Analysis of electricity energy savings with Grid-Tie system connected to utility grid.

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Abstract. The microgrid consists of at least one energy source that is connected to a load in a relatively small area. In practice, microgrid are divided into two types, off-grid systems or often said to be standalone systems and on-grid systems that are connected to utility networks. The use of renewable energy sources, such as photovoltaic, has become an alternative energy for the problem of electricity energy deficits. This research examines the possibility of saving power consumption from the network using a grid-tie inverter (GTI) power converter in a microgrid configuration so synchronization can be made between renewable energy systems and utility networks. The integration of photovoltaic energy resources with the grid system will increase the value of electricity capacity while reducing the use of fossil fuels, as well as a positive impact where the use of renewable energy can reduce energy use and bills to be paid. Integration of grid tie testing carried out without a load can convert the power generated by almost 90% distributed in the utility network, while testing with a load using a grid tie system, can save power up to 70% of the energy supplied by the utility network.

1. Introduction

Renewable energy sources have increased in many countries with renewable energy policies and due to emission factors. Among the renewable energy sources is solar energy which is an alternative energy that is being developed and has a reliable system. The supply of electricity used by power plants is still dominated by fossil fuels, especially from coal and oil, making renewable energy the best solution at the moment. Solar energy is one of the cleanest forms of energy available, converting energy from the sun into electricity without hazardous waste or by-products. This system can be installed on grid and off grid. In the off-grid system the energy produced by the solar panels is stored first to the battery using a charge controller and using an inverter to be used in AC loads, the system is not dependent on grid utility networks and is free from power problems and electricity costs [1]. While the on-grid system requires a main electricity network (cannot stand alone) that requires a reference voltage as a reference for its working system, resulting in the solar panel system not being used when the main source network is dead so the building cannot utilize energy produced by solar panels [2]. The use of grid tie inverter systems will increase the value of electricity capacity, while at the same time reducing the use of fossil fuels, as well as having a positive impact where the use of renewable energy can reduce the use of energy and the bill that must be paid. The use of two-way electricity also makes consumers a power producer if electricity produced by renewable plants owned by consumers has excess power then it can be sold to the state electricity company.
2. Photovoltaic System

The efficiency of solar cells is a very important factor. Currently, the efficiency that can be produced by solar panels is still around 18.3%, but the efficiency of the solar panel is relatively low, because of the space between cells in the panel [3]. System efficiency considers all components of the system performance. Several factors such as solar cell electrical performance, degradation factor, ability to generate power, environmental factors and cell operating temperature determine the performance of an array. The method being developed is a solar tracker. This method follows the sun's movements throughout the day, which allows the PV panel to capture more exposed sunlight, so the power generated is more optimal.

Figure 1. Photovoltaic Dual Axis.

Tracker is a general term used to describe devices that orient various charges to the sun. By maintaining the consistency of direct exposure from the sun to the panel, the tracker can increase the PV system output by up to 40 percent. Various tracking systems have been developed with many methods, algorithms and various types of sensors. Figure 2 is the result of a comparison between diesel with and without a tracker system [3].

Figure 2. Power output of Photovoltaic comparison.
3. Trend of Microgrid

Microgrid system refers to the modernization of the electrical energy processing system so that it can be monitored and optimize the operation between the interconnection elements, starting from the generation center to the consumer. Microgrids are characterized by the bidirectional flow of electricity networks. The energy produced by renewable energy is usually different from the grid utility. It requires an inverter to synchronize the voltage and frequency produced so that the system can be connected to the grid [4]. Microgrid network system is divided into on-grid and off-grid system. The off-grid system is a system that is not connected to a network utility or often called a standalone system. While the on-grid system is a system that is connected to a utility network that allows two-way electricity, which is imports and exports between consumers and producers.

![Micro grid flow diagram](image)

The energy produced by the solar panel array is still in the form of DC before being converted and filtered into the form of an AC grid injection. The inverter used needs to be considered, minus the loss across the inverter, transferred through the system and into the electricity network. The flow of power to the grid is strongly influenced by the phase shift to the inverter and the voltage amplitude of the inverter with the grid [7]. The energy produced by a PV system can be calculated from the average power times the time [8]. The total energy for a certain period will be calculated using equation (3).

\[
E = \int_{0}^{t} p(t) \, dt \tag{1}
\]

The electrical energy generated per year can be calculated using this equation:

\[
E_{\text{Year}} = E \times 365 \, \text{Day} \tag{2}
\]

The stored energy can be calculated using this equation:

\[
E_{\text{saving}} = E_{\text{Year}} \times \text{Electrical Tariff} \tag{3}
\]

With the increasing development of renewable energy, energy storage components are becoming very important. For micro grid using solar energy the use of batteries as storage is generally considered suitable. With the many technological advances that occur throughout the world capital from a battery technology, in general, has decreased prices. Battery life depends on the type of service the provider provides, which ranges from 5 to 15 years, depending on the number of cycles, the charge, and discharge rate and how the temperature of the battery.

