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OFF-GRID SOLLAR POWER SYSTEM DESIGN FOR THE OFFICE OF OIL PALM PLANTATION COMPANY (PT.X) IN WEST KALIMANTAN PROVINCE

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ABSTRACT

The national solar power potential is equivalent to 207,898 MW, but only 0.05% or 100 MW has been utilized.Energy sources from the sun are one of the alternative choices because of their abundant availability and lower levels of pollution than fossil fuel power plant. This is what makes photovoltaic system technology one of the most popular renewable energy technologies in the world In this study, electric energy needs for PT X was determined to be 2162 watt-hour, with 2 units of AC ½ pk, 2 units of LED television, 2 units of refrigerator, 2 units of washing machine, 1 unit of rice cooker, 8 units of lamp, and 5 units of computer. So, the total estimated electricity need for PT X is 13,000Wh/day. For solar panel plan requirement, the results of the analysis with the capability of 200 wp/panel showed a total need of 16 pieces with the arrangement of 3 on the x and y axes being 6, with a total voltage obtained being 105 volts and the total output current being 30 amperes with a total power of 3133 WP. The demand charge controller needed is 3 amperes and the inverter capacity is 3937 watts. For power storage, the required battery capacity is 4025 Ah, so it takes 4 batteries with a capacity of 2 volts 1000 ampere hours. Based on the simulation results that have been carried out, the estimated total electrical energy that can be generated for one year by off-grid Solar Power System is 13 KWh/day. This Design is able to meet the needs of the branch office electricity load of 95.85%.

RESEARCH BACKGROUND

With time and advancements in technology, the use of electric energy is also increasing. Natural resources are decreasing and it will only keep decreasing with the long-term use of electricity from fossil fuels.[1]

This poses serious problems for the provision of energy to all people in the world. One effort to overcome this is to use alternative energy, such as solar thermal energy with solar panels that can convert sunlight into electrical energy.[2]

Indonesia is located in the equatorial zone with abundant sunlight every day. The potential for sunlight that can be utilized for Solar Power Plants in Indonesia is on average 4.8 kWh/m2/day, otherwise known as the potential for solar radiation.[3] or in scientific terms, insolation. The national solar power potential is equivalent to 207,898 MW, but only 0.05% or 100 MW has been utilized.[4] Energy sources from the sun are one of the alternative choices because of their abundant availability and lower levels of pollution than fossil fuel power plants.[5] This is what makes photovoltaic system technology one of the most popular renewable energy technologies in the world.[6]

Solar power plant itself is an application of tools for the use of solar energy as renewable electric energy, namely solar cell technology (photovoltaic) which is used as a producer of electrical energy.[7]

The installation consists of 4 important components so that Solar Power System can function optimally, namely: (a) Solar panels, which function to convert sunlight into electric energy which is an important component that must exist in a Solar Power System.[8] (b) Solar Charge Controller, is an electronic device that is placed between the array of solar modules and batteries. This tool serves to regulate the charging power of the battery from the output power of the solar module so that the battery does not overcharge.[9] (c) Battery, which serves to store the energy produced by solar panels. In the process of charging the battery, the term Depth of Discharge (DOD) is a determination of how much battery power can be supplied to the load through the inverter. The power from the battery cannot be discharged all the way until the battery is empty, only 80%, or otherwise it will decrease battery life quality.[10] (d) Inverter is a device used to convert direct electric current (DC) into alternating electric current (AC). In designing solar panels, 4 main components are needed, namely power and load time while on, inverter power, solar panel power and battery power. Solar Power System produces maximum power depending on the intensity of the incoming light every day and weather is the main factor that can interfere with the absorption of light by solar panels to be processed into electrical energy.[11] Based on the installation, Solar Power System is divided into 2, namely Off-grid and On-grid connected systems. Off-grid Solar Power System is also known as standalone system and On-grid Solar Power System is Solar Power System that is connected to the utility grid or connected to the PLN network.[12]

Standalone here is usually referred to as off-grid or not connected to the PT PLN (Persero) electricity network, which is usually designed to utilize sunlight independently in isolated areas, hinterlands, or islands that are not yet connected to the transmission and distribution system Solar Power System. While the on-grid system is the opposite, which is connected to the PLN electricity network.

Several PT X branches in certain sub-districts still have palm oil management offices that are not yet served by electricity through the distribution network of PT PLN (Persero). One of them is the PT X branch in Ketapang Regency. By taking into account the company's economy and investment costs for the construction of a Solar Power Plant, which is directly proportional to the generated power capacity, centralized Solar Power System planning (Off-Grid) is needed at PT X Ketapang Regency.

