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Design Of Microgrid Energy Management system At nurul Jadid Islamic Boarding School Proboling go Indonesia

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Abstract- Along with developments in technology, the demand for electric power is increasing so that electrical energy providers are required to provide an adequate supply of electricity. However, the electrical energy distributed to consumers still uses fossil energy and gradually the amount of fossil energy will be depleted. Solar cells utilize solar energy as renewable energy that can be maximized in Indonesia. The operation of solar cells on a microgrid needs to be evaluated and optimized to achieve a reliable but still efficient performance. This paper develops an energy management model for microgrid optimization. The power sources connected to the microgrid consist of the PV mini-grid system, battery system, and electricity from the public grid. The design resulting from this research is able to optimize energy management. So that the use of electrical energy is dominated by solar panels. The percentage of solar panel energy use increases to 75% and the cost of electricity generation decreases).

Keywords- Renewable Energy, Solar Cell, Energy Management, Particle Swarm Optimization

I. INTRODUCTION

The demand for electric power is increasing along with developments in the field of technology so electrical energy providers are required to provide an adequate supply of electricity. A total of 87.98% of the electrical energy distributed to consumers is electrical energy produced by fossil energy (Badan Pusat Statistik, 2019). But over time, the amount of fossil energy will be depleted. Renewable energy is alternative energy to replace the fossil energy. Renewable energy is energy that comes from nature and can be continuously produced without having to wait millions of years like fossil-based energy. Renewable energy sources that are currently being widely developed in Indonesia are solar power plants (PLTS). The factor that strongly encourages the development of PLTS in Indonesia is because Indonesia is geographically located at the equator and has a large enough potential for solar energy with an average daily solar insolation value of 4.8 kWh/m2 (Tharakan, 2015). The energy produced by solar energy is intermittent, that is, it depends on the environment and fluctuates. Thus, photovoltaic needs to be integrated with the main electricity network (main grid) and the energy storage system (battery) to operate under on-grid or off-grid conditions (Wurtz & Delinchant, 2017).

The integration of renewable energy, main grid, and energy storage system in a small-scale distribution system is called a microgrid. The application of the microgrid system can drastically increase the efficiency and stability of the distribution grid (Dall'Anese, Zhu, & Giannakis, 2013). The efficiency is assessed by two parameters, namely self-consumption and self-sufficiency (Soelami, et al., 2020). Self-consumption shows the energy capacity that can be used by local loads generated by the microgrid itself. While self-sufficiency shows the percentage of load that can be supplied by the microgrid itself. in the smart microgrid system, if the grid produces more power than the load (off-peak) on the grid, the power that is not used by the load will be stored in the battery (Fikri, 2018). In a solar power plant, energy management is needed to maximize the use of energy produced by a solar power plant. So that it can reduce the use of electrical energy from main grid. Energy management is an organized activity using management principles, with the aim that energy conservation can be carried out so that energy costs as a component of the operation of using electrical energy can be kept as low as possible (Kartika, 2018).

II. METHODS

In general, this research is classified as basic research which refers to a quantitative approach. Where the results of the research that will be carried out will produce a system design that can optimize the use of solar energy.

1. Photovoltaic System Configuration

In general, photovoltaic system with off-grid configuration as shown in Figure 1. Panelsolar energy converts solar radiation into electrical energy.

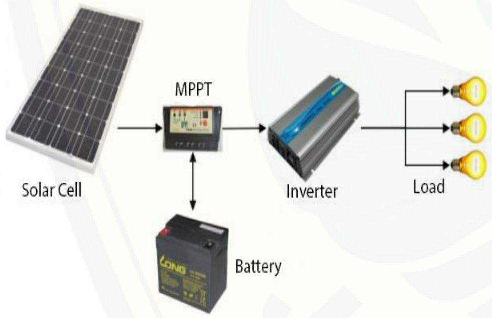


Fig. 1. Off-grid Solar PV System.

