Aceh Int. J. Sci. Technol., 12(3) : 317-326
December 2023
doi: 10.13170/aijst.12.3.30259

Aceh International Journal of Science and Technology
ISSN: p-2088-9860; e-2503-2398
Journal homepage: http://jurnal.usk.ac.id/aijst

Energy Assessment of Solar Power Plant on-Grid Bi-direction 3 KW 1 Phase

Andrew Joewono[1], Peter R Angka[1], Rasional Sitepu[1*], Yuliati Yuliati[1], Diana Lestariningsih1 Antonia

[1]Electrical Engineering Department of Engineering Faculty of Widya Mandala Surabaya Catholic University, Indonesia
*Corresponding author: rasional@ukwms.ac.id

Received : January 12, 2023
Received in revised from: July 5, 2023
Accepted : October 16, 2023
Online : October 31, 2023

Abstract – The potential for generating electricity from solar energy as one of the renewable energies is suitable for rural areas, small populations, or communal systems. However, this type of power plant requires a high investment budget. Photovoltaic power systems must be designed to meet the demand for electrical energy but require a large supply. To build a more efficient system, it is necessary to build a communal system. For a small population, a 3000-watt power generation system is made. It will be distributed directly to users; a 5000-watt system is made for a larger area. It will be distributed directly to users and interconnected between generators with the principle of load control. In this study, a solar power plant (PLTS) was designed with an on-grid bidirectional system. Solar panels' conversion of electrical energy is channeled to users and stored in a battery backup system. This PLTS system produces a maximum power of 3000 watts by using 8 units of 450wp solar panels, an inverter with a 48-volt on or off-grid mode system, and 4 12V 200 Ah backup batteries. From the measurement results, the PLTS system will start converting DC current into AC with a radiation value of 356 to 1258 W/m2. Produce on-grid AC current energy, a maximum of 2297 watts, and charge backup batteries with DC current, a maximum of 14.3 A. This on-grid (bidirectional) backup PLTS system can convert DC current into AC, supply it directly to the network electricity (grid), and perform energy backups when solar energy is not energized.

Keywords: Generators; on-grid; photovoltaic; power plant; solar energy.

Introduction

The issue of environmentally friendly renewable energy is a strategic issue not only for Indonesia's interests but also for all countries worldwide. This EBT source is also expected to reduce dependence on fossil energy, which is non-renewable energy, and of course, will reduce its reserves, reduce CO2 emissions, overcome the problem of climate change, and increase the efficiency of energy use (Abolhosseini, Heshmati and Altmann, 2021). The energy sector is a strategic issue because along with the increasing demand for energy, it is followed by the fulfillment of very large investments. Therefore, energy management and audits are needed to achieve and maintain optimal energy supply and utilization (Oyelaran, Twada and Sanusi, 2016). Energy demand is a strategic commodity because, in the current era, the dynamics of systems and human life depend on the availability of energy as the lifeblood of life (Ministry of Energy and Mineral Resources, 2016). Various new and renewable energy sources have been studied and developed, including solar energy, wind, biomass, wind, water, biofuels, and geothermal as alternative energy sources to meet energy needs and support future economic development (Handayani and Ariyanti, 2012).). The potential and economic analysis of this new renewable energy has also been studied by several researchers (Jahangiri, 2019)(Jannis Langer, 2021). The development of new renewable energy in Indonesia includes wind energy of 950 Megawatts, solar power of 11 Gigawatts, hydropower of 75 Gigawatts, 32 Megawatts of biomass energy, 32 Megawatts of biofuels, marine energy potential of 60 Gigawatts, and geothermal energy. Geothermal) which is estimated to have a potential of 29 Gigawatts. The EBT mix in 2025 and its utilization is expected to reach up to 23 percent. Energy transformation towards new and renewable energy must begin. Green economy, green technology, and green products must also be strengthened in order to be able to compete in the global market (Personal, 2021)

doi: 10.13170/aijst.12.3.30259

Indonesia's potential as a country that stretches across the equator has a radiant radiation power of 4.80 kWh/m2/day. Of course, this is very profitable for developing solar energy EBT sources. Electrical energy is a significant need in life (for lighting life, everyday household appliances, and even equipment for community needs). However, its fulfillment is uneven due to the need for network creation and the increasing use of non-renewable energy, for example, oil, coal, and natural gas.

The availability of materials from non-renewable energy sources needs to be considered due to the limited reserves that remain, so it is necessary to make efficient use of them. Apart from that, the equal distribution of electrical energy also needs to be considered so that it can be implemented so that all regions can enjoy the use of electrical energy for their daily needs. One way to do this is to create an on-grid/backup hybrid solar power generation system (Joewono and Sitepu, 2015).

