	0.808
May	144.3	78.50	26.68	155.8	148.9	2005	1890	0.809
June	140.3	69.50	25.98	155.3	148.9	2010	1895	0.813
July	152.4	73.08	25.84	167.8	160.9	2171	2046	0.813
August	159.6	82.36	26.15	169.3	162.3	2181	2055	0.809
September	162.0	82.45	26.15	163.7	156.4	2101	1980	0.806
October	171.0	98.75	26.78	165.3	157.5	2118	1998	0.806
November	141.7	90.44	26.03	132.0	124.9	1700	1607	0.812
December	134.6	81.99	26.05	122.8	115.8	1576	1489	0.809
Year	1760.0	977.04	26.10	1774.2	1690.3	22827	21532	0.809

It appears that the energy yield received by solar panels was 22,827 MWh while that passed to the load of 21,532 MWh. It's also apparent that the average performance ratio is 80.9%.

The following image shows the losses diagram of the simulation. It can be seen that the greatest losses are due to operating temperatures of about 6.9% followed by soil loss losses and LID losses each resulting in losses of 2%.

As a note that the losses diagram is a picture of losses produced in the first year where the degradation of solar panels in its first year was 2%. In the second year and beyond the degradation of 0.5% - 0.6% per year.

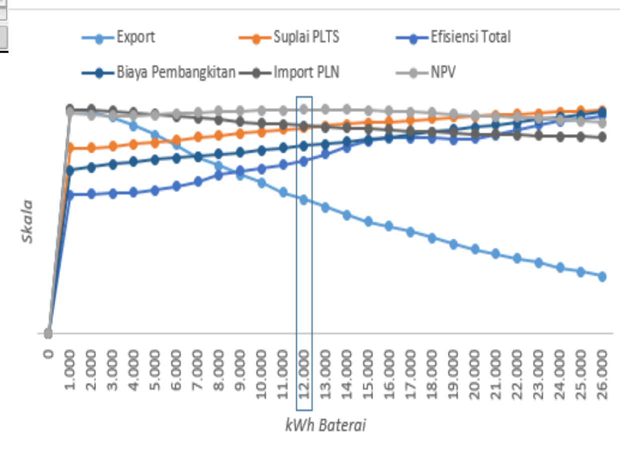

Figure 7. Battery Need Analysis

By scaling each parameter, the optimal value of the battery capacity can be determined through the graph above. In this case, based on the NPV value discussed earlier, and other parameters, the optimal battery capacity is 12,000 kWh.

With PLTS Hybrid configuration 15,000 MWp with battery capacity 12,000 kWh achieved efficiency 18,696 MWh/year and IDR Millions/year 19,351. Construction costs of Rs. 548/kWh and development capital of IDR 161.973 million (already including GDP 11%). In terms of the environment, the construction of the PLTS Hybrid could contribute to the reduction of 747.8 tons of CO2 per year. Faced with the social community, the development of the PLTS Hybrid can open up job vacancies and also as a centre of education and research on the advanced PLTS hybrid technology.

4. Conclusion

Based on the research that has been carried out, the authors come to the following conclusions:

1. By scaling each parameter, the optimal value of the battery capacity can be determined through the graph above. In this case, based on the NPV value discussed earlier, and other parameters, the optimal battery capacity is 12,000 kWh.
2. With PLTS Hybrid configuration 15,000 MWp with battery capacity 12,000 kWh achieved efficiency 18,696 MWh/year and IDR Millions/year 19,351. Construction costs of Rs. 548/kWh and development capital of IDR 161.973 million (already including GDP 11%).
3. In terms of the environment, the construction of the PLTS Hybrid could contribute to the reduction of 747.8 tons of CO2 per year. Faced with the social community, the development of the PLTS Hybrid can open up job vacancies and also as a centre of education and research on the advanced PLTS hybrid technology.

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