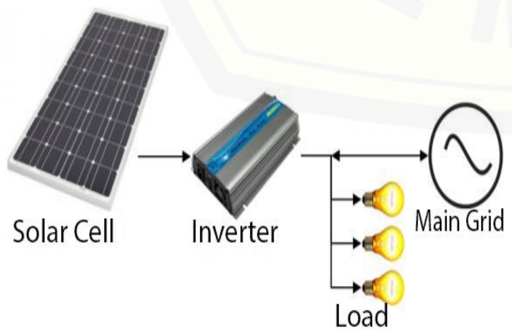


Fig. 2. On-grid Solar PV System

The amount of power out of the solar panel is:

$$P = V \times I \quad (1)$$

Maximum power point tracking (MPPT) functions to regulatecharging and discharging the battery so it doesn't happen over charging and over-discharge.

$$I_{MPPT} > I_{PV} \quad (2)$$

In the photovoltaic system, the battery is used to store excess power from solar panels when load power is low and participates in supplying the load when power from solar panels not enough to supply the load. Payload capacity battery in Ampere-Hours (AH). To calculate the capacity (Ah) of the battery, do the calculation as follows.

$$Ah = \frac{E_{consumer}}{(V \times Pf)} \quad (3)$$

Pf = Power factor

$E_{consumer}$ = Consumer energy needs

Depth of Discharge (DOD) is applied to the battery according to the terms of use of deep cycle battery which is only discharged as much as 50% of the capacity the total, then the Ah value of the battery we get we multiply2. Inverter as used to convert DC power into AC power. The basic circuit of the inverter to be able to change the power DC electricity to AC is an H bridge circuit, like can be seen in Figure 3.

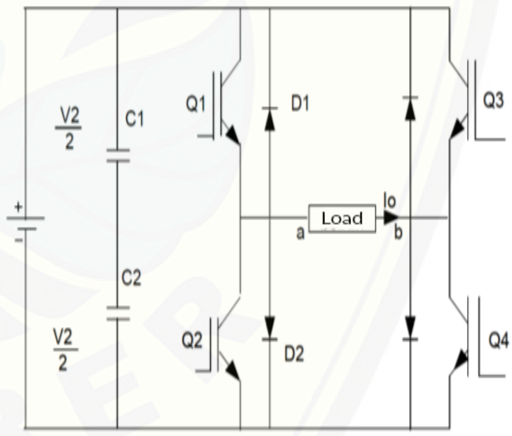
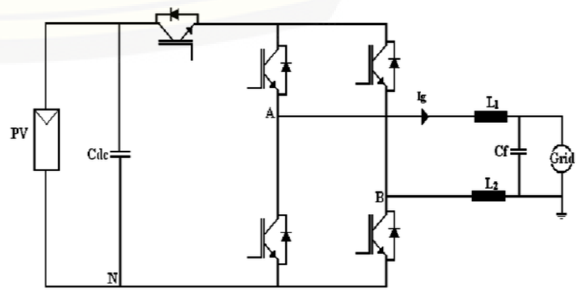


Fig. 3. H bridge topology on an off-grid inverter



On an off-grid inverter, the inverter output is only connectedto the load. While on the external grid

inverterthe inverter is not only connected to the load but also connectedto the network. The on-grid inverter is equipped with the MPPT method(Maximum Power Point Tracking) so that the energy fromsolar panels can be converted into electrical energy directly maximum. There are several MPPT methods that can be usedused to get the working voltageaccording to the MPPT, the point to get powermaximum, among others, perturb and observe (P&O) andincremental conductance (INC).
The off-grid inverter is not equipped with MPPTbecause the power generated by the inverter is adjusted toload requirement. The advantage of solar panelssaved the battery.

2.Particle Swarm Optimization

The PSO method is an optimization technique whose search for solutions follows social behavior that occurs in the lives of bird populations (flock of birds) and fish populations (school of fish) in survival (. PSO is a population determination technique based on stochastic optimization developed by Dr. Eberhart and Dr. Kennedy in 1995. This determination technique was inspired by the social behavior of a flock of birds or a flock of animals looking for food (Rosita & Purwanto, 2012). The PSO algorithm is a suitable method for solving complex multi-stage decision problems. But this algorithm can easily fall to the minimum point and has a slow convergence speed so it needs to be improved with semantic relationships (Shao, Bai, Qiu, & Du, 2012).