Fulfillment of electrical energy for areas that have not been reached by state electricity needs to be a thought in innovating to make this solar power generation system with a communal (centralized) pattern of use in the district, with an on-grid generating system (used directly when the sun is energized). Furthermore, backed up in a battery (used when the sun is not energized), each district will experience excess or deficiency in the use of electrical energy, so it is necessary to create an interconnection system that meets each other's electrical energy needs for each district with the principle of controlling the load used.

Therefore, the system that will be made is expected to increase the efficiency value in each district's electric energy generation system by controlling the load so that the energy used or stored can be used optimally. The availability of electrical energy in the regions is also uneven due to the lack of an electricity distribution network, bearing in mind that development for distribution requires substantial funding. Generation of electricity, which so far uses the PLN network, requires system efficiency for its sustainability, so it is thought to create a hybrid power generation system that can reach areas that have not yet been connected to the PLN electricity network to be used at any time when needed (dry season which results in drought). , then a water pump is needed, which is generally driven by electrical energy). The developed hybrid system combines electrical energy from sunlight and an electric generator designed to be easily moved (moving).

Solar energy has the potential to be developed in Indonesia, considering that Indonesia is a country located on the equator. The solar energy generated by Indonesia, which has an area of 2 million square kilometers, is 5.10 mW or 4.8 kWh/m^2/day, equivalent to 112,000 gWp. (Ministry of Energy and Mineral Resources, 2016). The potential for solar energy in Indonesia is found in West Kalimantan, South Sumatra, East Kalimantan, North Sumatra, and East Java. Indonesia is rich in renewable energy with a potential of more than 400,000 Mega Watt (MW), 50% of which, or around 200,000 MW, is solar energy potential. However, currently, it is only around 150 MW or 0.08% of its development potential. (Ministry of Energy and Resources Minerals of the Republic of Indonesia, 2020) (Personal, 2021)

Some of the advantages of PLTS include: - Abundant sources of solar energy are available, PLTS technology is easily understood and accepted by the general public, PLTS is very environmentally friendly, does not produce gas emissions, is not noisy, works at room temperature, and there is no risk of disaster to human safety also the environment.

However, several obstacles in the PLTS and electricity sector include - Geographical Conditions and

Inadequate infrastructure facilities for 3T areas (frontier, remote, and lagging) - Demand growth is not in line with the target, obstacles in land acquisition, borrow-to-use permits for forest areas, acceleration of island and island interconnection networks between islands, readiness of the network system to receive electricity from EBT generators (Ministry of Energy and Mineral Resources of the Republic of Indonesia, 2020)

Solar energy is continuous, and large amounts encourage humans to use it as a new energy source besides petroleum fuel (Iskandar, Rizqiawan, and Heryana, 2015). The utilization of solar energy is considered a breakthrough because the potential of solar energy is a huge energy source and does not have a negative impact on the environment (Kementerian ESDM, 2016). Assessing solar energy potential in a location where a PV system is planned to be installed is necessary and would affect the system's success. The potential of solar energy in a location depends directly on the local exposure to sunlight.(Elisier Tarigan, 2018). Solar Power Plants (PLTS) have been widely developed and used by developed and developing countries as an alternative energy source other than petroleum, such as Germany, China, America, Japan and others (Abolhosseini, Heshmati and Altmann, 2021), even the contribution of energy sources from PV mini-grid in Europe can reach 42 TWh in 2020. Indonesia, a tropical country, is blessed with much solar energy. However, light from

doi: 10.13170/aijst.12.3.30259

the sun has not been fully utilized as an energy source. Even though the energy potential of Solar energy in Indonesia is enormous, around 4.8 KWh/m2 or equivalent to 112,000 Giga Wp, only about 10 Mega Wp has been used (ESDM, 2019) . The average solar radiation information data per month can be shown in Table 1.

