Analysis of the Need for a Centralized Solar Power Plant (PLTS) as an Alternative Electricity Supply for Sucker Rod Pump

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Abstract

The PLTS system is an effort to improve electrical power reliability, electrification ratio, and renewable energy utilization. The availability of electricity is extremely urgent. This is to complement the needs of the production process, especially the SRP pumping motor. The current electrical conditions of the industry still rely on PLN electricity and generators for production activities every day. However, the design of the PLTS system is expected to be able to achieve the electricity needs of SRP in the industry. Electric power networks in the industry are obtained from PLN and generators. So in this case of course the generator is still very necessary. To find out the capacity of panels and batteries that will be used in the Centralized PLTS Development in the industry, especially at the Sucker Rod Pump. The method used in this study is a quantitative method because it involves calculating the capacity of solar panels, daily energy requirements, and numerical system analysis. The results of this study show that the total energy demand for electricity supply for SRP needs is 264 kWh/day. The total panel capacity required is 106kWp with a total of 200 monocrystalline panels with a capacity of 550Wp and 128 batteries with a capacity of 24V 200Ah. The inverters used are PV1800 ECO Series 6,200W inverters of 20 pieces.

Keywords: Kebutuhan PLTS, Alternatif Suplai Listrik *Sucker Rod Pump*

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Introduction

Energy is needed by humans in living their daily lives, both individually, in households, businesses and countries. Energy needs in Indonesia are still dominated by fossil fuel sources such as petroleum, natural gas and coal. Energy consumption in Indonesia is increasing due to the need for energy supply both in household life and the business sector. The ratio of fossil fuel consumption to energy supply is still in deficit and exceeds the domestic energy supply so that it is necessary to import fossil resources from abroad. To prevent this, it is necessary to create energy sources through the utilization of natural resources in the surrounding environment and convert them into renewable energy.

The fundamental change from the dominance of fossil energy to renewable energy has a significant impact on various aspects of life, such as environmental, social and economic conditions. Efforts to increase the share of renewable energy still face major challenges, one of which is the price of renewable energy that is not yet competitive with fossil energy. Most likely, given the slow development of renewable energy, dependence on fossil energy, especially oil and gas, will continue. In the production process, fossil energy such as petroleum and natural gas also requires energy for the operation of production machinery.

One of the machines used in the oil and gas industry is the artificial lift type Sucker Rod Pump (SRP). The performance of this pump is based on an artificial lifting process that uses electricity or gas from an energy source to drive the pump, so that the resulting liquid can rise to the surface. the use of renewable energy in the oil and gas industry has great potential to reduce greenhouse gases and save hydrocarbon resources, therefore, further research and development is needed to overcome challenges and realize the full potential of renewable energy in the oil and gas industry, one of which is by using a Solar Power Plant system as a source of electricity.

Solar Power Plant (PLTS) is one type of renewable energy power plant that utilizes solar energy to generate electricity. PLTS is one of the sources of electrical energy generation with great potential in Indonesia due to Indonesia's strategic location which is on the equator so it is ideal for getting peak solar energy with the average solar irradiation generated reaching 4.8kWh/m2 / day. From the description above, the problem of energy resources can be solved by using solar energy as an energy source in SRP.

Literature Review

2.1 Electricity Requirement

The need for electricity for the sucker rod pump is very important because this pump requires electrical energy to drive the plunger and lift fluid from the well to the surface. Sucker Rod Pump (SRP) is an artificial lift used in the oil and gas industry to lift oil from underground to the surface. The SRP pump is also called a nod pump which is a method that uses an energy source in the form of electricity or gas to drive the pump so that the liquid or fluid can rise to the surface. The advantage of using this SRP pump over other artificial lifting methods is that it is easy to use in the field. In addition, the equipment has a longer life so that after being used in a well (production ends) it can be moved to another well at a relatively low cost. To achieve optimal production in the SRP pump design, the standardization is the pump capacity. The SRP pump is expected to use solar cell electricity as an alternative energy source.