MATERIAL AND METHOD

For Power (watt-peak) generated by a Solar Power System to meet energy needs, it is calculated with the following steps and equations.[13]

Step 1: Array area (PV area) is calculated with the following equation:

$$PV\ Area = \frac{E_L}{G_{AV} \times TCF \times Eff_{PV} \times Eff_{Out}}$$

E_L = Energy generated [kWh/day]

PV Area = Solar panel surface area [m2]

G_{AV} = Daily solar radiation intensity [kW/m2/day]

TCF = Temperature coefficient factor [%]

Eff_{PV} = Solar panel efficiency [%]

E_{ffOut} = Output efficiency [%] assumption 0.9

Step 2: From the array area, then the amount of power generated by a Solar Power System (watt-peak) can be calculated by the following formula.[14]

$$P_{watt\ Peak} = PV\ Area \times PSI \times E_{Pv}$$

PV Area= Solar panel surface area [m2]

PSI = Peak Solar Insolation: 1.000 W/m2

Solar Panel Efficiency = Solar Panel Efficiency [%]

Step 3: Furthermore, based on the amount of power to be generated (watt-peak), the number of solar panels needed is calculated by the following formula:[15]

$$The\ Number\ of\ Solar\ Panels = \frac{P_{watt\ Peak}}{P_{mpp}} (Unit)$$

$P_{watt\ peak}$ = Power Generated [WP]

P_{mpp} = Solar panel maximum output power [watt]

Step 4: Then, the capacity of the charge controller is determined by the following formula:

$$Charge\ Controller\ Capacity = \frac{Demand\ Watt \times Safety\ Factor}{System\ Voltage}$$

Step 4: The amount of battery capacity needed to meet daily energy consumption can be calculated by the following formula:[16]

$$C = \frac{N \times E_d}{V_s \times DOD \times Eff}$$

Dimana

C = Battery Capacity [Ampere-hour]

N = Number of Days [Days]

E_d = Daily Energy Cosumption [kWh]

V_s = Battery Voltage [Volt]

DOD = Maximum depth for battery discharge [%]

Eff = Maximum depth for battery discharge

The inverter capacity is determined by the following formula:

$$CAP\ INV = DEMAND\ WATT \times SF$$

RESULT AND DISCUSSION

Solar insolation and temperature data in the West Kalimantan region from 2019 to 2020 were obtained from climate data issued by the Pontianak Meteorology, Climatology and Geophysics Agency (BMKG) in Table 1.

Table 1: Temperature and Solar Insolation Data.

Year	Month	Temperature(°C)	Solar Insolation (kWh/M2 /Day)
2019	January	27.5	5
	February	26,7	4,96
	March	27,1	5,13
	April	27,5	5,10
	Mei	27,6	4,92
	June	27,4	4,98
	July	27,5	4,88
	August	28,3	5,07
	September	28,1	5
	October	27,6	4,96
	November	27,3	5,13
	December	26,8	5,10
2020	January	26.5	4,97
	February	26,7	5,49
	March	27,1	5,94
	April	27,5	5,74
	Mei	27,5	5,38
	June	27,4	5,24
	July	27,5	5,24
	August	28.9	5,40
	September	28,1	5,15
	October	27,6	5,02
	November	27,3	4,92
	December	26,8	4,98
Maksimum		28.9	5.94
Minimum		26.7	4.88
Rate		27.63	5.15

For Solar Power System planning, minimum daily solar insolation value is generally used, namely 4.45 kWh/m2 /day, with the aim that at the time of daily insolation the sun is at its lowest value, so that the Solar Power System to be developed can still meet the large capacity generated.

Temperature data (earth temperature) for the West Kalimantan region throughout 2019 to 2020 on average is 27.63. For Solar Power System planning, the maximum temperature value is generally used, which is 28.9 with the aim that when the temperature is at its highest value, the temperature correction factor can be obtained in the Solar Power System to be developed.

In this study, electric energy needs for PT X was determined to be 2162 watt-hour, with 2 units of AC ½ pk, 2 units of LED television, 2 units of refrigerator, 2 units of washing machine, 1 unit of rice cooker, 8 units of lamp, and 5 units of computer. So, the total estimated electricity need for PT X is 13,000Wh/day, which is shown in the table below:

Table 2: Company Electricity Needed.

Item	Qty	Unit	Power Capacity per-unit (W/unit)	Usage Hour per day	Power Capacity (wh)
AC 1/2 PK	2	unit	400	7	5600
TV LED	1	unit	55	6	330
Refrigator	1	unit	90	24	2160
Washing Machine	1	unit	250	2	500
Rice Cooker	1	unit	150	1	150
Lamp	10	unit	24	7	1680
Computer	3	unit	100	7	2100
Total Power Capacity (Wh/day)					12520
Total Power Capacity (assumption) (Wh/day)					13000

As we know that every 1 degree increase in temperature (from the standard temperature) on the solar panel will result in a decrease in the power generated by the solar panel by about 0.5% (Foster et al, 2010). The maximum temperature data for the Mempawah Regency area for the period 2019 to 2020 is 28.9 (data can be seen in Table 3.5). This temperature data shows that there is an increase in temperature of 3.9 from the standard temperature (25) required by solar panels.