Equitable distribution of electrical energy needs to be considered to fulfill its life needs; one way is by making an on-grid solar power generation system communal and bidirectional (Joewono and Sitepu, 2015). For fulfillment of electricity needs for areas that have not been reached, it is necessary to innovate by creating a power generation system this solar electricity with a communal pattern, on-grid/backup system (direct use) and backed up in battery (used when the sun is not energized), and during use electrical energy in the district experiencing excess or shortage is overcome by making interconnection system to meet each other's electricity needs by controlling the load used. The design developed is to make a solar power generation system directly used (on-grid) and stored (backup) which is used together the same (communal) and connected between generating systems with the principle of load control used. A number of research has been conducted on the topic of building rooftop PV installation potential in Indonesia and many countries (Merrouni, Amrani and Mezrhab, 2017)and (Abolhosseini, Heshmati and Altmann, 2021) The installation of a solar PV system requires an open space for mounting of PV modules to optimize capturing of solar irradiation.(Elisier Tarigan, 2018)and (Arifin, Firdaus S. A. and Putri, 2022). On-grid backup solar power plants (PLTS) work by changing solar energy into electrical energy directly using a photovoltaic array with photoelectric effect, the electricity produced is direct current (DC) electricity will be converted into alternating current (AC) and rectified into direct current (DC) for channeled to the battery to charge the battery, and distribute alternating current (AC) directly to equipment that requires AC electrical energy, so that the function fulfillment of energy from consumers can be carried out and perform energy backups (PLTS system) ongrid backup (bidirection), which will be used when the sun is no longer have enough energy. In this PLTS system, it is necessary to analyze the needs of any components in the PLTS system. Based on the background of the existing problems, the main problems in making connected to the 220V/50Hz PLN network, as well as measuring the energy produced. This plan includes calculations on equipment to determine PLTS equipment including solar panels, batteries, and the bidirectional inverter that will be used. In this study, the design of an on-grid/communal backup solar power generation system with load control was carried out, meaning that there are several communal solar power plants that can be interconnected in one network, so that they can mutually support the power between the PLTS, with load control limits. With the creation of this research tool, the tool can be used to fulfill the electricity needed by the community, especially in small districts in carrying out their life activities.

Table 1. Annual Data Information (ESDM, 2019)

Month	Solar Insolation ($kWh/m^2/day$)	Average temperature (^oC)	Wind velocity (m/sec)
Jan	4.18	24.6	3.31
Feb	4.25	24.7	3.33
Mar	4.76	25	2.66
Apr	4.82	25.2	3.02
May	4.74	25.2	3.97
June	4.58	24.9	4.34
July	4.86	24.6	5.29
Aug	5.24	24.8	5.38
Sep	5.56	24.9	4.94
Oct	5.32	25	3.71
Nop	4.8	24.9	3.09
Dec	4.63	24.7	2.69

Materials and Methods

Materials

In this section, the materials and components used in the design of the solar energy conversion system are as follows: 1) Solar Module, the main photovoltaic (PV) component that can produce DC electrical energy is called

doi: 10.13170/aijst.12.3.30259

solar panels or solar modules. Solar panels made of semiconductor materials (generally silicon) can produce electric current when exposed to sunlight. This research uses 100 solar cell panels with 8-watt peaks (wp), as shown in Figure 1. 2) Battery A battery is a storage of electrical energy used when the sun does not illuminate solar panels. The battery used is a VRLA (Valve Regulated Lead Acid) battery. Used battery capacity of 100 Ah, 12 V, as many as 2 pieces, with an efficiency of 80%, with a battery/battery charging time of 12 hours, 3) hybrid controller and inverter, used a hybrid controller and a 1400-watt inverter, the input voltage of the solar cell panel is 24 volts, and it produces a 24-volt battery charging voltage. The battery regulator is used to regulate the charging of electric current from the solar module to the battery. When the remaining battery charge is 20% to 30%, then the regulator will decide with a burden. The battery regulator also regulates the excess battery charge and the excess voltage from the solar module. The benefit of this tool is also to avoid full discharge and overloading and monitor battery temperature. The battery regulator is equipped with a diode protection that prevents the DC current from the battery from entering the solar panel again. Inverter (converters DC voltage to AC), produces 220-volt AC phase 1 phase, with a maximum power of 1400 watts, and 4) Inverter, inverter is a device that converts DC into AC in accordance with the needs of the electrical equipment used. This tool converts the DC current from the battery / battery into an AC current for the needs of loads that use AC current.

Figure 1. Panels or solar cell modules are made of semiconductor materials (Joewono and Sitepu, 2015).

Methodology

The design of an on-grid/backup solar power generation system with load controllers is carried out by designing solar panel housings, solar panel voltage stabilizer circuits, manufacturing of on-grid/backup inverter systems, electric power sensors, safety systems, and used load controllers, and systems interconnection between PV mini-grids. The steps for implementing the design are as follows: 1) manufacture of solar panel housing. For a 450 wp solar panel, 8 sheets; 2) making a system control room of 4 x 2.5 x 3 m; 3). Manufacture of on-grid/backup inverter systems; 4). Testing this system by measuring the generated electric voltage and the energy backed up in the battery; 5). Making a series of electric power sensors; 6). testing the electric power sensor circuit is carried out by measuring the power generated from the inverter system; 7) manufacturing of safety systems and using load control; 8) testing this system by measuring the loading energy used for each channel; 9. creating an interconnection system between PV mini-grids; 10). they were testing this interconnection system by measuring the energy produced by each PV mini-grid and carrying out the electrical energy that can be distributed to users.