Figure 1. Sucker Rod Pump

2.2 Solar PV Systems and Calculations

When it comes to solar power plants, it is very important to calculate the total energy requirement. This involves collecting data on the amount of energy consumed by all equipment and resources used. By identifying the existing electrical appliances and their specifications, we can collect daily data on the amount of energy consumed by each appliance. To calculate the total energy requirement, we can use the following equation:

Usage Load = Total power ($Watt$) Length of use (h) ....(1)

To calculate the panel capacity requirement, the following equation can be used:

$$PV\ Capacity\ (kWp) = \frac{\text{Daily Load (kWh)}\ x\ Safety\ Factor}{PSH\ (h)} \qquad (2)$$

To calculate the number of panels needed, you can use the following equation:

$$Number\ of\ Panels = \frac{\text{Load PV}}{Panel\ Capacity} \qquad (3)$$

To calculate battery requirements, you can use the following equation:

$$Battery\ Quantit = \frac{\text{Daily Load (W)}}{Battery\ Capacity\ (W)} \qquad (4)$$

Research Methods

The method used in this research is quantitative method. Quantitative method is a research method that uses data in the form of numbers to produce objective and measurable information. The object of this research is the Sucker Rod Pump pumping unit to calculate the need for a Centralized Solar Power Plant (PLTS) as an alternative electricity supply for the Sucker Rod Pump

Research data is information that is collected, recorded, organized or processed to validate research results. Survey data can be in the form of numbers, symbols, text, images or sounds, and often in digital form.

3.1 Sucker Rod Pump Drive Motor Data

The drive motor data for sucker rod pumps can vary depending on the type of pump and the specific needs of each well. However, here is some information about the drive motors used in the sucker rod pumps analyzed by the authors.

Table 1. Pump Type Electric Motor Specifications

No	Pump Type	Electric Motor Specifications
1.	Tipe Conventional Merk Churchill	a. Type : Foot Mounted Merk Wen Bau 3 Phase b. Serial Number : 78141 c. Berat : 120kg d. Power :5,5 Kw

No	Pump Type	Electric Motor Specifications
		e. Voltage : 380 V f. Current: 13,3 A g. Rpm: 720 r/min h. Hertz : 50Hz
2.	Tipe Conventional Merk Jensen	a. Type : Foot Mounted Merk Teco 3 Phase b. Serial Number : Q4218020002 c. Berat : 53,5kg d. Power :5,5 Kw e. Voltage : 380 V- 415V f. Current: 12 – 11 A g. Rpm: 1.465 r/min h. Hertz : 50Hz

3.2 Solar Radiation Data

Radiation data for the research location with coordinates (-03.1056°, 130.5009°) obtained from solargis via the website https://globalsolaratlas.info/map are as follows:

Table 2. Solar Radiation Data

Direct Normal Irradiation	DNI	3.698 kWh/m^2 per day
Global Horizontal Irradiation	GHI	4.901 kWh/m^2 per day
Diffuse Horizontal Irradiation	DIF	2.249 kWh/m^2 per day

The PSH value is the amount of radiation received per day in an area in units of kWh/m2 per day. Based on the data above, the GHI is 4,901 kWh/m2 per day and the PSH is 4901 hours ≈ 5 hours

Results and Discussion

Result

4.1 Electricity Demand Calculation

The electric motor driving the Sucker Rod Pump (SRP) has a load power of 5.5 kW for each unit so the total load power is 11kW and operates without interruption for 24 hours. With this capacity, the electric motor can ensure stable and consistent performance in driving the SRP, which enables effective and efficient fluid removal from the well depth. This 24-hour-a-day operation requires careful design and maintenance to ensure the reliability of the electric motor and optimal pump performance.

Table 3. Pump Drive Motor Load

Time	Load
24 h	5,5 kW
24 h	5,5 kW
Total	11 kWh

To calculate the usage load, the following equation can be used:

Usage Load (kWh) = Total Power $(Watt)$ x Length of Use (h)

Usage Load (kWh) = 11.000 $Watt\ x\ 24h$

Usage Load (kWh) = 264.000 Wh = 264 kWh.
Based on the data obtained, the total usage load for 24 hours is 264 kWh.