The algorithm from PSO is to perform a parallel search using a group of individuals who are almost the same for optimization techniques based on artificial intelligence. Each individual is responsible for finding potential solutions to solve existing problems. Individuals in a herd are approached to get the optimum point by considering speed, previous experiments, and experiments carried out by their neighbors. In a physical search space with “n”-dimensional, individual positions and velocities, “i” is represented as a velocity vector. Using this information, individual "i" and its speed update can be modified using equation 4.

$$V_i^{k+1} = V_i^k + a_i\left(x_i^{lbest} - x_i^k\right) + \beta_i\left(x_i^{gbest} - x_i^k\right) \quad 4$$

$$x_i^{k+1} = x_i^k + v_i^{k+1} \quad 5$$

Each individual or particle is treated as a point in a certain dimension of space. There are two factors that characterize the state of the particle in the search space, namely the position of the particle and the velocity of the particle. The following is a mathematical formulation that describes the position and velocity of particles in a certain dimension of space:

$$x_j(i) = x_1(1), x_2(1), \dots, x_{jN}(i) \quad 6$$

$$v_j(i) = v_1(1), v_2(1), \dots, v_{jN}(i) \quad 7$$

The equation for the particle state updating mechanism is as follows :

$$v_j(i) = v_j(i-1) + c_1 r_1\left(P_{best\ .j} - x_j(i-1)\right) + c_2 r_2\left(G_{best} - x_j(i-1)\right) \quad 8$$

$$x_j(i) = v_j(i) + x_j(i-1) \quad 9$$

III. RESULTS AND DISCUSSION

3.Generator Characteristics

The microgrid includes a small-scale distribution system, which consists of distributed energysources including renewable energy sources with energy storage media and flexible loads. This study using 3 types of generators with different amounts

Table 1. Generator Characteristics

Generator type	Generating power capacity (W)	Number of generators	Total generating capacity (W)
PV	180	90	16.200
Battery	2400 (12*200)	10	24.000
PLN	23.000	1	23.000

4. Photovoltaic (PV)

The power generated by PV is intermittent and fluctuating. Where radiation and temperature from the sun greatly affect the output power of PV.

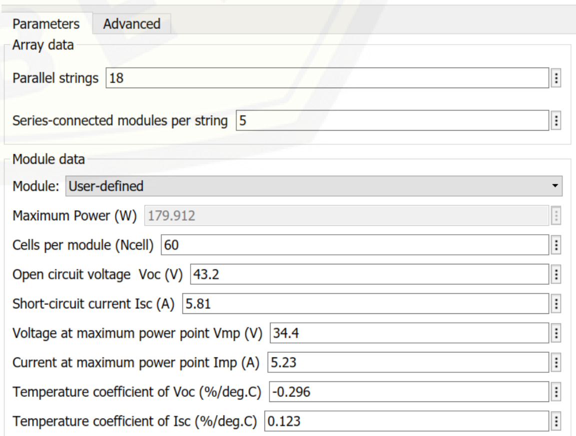


Fig. 5. PV Specifications

Figure 3 shows the maximum power capacity. Where the solar radiation of 1000 W/m^2 with a temperature of 25°C produces an output power of 16,192 W. However, in research conducted at the research location, the maximum radiation obtained from measurements using a tool obtains a value of 950 W/m^2 with a temperature of 32.5°C. The characteristics of radiation and solar temperature for 24 hours can be seen in Figures 4 and 5 below.