Table 3: Off-grid PV System Requirement.

Variable	Amount	Unit
Company Electrical Demand	13	KWH/day
Panel Power	200	WP
Tegangan	35	Volt
Current	5	Ampere
Array arrangement		
x-axis	6	Unit
Y-axis	3	Unit
Max. Temperature	28.7	C
Power Loss	3.7	Watt
P	196.3	Watt
TCF (Temperature Correction Factor)	0.9815	
PV area	19.6	m2
Pwatt peak	3,133.1	WP
Number Panel Needed	15.7	Unit
PV Unit Plan	18	Unit
Total Voltage	105	Volt
Total Current	30	Ampere
Total Power	3150	WP
Demand Charge Controller	37.5	Ampere

Variable	Amount	Unit
Capacity Of Inverter	3937.5	Watt
Baterry Capacity	4024.7	AH
Number Of Batteries With A Capacity Of 2v 1000 Ah	4.02	Unit
Number Of Baterry Plan	4	Unit

For solar panel plan requirement, the results of the analysis with the capability of 200 wp/panel showed a total need of 16 pieces with the arrangement of 3 on the x and y axes being 6, with a total voltage obtained being 105 volts and the total output current being 30 amperes with a total power of 3133 WP. The demand charge controller needed is 3 amperes and the inverter capacity is 3937 watts. For power storage, the required battery capacity is 4025 Ah, so it takes 4 batteries with a capacity of 2 volts 1000 ampere hours. A single diagram can be seen in the following figure.

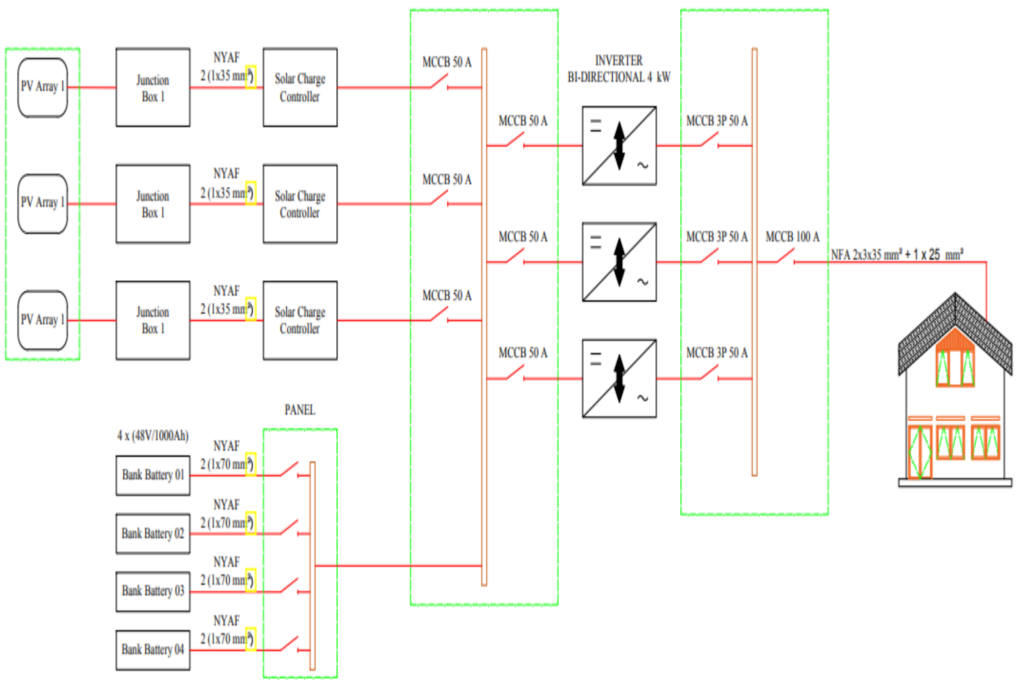

Figure 1: PV Off-Grid System Single Line Diagram.

Based on the simulation results that have been carried out, the estimated total electrical energy that can be generated for one year by off-grid Solar Power System is 13 KWh/day. This figure is able to meet the needs of the branch office electricity load of 95.85%.

CONCLUSION

Based on the centralized (off-grid) Solar Power System planning at PT X West Kalimantan, the following conclusions can be drawn:

1. Based on the calculation results, the total estimate PT.X's daily energy requirement is 13 kWh per day.
2. In the Off Grid Solar Power System Centralized, it is planned that there will be 3 (three) arrays, each of which produces a power of 3,100 Wp, so that 3. The total solar panels are 18 units, and the total power generated is 3.1 kWp.
3. Based on the simulation results the design is able to meet the needs of the branch office electricity load of 98.85%.

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