4.2 Calculation of Solar Panel Capacity Requirement

$$PV\ Capacity\ PV\ (kWp) = \frac{\text{Daily Load (kWh)}x\ Safety\ Factor}{PSH\ (h)}$$

$$Kapasitas\ PV = \frac{\text{264 kWh x 2}}{5\ Jam}$$

$$PV\ Capacity = \frac{\text{528 kWh}}{5\ h}$$

$$PV\ Capacity = 105{,}6\ kWP \approx\ 106\ kWP = 106.000WP$$

From this calculation, the PV system required is about 106 kWp to meet the energy demand of 528 kWh.

4.3 Calculation of Number of Solar Panels

Before determining the number of solar panels needed, we must first determine the type and capacity of the solar panels used. This is very important because the type and capacity of solar panels affect the efficiency of solar energy use and the ability to meet daily energy needs. In this study, monocrystalline solar panels with a capacity of 550 WP were used because monocrystalline solar panels have a higher efficiency than other types of panels, namely 21.29%. Monocrystalline solar panels have high performance and durability. The monocrystalline cell technology used in 550 Wp solar panels utilizes the best technology in converting solar energy into electricity. Monocrystalline solar panels also offer more cost-effectiveness compared to other types of panels. Thus, the use of monocrystalline solar panels with a capacity of 550 Wp in this study was chosen due to the combination of high efficiency, good performance, and cost-effectiveness.

Table 4. 550 Wp Monocrystalline Solar Panel Specification

Criteria	**Description**
Panel Type	Monocrystalline
Capacity (Wp)	550 Wp
Efficiency (%)	21,29%
Max Power Voltage (V)	42,49 V
Max Power Current (A)	12,98 A
Operational Temperature (˚C)	-40˚C - -85˚C
Dimension of module (mm)	2278 x 1134 x 35
Weight (Kg)	29 Kg

After determining the type of panel to be used, the next step is to calculate the number of panels needed to meet daily electricity demand. To calculate the number of panels, the following equation can be used:

$$Number\ of\ Panels = \frac{\text{PV Load}}{Panel\ Capacity}$$

$$Number\ of\ Panels = \frac{\text{106.000 WP}}{550\ WP}$$

$$Number\ of\ Panels = 192{,}72 \approx 200\ pieces$$

To meet the daily electricity demand of 106,000 wp, we need about 193 panels with 550 wp per panel. However, since we have to ensure that the solar panel system can operate effectively and efficiently, the panel usage is rounded up to 200 pieces

4.4 Battery Requirement Calculation

Calculating the number of batteries should be done after determining which batteries to use first. This is very important because the type and capacity of the battery affects energy consumption and the ability to meet daily energy needs. The battery to be used in this research is a LiFePo4 24V 200Ah battery because LiFePO4 (Lithium Iron Phosphate) batteries have the advantage of a long cycle life, reaching between 2000 to 10000 charge and discharge cycles, making them an ideal choice for long-term energy storage applications. With high durability, these batteries are capable of lasting more than 5000 cycles under normal usage conditions and exhibit minimal degradation during those cycles. In addition, these batteries are efficient, can be recharged up to 90% without damaging their capacity, and have good chemical stability that reduces the risk of fire. LiFePO4 batteries are also environmentally friendly as they are made from non-toxic and recyclable materials.