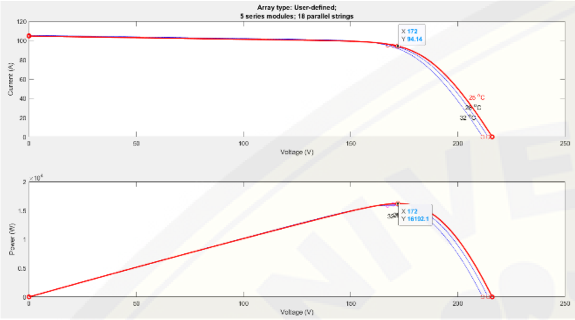


Fig. 6. PV max power capacity

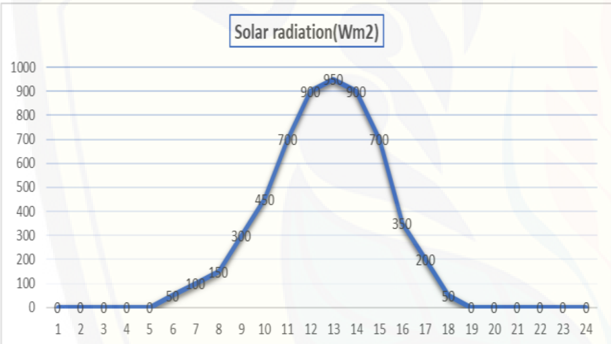


Fig. 7. Characteristics of solar radiation at the research site

4.Battery

The battery in this study is used as an energy storage medium when PV produces electrical energy during the day.

Table 2. Battery Specifications

Total Load + 5% (W)	Battery Voltage (V)	Battery power (Ah)	Number of Battery
22547,37	12	200	10

3. Main grid (PLN)

The power released by PLN is stable. In this study, PLN is used as a backup generator to supply the load if the power generated by PV and the battery is no longer able to supply the active load.

5.Load Characteristics

In this study, the load profile was obtained from the results of observations of activities that took place at the research site. Activities that take place include active student days and student holidays. However, after in-depth observations, the load profile on students' active days and students' holidays did not experience significant changes. So it is concluded to use the average load profile data for 24 hours. The details of the load profile in 24 hours can be seen in Table 4.3 below.

Table 3. Load Characteristics

Time	Floor Load 1		Floor Load 2				Floor Load 3	
			Friday (4 Day)		Istighosah		Istighosah	
	W	Cost (Rp) * 30 days	W	Cost (Rp) * 4 days	W	Harga (Rp)* 1 hari	W	Harga (Rp)* 1 hari
01:00	1650	44550	0	0	0	0	0	0
02:00	1650	44550	0	0	0	0	0	0
03:00	5300	143100	0	0	0	0	0	0
04:00	7820	211140	0	0	0	0	0	0
05:00	7820	211140	0	0	0	0	0	0
06:00	6170	166590	0	0	0	0	0	0
07:00	3930	106110	0	0	0	0	0	0
08:00	0	0	0	0	0	0	0	0
09:00	0	0	0	0	0	0	0	0
10:00	0	0	0	0	0	0	0	0
11:00	0	0	3500	12600	3500	3150	0	0
12:00	2470	66690	3500	12600	3500	3150	0	0
13:00	0	0	3500	12600	3500	3150	0	0
14:00	0	0	0	0	0	0	0	0
15:00	2470	66690	0	0	0	0	0	0
16:00	5750	155250	0	0	0	0	0	0
17:00	7820	211140	0	0	6800	6120	6800	6120
18:00	7820	211140	0	0	6800	6120	6800	6120
19:00	7820	211140	0	0	6800	6120	6800	6120
20:00	7820	211140	0	0	6800	6120	6800	6120
21:00	1650	44550	0	0	6800	6120	6800	6120
22:00	1650	44550	0	0	6800	6120	6800	6120
23:00	1650	44550	0	0	6800	6120	6800	6120
00:00	1650	44550	0	0	0	0	0	0
Total	2238570		90090				42840	
	Rp							2.371.500

6.Multi objective Solution Using PSO Method

Multi-objective solution using the PSO method is used to find the most optimal value in scheduling power generation to supply fluctuating loads.

7. Design of Energy Management System

In this study, consumers will schedule electronic equipment according to their wishes. From the results of scheduling, the system will calculate the cost of electricity consumption based on existing prices. Based on the amount of usage and the price per/KWh, the amount of expenditure needed for 1 month is as follows.