4. Research Method

In this study, the micro grid system uses a 100 Wp polycrystalline solar cells with a dual-axis tracker system connected with a 200W grid tie inverter, this on-grid system is connected to the Indonesian State Electricity Enterprise network. The scope of research is shown in Figure 4 below.
It is known that solar cells with tracking methods have advantages in terms of capturing sunlight so that the power that can be supplied to the grid also increases. While the focus of this research is to look at how the effect of saving electricity by integrating the grid tie system on power usage and utility grid (PLN) costs. Measurements are done in two steps, without load, and with the load. Without the load testing, it means that GTI is directly connected to the utility network, and then measurements from the side of DC input power and AC power supplied to the network [6]. Figure 5 is a series of tests with local loads that must be carried out to see the power distribution mechanism generated by grid-tie on the power supplied to the grid network. Load measurement is parallel with being supplied by two sources so that the current supplied to the utility network can be counted.

5. Result and Discussion

5.1 Solar Energy Potential
Monitoring data on the photovoltaic system includes voltage, current, and power to see how the potential of solar energy generated in the area of Banda Aceh. The average solar panel starts generating power from 6:00 to 18:00. The peak power time is from 10:00 to 16:00 with some fluctuations depending on weather conditions, Figure 6 shows fluctuations in solar energy potential with sunny weather conditions, with an average maximum power reaching 80 W.
5.2 Energy Saving Analysis

The use of a grid-tie system has a function that can make electricity flow in two directions, exports and imports. By using a grid-tie inverter (GTI), electricity generated by solar panels can be directly channelled into the home load installation system that is connected to a utility grid, this on-grid system can reduce the use of electricity supplied by PLN (Indonesia State Electric Enterprise). Data collected during working hours around (8 hours), starting at 8:00 to 6:00 pm with very sunny weather conditions. The higher power generated by the solar cell, the more power can be channelled to the grid. Figure 9 shows how the power at a load that uses PLN power was saved by adding a grid-tie system. PLN power used to supply loads has decreased as solar cell output power has increased. As a sample the grid savings test is carried out with one of the 35 W household load.

\[
P_{saved} = P_{load} - P_{out GTI}
\]  

Table 1 shows the comparison of load power conditions when connected with and without a grid tie system (only uses PLN). The power stored by adding grid tie can be calculated using the following equation.
As shown in Table 1 when the system is not connected to the grid-tie, the 35 W load is supplied by PLN completely, after installing the grid-tie, the power supplied by PLN can be saved according to the output produced by the grid-tie. Of the 35 W of power needed by the load, only about 8 to 9 watts of power load is supplied from the utility grid, even excess power can be exported into the utility grid, the minus data in table 1 shows the changing power flow leading to export into the utility grid. The power used from the utility grid decreases as photovoltaic produce greater power. It shows by using a grid tie configuration, the electric power required for the charge that should be supplied from the grid can be reduced by up to 70% or even fully supplied by the grid-tie, depending on the power that can be generated by the grid-tie. It is known that PV can only work for 12 hours and produce electrical energy per day with the average power supplied to the grid is 80 W, using equation (4), the energy produced by PV 100 Wp reaches 960 Wh per 12 hours. While the energy produced during a year can be calculated using equation (5), it will produce 175 kWh, but this power is not constant because the fluctuation of PV output depends on weather conditions.

5.3 Cost Saving Analysis
The electrical capacity used in this study is 900VA with a sample load testing of 35 W. Therefore, the energy cost is followed by the tariff adjustment mechanism. For March 2019 the 900 VA tariff was
IDR 1,352 (Indonesian Rupiah), but this rate may change at any time depending on PLN's policy. With a sample load of 35 W, this load takes around 0.42 kW for 12 hours, if calculated for a month the cost paid using the utility grid is an average of IDR 17,232,538. Figure 10 shows how the effect of using grid tie on the cost utility grid for a month, with the addition of the PV grid-tie system paid to PLN, reduced to IDR 8,249.52, which means that the PV grid-tie system could save as much as IDR 8,983,018.

![Figure 9. Cost comparison with and without PV system.](image)

### 6. Conclusion

Grid-tie will operate if it is connected to the network. When there is no supply from the network, it will stop sending power to the utility network. Grid-tie will supply power to the local load and excess power will be distributed to the network. Conversely, if the grid-tie output power is minimum or unable to supply, then the load will be supplied by PLN, this depends on the grid-tie power output. The measurement results show, when the zero load test, shows that almost 90% of the power generated by the grid-tie is distributed to the PLN grid. This shows that the electric power supplied to the network can be used to replace the use of grid electricity when there is no supply of energy sources generated from the main generator.

Costs for PLN electricity consumption can be reduced, test results using local loads and microgrid configurations show that by using a grid-tie system. The electrical power requirements for loads that should be supplied from the grid can be reduced by 70%, or even fully supplied by grid-tie, depending on the power that can be generated by the grid-tie, this also results in lower electricity costs.

### Acknowledgment

The author would like to express his gratitude for the support of Syiah Kuala University through the professor's research assistance for 2019. We also expressed our gratitude to the research assistant of the PUSKMATIK (Center for Automation and Robotic Research), Muhammad Ikhsan and Ikhramuddin.

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