Aceh Int. J. Sci. Technol., 12(3) : 317-326
December 2023
doi: 10.13170/aijst.12.3.30259

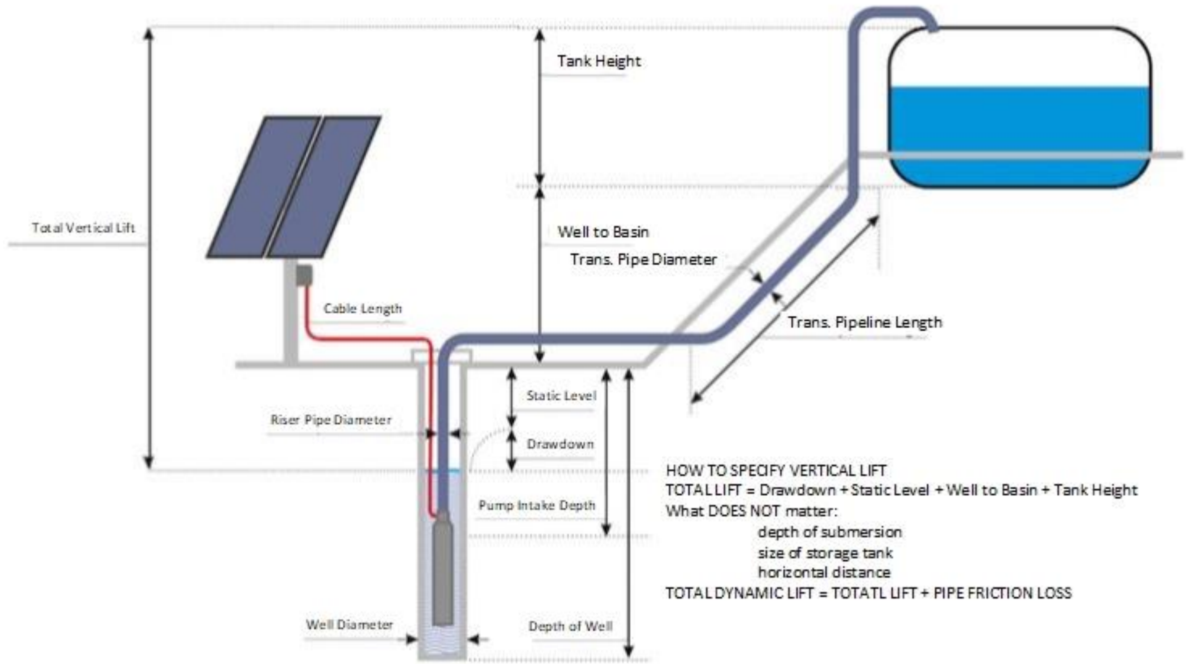

Figure-2. Photovoltaic applications in solar water pumps (Joewono, Sitepu and Angka, 2020)

Utilization of Solar Energy

Solar energy is in the form of electromagnetic radiation emitted to the earth through sunlight consisting of photons or particles of solar energy converted into electrical energy. The solar energy that reaches the earth's surface is called global solar radiation, measured by the power density on the surface of the receiving area (Joewono, Sitepu, and Angka, 2020). The average solar radiation of the earth's atmosphere is 1.353 W/m2, expressed as the solar constant. The intensity of solar radiation is influenced by the time of the earth's rotation cycle and weather conditions, including the quality and quantity of clouds, the change of seasons, and latitude position. It is assumed that the intensity of solar radiation in Indonesia lasts a maximum of 4-5 hours per day. Solar energy production in an area can be calculated as follows:

$$E = I \; x \; A \tag{1}$$

Where: E = Solar energy (power) generated (W); I = Isolation/Intensity of average solar radiation received for one hour (W/m^2); A = area (m^2).

Solar energy that is converted into electrical energy is also called photovoltaic energy. At first, this technology was used as a power plant in remote rural areas, then developed into solar energy, street lighting, and electricity supply in public places such as houses of worship, health services, and government agencies. Even though initially it was only enough for lighting needs, PLTS was enough to help electrify where it was needed. Apart from that, a solar water pump is also available, which is used for irrigation or as a source of clean water (drinking water).