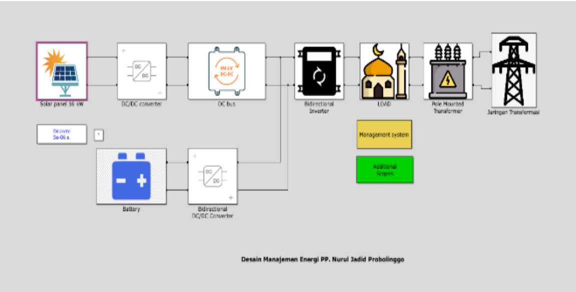


Fig. 8. Photovoltaic system

In this study, energy management is made based on the value of the power output generated by PV and the percentage of power stored in the battery. So that by using the PSO method, it can produce a schedule for the use of Battery and PLN. So it can reduce the cost of electricity generation.

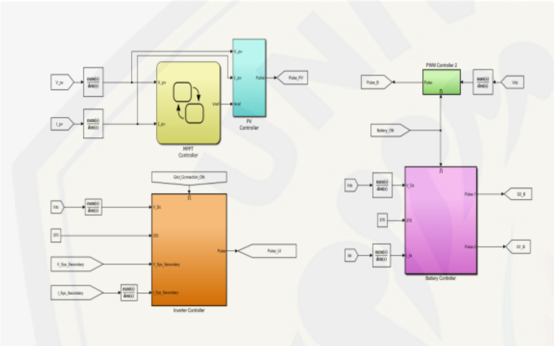


Fig. 9. Energy Management System

Scheduling obtained from the use of an energy management system is obtained from the input data from the power stored in the battery and the load value. This results in scheduling the use of energy generated by PV which is stored in the battery and PLN. The scheduling of the use of electrical energy originating from PLN (main grid) and the battery is set out in Figure 10 below.

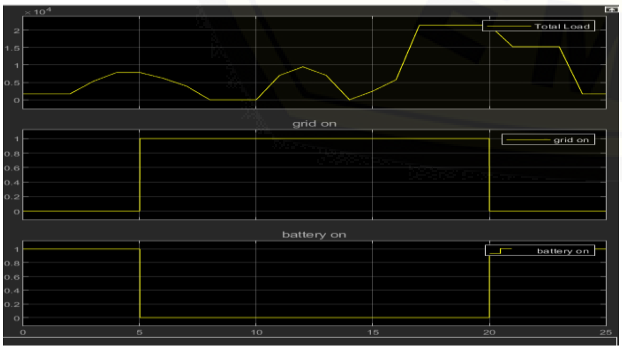


Fig. 10. Scheduling use of battery and PLN

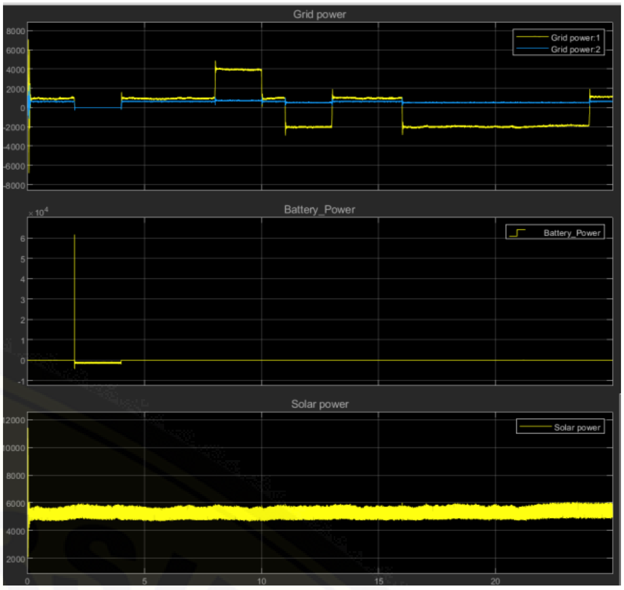


Fig.11 Output usage energy management system.

IV. CONCLUSION

In this research, an energy management system design has been produced at a solar power plant (Photovoltaic) at the Nurul Jadid Islamic Boarding School. With the energy management system in a solar power plant, it can increase the efficiency of energy generation costs. Thus reducing the use of energy that comes from the main grid. The efficiency achieved in this study was >40%. Where in the condition before the use of an energy management system, the use of energy from the battery is not scheduled. So that the use of energy generated by PV is not optimally used.

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