Analysis of The Need For Solar Power Plants (PLTS) as a Backup Source of Electrical Energy at Base Transceiver Stations (BTS)

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Abstract

The electricity supply for BTS power needs generally uses generator sets as the main energy source. On the other hand, the continuous use of generator sets also has a negative impact on the environment. Based on these issues, the use of environmentally friendly technology is one of the most suitable alternatives to be applied to the BTS system owned by telecommunications service providers. The use of solar energy as an alternative energy source will have a significant impact on saving fossil fuel consumption. From the data obtained, it is known that the power capacity for BTS operation per day is 10.6 kVA or 8.48 kW. If the BTS operates at a constant power for 24 hours, the total power required is 203.52 kWh. The next step is to determine the assumption of losses with a value of 15%. This is because all the components of the system used are new (not old or used components). Thus, the total energy requirement for the microgrid system will be 234,048 Wh or 234.048 kWh Translated with DeepL.com (free version). Based on the results of calculations and direct measurements, the BTS requires a power capacity of 10.6 kVA or 8.48 kW per day. The inverter capacity uses 10 kW more than the power required by the BTS to avoid overload when using the BTS load. The solar power plant at this BTS uses mono-crystal solar panels with a capacity of 455 Wp/panel and 183 solar panel modules are installed, bringing the total to 83,265 Wp. This solar power plant uses 11 batteries with a capacity of 48V 100 Ah. It uses 11 Solar Charger Controllers (SCC) with a capacity of 100-25A each Translated with DeepL.com (free version).

***Keywords**:* Base Transceiver Station (BTS), Solar Power System, Renewable Energy Microgrid, PLTS.

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Introduction

The demand for a more efficient communication system has forced state-owned telecommunications companies to build many Base Transceiver Stations (BTS) to meet customer needs. On the other hand, the construction of BTS facilities by telecommunications companies faces many problems. One of these problems is that BTS must cover all areas, including areas that are not supplied with electricity, such as mountainous areas, islands far from the mainland, deserts, and so on. In general, many BTS are built in rural and remote areas. The electricity supply for BTS in these areas generally uses generator sets as the main source of energy. On the other hand, the continuous use of generator sets also has a negative impact on the environment. The combustion of diesel fuel in generator sets produces CO2 gas pollutants that are harmful to the environment. Based on this problem, the use of environmentally friendly power supplies that do not use fossil fuels is the right solution to overcome the problem of diesel combustion gas pollutants.

The telecommunications industry (ICT) consumes approximately 900 MWh of power for BTS power supply each year, equivalent to 10% of global electricity consumption. Of this percentage, the largest contributor is the mobile telecommunications industry, with approximately 60% to 80% of consumption used for BTS operations. In response to this, there are several solutions for optimizing electricity consumption, namely switching off elements when traffic demand is low, reducing the electricity load, and selecting environmentally friendly or low-power components. Based on these three strategies, the use of environmentally friendly technology is one of the most suitable alternatives to be applied to the BTS systems of telecommunications service providers in these remote island regions.

The use of solar energy as an alternative energy source will have a significant impact on reducing the use of fossil fuels. Numerous studies supporting the use of solar power systems (photovoltaic) in rural areas or remote islands show that these systems are more feasible to build than diesel generators and high-voltage electricity from local electricity providers (PLN/IPP). On the other hand, the cost of installing photovoltaic systems is also beginning to decline. The decline in the cost of photovoltaic modules, operational costs, and maintenance plays an increasingly important role in the effectiveness of photovoltaic installations. To optimize the installation of photovoltaic systems, an economic value analysis is needed so that the interaction between installation and system costs can run smoothly. In addition to optimization, the development of photovoltaic system technology also supports the planning and installation of solar power systems. One type of software used in the design or modeling of photovoltaic systems is PVSyst software. The use of software can facilitate the design of photovoltaic systems from both a technical and economic perspective.

The use of PVSyst software to analyze the technical and economic feasibility of photovoltaic installation projects is widely used in research. The feasibility study of on-grid rooftop photovoltaic projects in building facilities also uses economic analysis. PVSyst provides information on the specifications of the main components of off-grid systems, including PV modules, solar charger controllers (SCC), and batteries. Based on this and existing issues, the purpose of this paper is to design a micro-grid-based solar power (photovoltaic) system installation used to power BTS on Genting Island, Karimunjawa. In addition, technical and economic analyses were also carried out, configured with software simulations using PVSyst software.