Results

The ongrid/backup PLTS system, the system control room, and testing of the ongrid solar power generation system with backups using a battery using a 48-volt system.

The approach in designing this PLTS system starts from: 1). load profile to be supplied, namely using a maximum resistive load of 3790 watts with a maximum usage time of 30 hours/day (year-1), added an inductive load of 6300 watts with a usage time of 27 hours/day (year-2), additional total power

Aceh Int. J. Sci. Technol., 12(3) : 317-326
December 2023
doi: 10.13170/aijst.12.3.30259

10,090 watts and generator interconnect (3-year). In year 1, the required power is 1000 watts x10 hours = 10,000 watts/hour (maximum); 2). The solar module used is a 450wp monocrystalline type, Vmp = 41.5V, Imp = 10.85A, to meet the energy needs of the inverter conversion, a maximum of 8 chips (8 x 450wp = 3600 wp), maximum single string voltage (8 x 41.5 V = 332) is used. V), for 1 string with Imp = 10.85 A; 3). Making the framework for the solar panels to be installed with 8 pieces of 450 wp solar panels, totaling 3600wp, and the system control room shown in Figure 3.

Installation of the ongrid/backup solar power generation system design, by assembling the equipment, which consists of: a 3600wp solar panel connection with DC protection, a DC input safety panel, an ongrid/backup inverter, a DC battery safety panel, the battery/battery assembled into 48V 200Ah and the load distribution panel along with the meter panel.

The figure 4 is a connection diagram of the equipment and equipment that is assembled:

Figure 3. System control room.

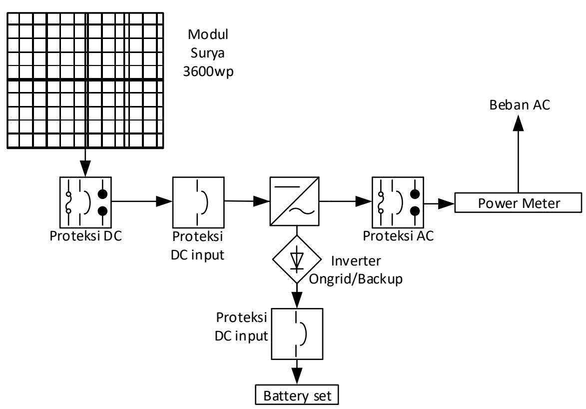

Figure 4. Equipment connection diagram.

Table 2. On/Backup Solar Power Generation System Measurements

Measurement date November 3, 2021													
Time	Solar Panel Energy			Backup/Battery						Load			
	Epv [wh]	Vpv [V]	Ipv [A]	Pout [W]	Ichg [A]	Vbat [V]	P(bat) [VA]	E (load) [VA]	Kapasitas (Load)	Vout [V]	Iout [A]	Pout [W]	Freq [Hz]
10.30	192	357	0.8	290	4	53.9	31	66	2%	220	0.26	32.56	50
11.00	346	360	0.8	270	4	53.9	37	65	2%	220	0.26	32.56	50
11.30	497	356	0.8	260	4	53.9	37	66	2%	220	0.26	32.56	50
12.00	671	365	0.8	240	4	53.9	36	66	2%	220	0.26	32.56	50

The measured data shows that the system can function according to the design by generating energy from solar panels, which are channeled directly to resistive loads (lamps) with a written power of 45 watts, and the

doi: 10.13170/aijst.12.3.30259

energy is also stored in a 48-volt system battery set. The measurement results assume a constant load of 200 watts with a lifetime of 10 hours, shown in Table 3.

Table 3. Parameter measurement of PLTS O/B.