Table 5. Specifications of 24V 200Ah LiFePo4 Battery

Criteria	Description
Voltage (V)	24V
Capacity (Ah)	200Ah
Energy Capacity (W)	4800W
Temperature Resistance	-20°C – 45°C
Dimensions	300 x 200 x 200 mm

The battery to be used is a Lifep04 battery, with a value of 24V 200Ah and the load to be stored in a battery of 264,000 wh with an autonomy of 2 days (264,000× 2 = 528,000) then calculated using the following equation:

$$Battery\ Quantity = \frac{\text{Daily Load W}}{Battery\ Capacity\ W\ x\ DOD\%}$$

$$Battery\ Quantity = \frac{528.000\text{W}}{24V\ x\ 200A\ x\ 90\%}$$

$$Battery\ Quantity = \frac{528.000\text{W}}{4.800W\ x\ 0{,}9}$$

$$Battery\ Quantity = \frac{528.000\text{W}}{4.320W}$$

$$Battery\ Quantity = 122{,}2\ Buah \approx 128\ pieces$$

Then the number of batteries used by this PV system is 128 pieces with a capacity of 24V 200A each

4.5 Inverter Determination

After performing calculations to determine the number of batteries and solar panels needed, the next step is to determine the right inverter for the solar panel system (PLTS). The inverter is an important part of the PLTS system which is tasked with converting direct current (DC) produced by solar panels into alternating current (AC) which can be used directly. In the solar power generation system (PLTS) designed according to the calculations above, there are 20 strings of solar panels, each string consisting of 10 solar panels and producing 5,160W of power, where each string will be installed with 1 inverter and the battery bank that will be connected to the inverter has a total voltage of 48V each for 16 inverters and 48V each for 4 inverters. Then the inverter used is an inverter with a power of 5,160W, so the inverter used in this study is PV1800 ECO Series 6,200W as many as 20 pieces.

Table 6. Specifications of PV1800 ECO Series 6,200W inverter

Model	PV18-6248 ECO
Default Battery System Voltage	48VDC
INVERTER OUTPUT	
Rated Power	6200VA/6200W
Output Channel	Dual
Surge Power	12400W
Waveform	Pure sine wave
AC Voltage Regulation (Batt.Mode)	230VAC±5%(Setting)
Inverter Efficiency(Peak)	>90%
Transfer Time	Typical < 10ms , 20ms max
AC INPUT	
Voltage	230VAC
Selectable Voltage Range	170~280VAC(UPS) / 90~280VAC(APL) / 184~253VAC(VDE)
Frequency Range	50Hz / 60Hz (Auto sensing)
BATERAI	
Normal voltage	48VDC
Floating Charge Voltage	54.8VDC
Overcharge Protection	60VDC
SOLAR CHARGER & AC CHARGER	
Maximum PV Input Voltage	500VDC
Charging Algorithm	3-Step (Flooded Battery, AGM / GEL / LEAD Battery), 4-Step (Li)
Maximum PV Array Power	6200W
PV Array MPPT Voltage Range(Typ.)	120~450VDC
PV maximum input current	28A
Maximum Solar Charge Current	120A
Maximum AC Charge Current	100A
Maximum Charge Current	120A
MECHANICAL SPECIFICATIONS	
Machine Dimension (W*H*D)(mm)	318*428*140
Package Dimension (W*H*D)(mm)	550*400*220
N.W (kg)	10,0kg
G.W (kg)	11,6kg
OTHER	
Humidity	5% to 95% Relativ Humidity (Noncondensing)
Operating Temperature	0°C~50°C
Storage Temperature	-15°C -60°C

With a total of 128 batteries, this system uses 64 battery banks. Each battery bank each contains 2 batteries connected in series. every 3 battery banks will be connected in parallel as many as 16 circuits with a total voltage of 48 volts and every 4 battery banks will be connected in parallel as many as 4 circuits with a total voltage of 48 volts. This results in 20 circuits that will be connected to 20 inverters. Thus, this system uses a combination of two types of circuits to achieve the required total voltage. The use of two types of battery banks allows the system to adjust to different voltage requirements, thereby increasing flexibility and energy use efficiency.

Conclussion

Based on the results of the research and discussion carried out above, this research can be concluded that:

1. Total energy demand per day is 264kWh
2. Total panel capacity required is 106kWp
3. The panel used is a type of monocrystalline panel with a capacity of 550Wp as many as 200 pieces
4. The number of batteries required is 128 pieces of LiFePo4 type with a capacity of 24V 200Ah
5. The inverter used is a PV1800 ECO Series 6,200W inverter type of 20 pieces

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