Research Methodology

The research method used in planning the use of photovoltaics as a renewable energy source for BTS in areas without electricity begins with the collection of data used for mathematical calculations and simulations. The data used for the calculations is the total electrical power required by the BTS to operate in order to produce good communication network quality in accordance with the specified parameters.

The secondary data used for calculations and simulations includes geographic position data based on latitude and longitude, solar radiation and energy data, existing load capacity, available solar energy in the installation area, installed solar power plant capacity, and economic data for the solar power plant installation. Subsequently, the obtained data will be compared with mathematical calculations and simulated using PVSyst software.

2.1 Solar Panel

The solar panels used in this study are monocrystal type, which have a high efficiency rate. In addition, monocrystal solar panel modules are also easily found on the market. The monocrystalline solar panel modules used are SUN-EARTH DXM8-54H brand with an output power variation of 455 Watt Peak (WP). The purpose of selecting these solar panel modules is their medium size, which facilitates the mobilization and installation processes as well as the panel mounting process. The datasheets for each solar panel module can be seen in the following table

Table 1 Results of Secondary Data Collection

Specification Data	Value	Unit
Rated Power (Pmax)	455	Watt
Maximum Power (Pmax)	455	Watt
Rate Voltage (Vmp)	31,25	Volt
Rate Current (Imp)	12,96	Ampere
Open-Circuit Voltage (Voc)	37,30	Volt
Short-Circuit Current (Isc)	13,98	Ampere
Module Efficiency	20,60	%

2.2 *Solar Charger Controller* (SCC)

The Solar Charger Controller (SCC) module used is brand 250/100-MC4 VE.Can (VITRON ENERGY). The SCC 250/85-MC4 VE.Can datasheet can be seen in Table as follows:

Table 2 Datasheet SCC 250/100-MC4 (*VITRON ENERGY*)

Specification Data	Value	Unit
Battery Voltage	48	Volt
Rated Charge Current	100	Ampere
Max PV Power	5800	Watt
Max PV Short Circuit Curren	70	Ampere
Max PV Open Circuit Voltage	245- 50	Volt
Max Efficiency	99	%

2.3 Battery

The battery used in this study is a lead-acid battery with a working voltage of 48 volts and 100 Ah. The battery capacity required will be adjusted to meet daily energy consumption.

2.4 Inverter

The inverter used is SUNNY ISLAND Puresine Wave Auto Chargering. The inverter datasheet can be seen in Table.

Table 3 Datasheet Invertrer Puresine Weva Auto Chargering

Specification Data	Value	Unit
AC Voltage Range	202- 53	Volt
Rated Frequency	45 - 65	Hz
Rated Power	6000	Watt
Battery DC Input	48 - 63	Volt
Battery Type (Lead Acid)	100- 10000	Ah
Max Efficiency	95,8	%

Results

3.1 BTS power capacity

The power capacity of a BTS is the total power and daily load used on a BTS tower. Based on the data obtained, it is known that the power capacity for operating a BTS for one day is 10.6 kVA or 8.48 kW. If the BTS operates at a constant power for 24 hours, the total power required is 203.52 kWh. The next step is to determine the assumption of losses with a value of 15%. This is because all the components of the system used are new (not old or used components). Thus, the total energy requirement for the microgrid system will be 234048 Wh or 234.048 kWh.

3.2 Solar Power Plant Power Calculation

For each capacity, the power capacity (Wp) of the solar panel can be calculated. The calculation of solar panel power uses the Peak Sun Insulation (PSI) parameter, which uses a value of 1000W/m² and the efficiency of the solar panel. These two parameters will determine the total power value calculated using the formula:

$$\textbf{Wp PV} = PV\ Area \times PSI \times \eta PV \qquad (1)$$

Where:
Wp PV : Total power PV (Watt)
PV Area : PVArea (m²)
ηpv : Solar module efficiency (%).
The power calculation results for a 455 Wp solar panel capacity can be seen as follows:
387 x 1000 x 21.60% = 83.592 kWp

3.3 Calculation of Solar Panel Quantity

Based on the results of the solar panel power capacity calculations that have been carried out, the number of solar modules required can be analyzed. The calculation of the number of solar panel modules uses the parameters of the PV power generated (Wp) and PV capacity. The calculation is carried out using the equation below:

$$PV = \frac{WP}{P_{PV}} \qquad (2)$$

$$PV\ Array\ Seri = \frac{V_{Max}\ SCC}{V_{mp}\ Modul} \qquad (3)$$

$$PV\ Array\ Paralel = \frac{I_{Max}\ SCC}{I_{mp}\ Modul} \qquad (4)$$

Where:
Wp : Total PV power (*Watt Peak*),
PPV : PV power capacity used (Watt),
Vmax SCC :Open circuit voltage SCC (Volt),

$Vmpmodul$: Average voltage on the PV module (Volt),
Imax SCC : Average charging current (Ampere),
$Impmodul$: Average current in the PV module (Ampere).