Clock	Irradiance (w/m^2)	Solar Panel		Inverter (on grid)			Battery (backup)	
		Voltage(V)	Current(I)	Voltage(V)	Current(I)	Energy(watt)	Voltage(V)	Current(I)
08.00	460	224	6	226	1.80	84	53,8	5,71(-)
08.30	708	297	9	225	1,71	82	54,3	8,36(-)
09.00	820	230	9	225	1,72	83	53,8	8,40(-)
09.30	933	232	9	226	1,75	84	54,2	8,54(-)
10.00	1200	232	14	281	4,99	1120	58,8	14,3(-)
10.30	1220	254	10	235	5,32	1120	58,8	10,2(-)
11.00	1234	267	8	234	5,45	1118	58,6	8,45(-)
11.30	1257	269	4	236	9,15	1110	56,2	3,72(-)
12.00	1258	270	4	232	9,25	2000	56,4	3,62(-)
12.30	1197	275	2	238	9,59	2001	56,4	2,53(-)
13.00	1212	284	2	234	10,00	2263	56,2	1,80(-)
13.30	1068	298	2	234	9,61	2317	56,3	1,29(-)
14.00	980	281	2	234	9,52	2297	56,2	1,00(-)
14.30	840	210	2	232	9,33	2240	56,3	0,82(-)
15.00	770	207	1	232	4,52	2223	56,4	0,78(-)
15.30	585	312	1	229	2,67	984	56,3	0,75(-)
16.00	356	324	1	230	2,64	214	56,2	0,69(-)
16.30	42	120	0	230	1,87	193	53,8	0,5(+)
17.00	30	90	0	230	0,07	186	53,7	4,60(+)
17.30	10	60	0	230	0,07	187	52,8	4,60(+)
18.00	0	0	0	230	0,07	187	52,7	4,61(+)
18.30	0	0	0	230	0,07	186	53,2	4,62(+)
19.00	0	0	0	230	0,07	189	53,0	4,59(+)
19.30	0	0	0	230	0,07	185	54,0	4,57(+)
20.00	0	0	0	230	0,07	186	53,4	4,56(+)

The measured data shows that the PV mini-grid system produces electrical energy by dividing the work system, a. when the sun's rays already have energy (shown in the irradiance column), then the inverter will convert DC current into AC current, charging battery backup for the measurement sign (-), as well as distributing electrical energy to the PLN power line (grids), b. when sunlight has no energy, then the DC current from the battery, the measurement sign (+), will be channeled to the inverter to be converted into AC current and distribute electrical energy to the user (consumer) channel.

Discussion

In the design of this research, On-Grid/Backup (Bidirection) Solar Power Generation Designs, such as the tool design block diagram as shown in Figure 5. Development of new renewable energy such as wind and solar energy by considering attention to environmental issues and climate change has also developed recently (Khan and Arsalan, 2016; Hardianto, 2019; Bello *et al.*, 2021). . Research development has discussed the estimation of solar photovoltaic potential using a geospatial engineering approach (Ugbong, Isma'il and Usman, 2023), (Gelves and Florez, 2020)with the Analytic Hierarchy Process (AHP) approach and techno-economic feasibility analysis approach has also been carried out (Xu *et al.*, 2019; Puranen, Kosonen and Ahola, 2021).

This study focuses on the Energy Assessment of Solar Power Plant On-Grid Bi-direction 3 KW 1 Phase with the following steps; 1) planning and installation of on-grid/backup solar panel electrical regulator and inverter systems. At this stage a series of 450 wp solar panel modules is planned, as many as 8 pieces and a regulator that

Aceh Int. J. Sci. Technol., 12(3) : 317-326
December 2023
doi: 10.13170/aijst.12.3.30259

stabilizes the voltage generated by the solar panel circuit, the resulting voltage will be regulated to be channeled to the battery charging (backup) and the dc voltage converter that is generated by the solar panel circuit to ac voltage ready to be distributed to the user (on-grid), controlled by the electric power used by the user.Tests carried out at this stage, by measuring voltage and current, are produced by solar panels and voltage regulators, so they are ready to be used to store energy in the battery (backup), and electrical energy is channeled directly to the user; 2) Design of a communal load control system and electrical power sensors. At this stage, the design of a series of electric power sensors produced by a series of solar panels has been converted into AC electrical energy, to be distributed to users with predetermined electrical power restrictions. This series of electric power sensors can also detect excess electrical energy generated from this PLTS system to be ready to provide electrical energy in an interconnected way to the next communal PLTS system. The tests carried out at this stage are by measuring the electrical power sensor circuit obtained from the solar panel circuit and the electrical energy used by the user. 3.) The design approach uses the HelioScope software simulation, obtains the irradiance value and energy value, and the annual production value is obtained: irradiance = 1,590.8 kWh/m2, with a total energy = 4,838.1 kWh.

Next, on-grid/backup PV mini-grid installation with inverter bidirectional. This section uses a series of 450wp solar panels, 8 pieces, 1 string, and a regulator voltage converter that converts the DC voltage generated by the solar panel circuit into AC voltage; some of the AC current is converted into DC current to be used to charge battery backup, and AC current will be forwarded to be distributed to the user (on-grid), by controlling the electrical power used by the user. Then, design a load control system with energy meter. In this section, load power control is carried out with an energy meter, which monitors the electrical energy from the inverter conversion from DC current (solar panels) into AC electrical energy, to be channeled into use with limited electrical power limitations has been determined, as well as detecting excess electrical energy generated from the PV mini-grid system to be ready to provide electrical energy interconnection to the PV mini-grid system. Test the load to be supplied, using a resistive load of approximately 200 watts with usage time of 10 hours/day, and direct energy supply to the grid. The solar panels used are monocrystalline 450wp (Vmp = 41.5V, Imp = 10.85A) as many as 8 pieces (8 x 450 wp = 3600 wp, maximum voltage inverter input (single string) (8 pcs x 41.5 V = 332 V), for 1 string with Imp = 10.85 A. Ongrid inverter/backup bidirection used (data sheet) shown in Table 4, and lastly, battery backup.

Prediction f fulfillment of electrical energy required by the load, 200 watts x 10 hours = 2000 Wh. To meet the required power, of 2000 watts, it takes prediction calculation Load :2000-watt x 1.5 (load multiplier) = 3000 watt. Battery :48 V x 200Ah = 9,600 Wh (80% consumption) = 7,680 Wh. From the above calculation, there is an excess power of 4.680Wh

Table 4. Data Sheet Ongrid Inverter/Backup Bidirection

PV Input	Battery	AC Output
• Max. input power : 3990W; • Max. input voltage : 600Vdc; • Start-up voltage : 120Vdc; • MPPT voltage range : 90Vdc - 580Vdc; • Max. input current : 12A; • PV short circuit current : 15A; • Number of MPPT : 1	• Baterai type : Lead Acid baterai; • Rated voltage : 48Vdc; • Voltage range : 42Vdc - 58Vdc; • Baterai type : VRLA AGM maintenance - free baterai; • Baterai capacity : 200 Ah optimized; • Max. charge current : 65 A; • Charging curve : 3-Stage; Rated discharge power : 3000W; • Max. discharge current : 70A; • Max. discharge efficiency : 50%	• Rated output power : 3000W; • Rated output voltage : 220, 230, 240 Vac; • Max output current : 13.7A; • Output AC voltage range : 180 - 276Vac; • Rated output frequency : 44-55 Hz; • Power factor : 1 default (0.8 leading - 0.8 lagging); THD : < 3%]

doi: 10.13170/aijst.12.3.30259

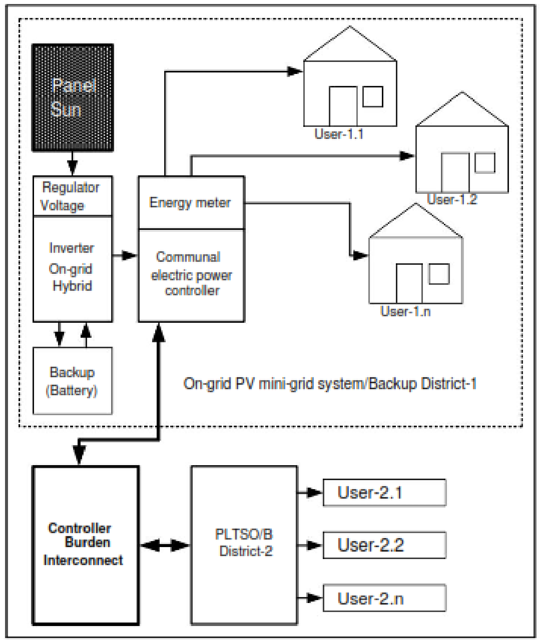

Figure 5. Block Diagram of an On-Grid/Backup Solar Power Plant.

Conclusion

From the measurement results, the PLTS system will start to convert DC current to , generates AC current energy AC rated Irradiance range, 356 to 1258 W/m² ongrid, a maximum of 2297 watts, as well as charging the backup battery with DC current, maximum 14.3 A, This ongrid backup (bidirectional) PV mini-grid system can perform Its function is to convert DC current to AC and channel it directly to the electricity grid (grid), and perform energy backups when the sun is no longer available have energy. Anticipating the fulfillment of the load's electrical energy demand involves predicting that 200 watts over 10 hours will total 2000 Wh. To satisfy the required power of 2000 watts, a predictive calculation is performed: Load prediction is 2000 watts multiplied by 1.5 (load multiplier), resulting in 3000 watts. For the battery, the calculation is 48 V multiplied by 200 Ah, yielding 9,600 Wh with 80% consumption, which equals 7,680 Wh. Consequently, the calculation indicates an excess power of 4,680 Wh.