Meanwhile, the results of calculations using equation 2, which aims to determine the power capacity of a 455 Wp solar panel module, can be calculated as follows

$$PV = \frac{83.592}{455} = 183 \text{ solar module}$$

Based on calculations using the equation for a solar panel capacity of 455 Wp, it was found that the number of solar modules required was 183 units.

3.4 Solar Charger Controller Capacity Calculation (SCC)

The Solar Charger Controller (SCC) used is a 250/100-MC4 type SCC. The SCC module was selected based on the BTS power operating system, which is 48 VDC. To determine the number of SCCs, the following equation can be used:

$$NSCC = \left(\frac{CPV \ x \ NVP}{VDC \ x \ CSCC}\right) + 1 \quad (5)$$

Where:
NSCC : Number of SCCs used
CPV : PV module capacity (Watt)
NPV : Total PV connected in series
VDC : Nominal working voltage (Volt)
CSCC : SCC output capacity (Ampere).

The SCC module calculation results for a solar cell capacity of 455 Wp can be calculated as follows

$$NSCC = \frac{455 \, x \, 183}{48 \, x \, 100} + 1$$

$$NSCC = 18{,}34 \text{ rounded up to } 19 \text{ units}$$

Based on calculations using the equation, it was found that the number of SCCs required was 19 units.

3.5 Battery Capacity Calculation

The battery used is a 48 Volt, 100 Ah Lead-Acid battery. To determine the daily battery capacity, it can be calculated using the following equation:

$$BAHR = \frac{(Et \, x \, n)}{(Vs \, x \, DOD \, x \, \eta)} \quad (6)$$

$$NBTR = \frac{B_{AHR}}{I_b} \quad (7)$$

Where:
BAHR : Battery capacity (Ah)
Et : Total load (Watt)
n : Number of days of power supply
Vs : Battery voltage (Volt)
DOD : Percentage of battery used (%),
η : Battery efficiency (%)
NTBR : Number of batteries
Ib : Battery current (Ampere).

The battery calculation results for a 455 Wp solar panel can be calculated as follows

$BAHR = \frac{455\,x\,83{,}592}{48\,x\,80\,x\,97} = 10.21$ So it was rounded up to 11 units of 100 Ah batteries 48 Vdc.

Based on the daily power consumption capacity of the BTS reaching 10.6 kVA or 8.48 kW, the current use of inverters in the BTS uses 10 kW inverters. This is to avoid overload usage in the BTS

3.6 Calculation of Energy Costs for Solar Power Systems

The maximum energy output of the solar power plant can be determined according to the rating capacity of the installed solar modules. The total capacity of the solar panels implemented is 83,265 Wp. The energy generated by these solar panel modules is used as a power supply for BTS in remote locations far from the electricity grid. The duration of sunlight exposure used is the average value of 4-5 hours of sunlight.

3.7 Calculation of Operational and Maintenance Costs

The operational and maintenance costs of the solar power plant are set at 1% of the total initial investment cost. This refers to the general operational and maintenance costs of the system, which are 1%. The annual operational and maintenance costs are 1% of the total investment cost. The life cycle cost is determined by the actual total cost of the solar power plant system, which consists of the initial investment cost, long-term maintenance costs, and operational costs (MPW). This study assumes that the system will operate for 25 years. The implementation period is determined based on the warranty provided by the solar panel manufacturer and the specifications of the solar panels.

Conclusion

The conclusions of this study are as follows:

a. Based on the analysis of electrical energy requirements as BTS power supply
b. Based on calculations and direct measurements, the BTS requires a power capacity of 10.6 kVA or 8.48 kW per day.
c. The inverter capacity uses 10kW more than the power required by the BTS to avoid overload when using the BTS load.
d. The solar power plant at this BTS uses mono-crystal solar panels with a capacity of 455 Wp/panel. A total of 183 solar panel modules are installed, bringing the total capacity to 83,265 Wp.
e. This solar power plant uses 11 batteries with a capacity of 48V 100 Ah.
f. Using 11 Solar Charger Controllers (SCC) with a capacity of 100-25A each.

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