Acknowledgment

Thanks to, Directorate of Research and Community Service, Deputy for Research Strengthening Development, Ministry of Education and Culture, Research and Technology, Higher Education Leading Applied Research (PTUPT) funding and Widya Mandala Surabaya Catholic University, as the parent university.

References

Abolhosseini, S., Heshmati, A. and Altmann, J. (2021) 'A Review of Renewable Energy Supply and Energy Efficiency Technologies', *SSRN Electronic Journal* [Preprint], (8145). Available at: https://doi.org/10.2139/ssrn.2432429.

Arifin, S., Firdaus S. A., A.H. and Putri, A.R.E. (2022) 'Integrated Solar Energy Application System Development to Catalyze Public Participation Towards Bali Clean Energy Through Crowd-Based Business Models', *Indonesian Journal of Energy*, 5(2), pp. 114–130. Available at: https://doi.org/10.33116/ije.v5i2.151.

Bello, U. *et al.* (2021) 'Renewable Energy Transition: A panacea to the ravaging effects of climate change in Nigeria', *Aceh International Journal of Science and Technology*, 10(3), pp. 182–195. Available at: https://doi.org/10.13170/aijst.10.3.23375.

Elisier Tarigan (2018) 'Simulation and Feasibility Studies of Rooftop PV System For University Campus Buildings in Surabaya, Indonesia', *International Journal of Renewable Energy Research*, 8(2), pp. 895–908.

ESDM, K. (2019) *Renewable Electric Energy Usage*.

Aceh Int. J. Sci. Technol., 12(3) : 317-326
December 2023
doi: 10.13170/aijst.12.3.30259

Gelves, J.J.P. and Florez, G.A.D. (2020) 'Methodology to assess the implementation of solar power projects in rural areas using AHP: A case study of Colombia', *International Journal of Sustainable Energy Planning and Management*, 29(October 2019), pp. 69–78. Available at: https://doi.org/10.5278/ijsepm.3529.

Hardianto, H. (2019) 'Utilization of Solar Power Plant in Indonesia: A Review', *International Journal of Environment, Engineering and Education*, 1(3), pp. 1–8. Available at: https://doi.org/10.55151/ijeedu.v1i3.21.

Iskandar, H.., Rizqiawan, A. and Heryana, N. (2015) 'Calculation and Determination of DC Cable Size for Solar Power Generation Applications', in *the National Seminar on Electricity and Its Applications (SENKA).*

Joewono, A. and Sitepu, R. (2015) 'Perancangan Sistem Elektrik Tenaga Hybrid untuk Pemfilteran Air Tanah.

Joewono, A., Sitepu, R. and Angka, P.R. (2020) 'Water pump and water filter using solar-hybrid energy with mobile vehicle', *ARPN Journal of Engineering and Applied Sciences*, 15(1), pp. 52–55.

Kementerian ESDM (2016) 'Jurnal Energi'.

Khan, J. and Arsalan, M.H. (2016) 'Solar power technologies for sustainable electricity generation - A review', *Renewable and Sustainable Energy Reviews*, 55, pp. 414–425. Available at: https://doi.org/10.1016/j.rser.2015.10.135.

Merrouni, A.A., Amrani, A.I. and Mezrhab, A. (2017) 'Electricity production from large scale PV plants: Benchmarking the potential of Morocco against California, US', *Energy Procedia*, 119, pp. 346–355. Available at: https://doi.org/10.1016/j.egypro.2017.07.118.

Oyelaran, O.A., Twada, Y.Y. and Sanusi, O.M. (2016) 'Energy Audit of an Industry: A Case Study of Fabrication Company', *Aceh International Journal of Science and Technology*, 5(2), pp. 45–53. Available at: https://doi.org/10.13170/aijst.5.2.4838.

Puranen, P., Kosonen, A. and Ahola, J. (2021) 'Technical feasibility evaluation of a solar PV based off-grid domestic energy system with battery and hydrogen energy storage in northern climates', *Solar Energy*, 213, pp. 246–259. Available at: https://doi.org/10.1016/j.solener.2020.10.089.

Ugbong, P.U., Isma'il, M. and Usman, A.K. (2023) 'GEOSPATIAL ESTIMATION OF ROOFTOP SOLAR PHOTOVOLTAIC POTENTIAL IN CALABAR MUNICIPAL, CROSS RIVER STATE, NIGERIA', *FUDMA Journal of Sciences (FJS)*, 7(3), pp. 272–281.

Xu, L. *et al.* (2019) 'Off-grid solar PV power generation system in Sindh, Pakistan: A techno-economic feasibility analysis', *Processes*, 7(5). Available at: https://doi.org/10.3390/pr7050308.