Integration of Solar Energy Supply on the Smart Home Micro Grid to Support Efficient Electricity and Green Environment

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Abstract. The development and utilization of renewable energy sources usually requires a complicated process and often still needs the support from fossil energy sources, so that a system that integrate both energy sources must be developed. Smart grid is a modern electricity network infrastructure with the ability to integrate alternative (nuclear, geothermal) and renewable energy sources (wind, water, air, diesel, etc.) and the ability to improve reliability, efficiency and security through automatic control and use of modern communication technology. Therefore the Smart Grid implementation will provide greater benefits because the number of renewable and integrated and integrated storage units increases, efficiency increases, operational costs decrease, reliability increases and CO2 emissions decrease. The implementation of the smart grid in the micro scale in this study is for the fulfilment of household electricity needs. The solar power as a renewable energy sources will be integrated to the smart grids so that households can become independent in providing electricity and not dependent on the state electricity company and also reduce monthly electricity costs. This study will discuss the integrating energy supply on the smart home micro grid.

1. Introduction

Energy supply is quite a global problem, given the increasing demand for energy and the depletion of raw materials for energy generation. Strategic steps have been taken, namely by using non-fossil power plants / renewable energy (solar cell, wind, water, etc.) as a substitute for fossil fuels. The development and use of renewable energy (renewable energy) is increasingly becoming a very important thing. The development and utilization of renewable energy sources requires a process that is not short and also need support fossil energy sources so that the integration between energy sources must be developed. Smart grid is a modern electricity network infrastructure with the ability to integrate alternative (nuclear, geothermal) and renewable energy sources (wind, water, air, diesel, etc.) and the ability to improve reliability, efficiency and security through automatic control and use of modern communication technology [1, 2].

The presence of smart grid will certainly reduce dependence on the use of fossil fuels so that it can reduce pollution and operational costs. Integration of energy sources allows the spread of stations to build up not only on the provider side but also on consumers. In this case consumers are not only users...
but also can produce energy by utilizing alternative and renewable energy sources, for example the use of solar cells in homes or buildings to produce energy from sunlight or referred to as smart home micro grid. The existence of this Smart home micro grid can 1) enable the use of renewable energy sources that are integrated in conventional electricity systems; 2) enabling the management of demand for electricity usage (demand respond) that regulates energy use in batteries and existing electricity; 3) allows the provision of reports on energy calculation in the grid (demand, supply, efficiency, etc.); 4) reduce the cost of using electricity; 5) reduce electricity subsidies issued by the government; 6) reduce CO2 pollution due to the use of fossil fuels by electricity providers.

This paper discussed the integrating energy supply on the smart home micro grid. The organization of the paper was as follow: First, research background. Related researches ware described in Sec. 2. Smart home micro grid was described in Sec. 3. Experiment and result discussed in Sec. 4. Conclusions were described in Sec. 5.

2. Related Works
Some smart micro grid research is on the development of demand response management [3-9], scheduling [10-12], metering [13, 14], communication [15-21] and others. In this study will be discussed related to the integration of electricity supply from solar energy and existing electricity. Integration is carried out for household areas with the aim of providing an alternative source of energy so that it does not depend on existing electricity source. The use of solar energy for the needs of home electric loads requires proper regulation so that the use of solar energy is more effective at the right time and event. DSM (demand response management) is a technique used in the demand response (DR) system in smart grid networks. DSM usually aims to reduce peak loads, reduce the burden of electricity payments and control the schedule of use according to electricity consumption patterns. The researcher [24] used the Minmax scheduling algorithm to reduce peak loads and pay for electricity usage by consumers. However, this algorithm does not consider the pattern of electricity usage by consumers in meeting the convenience of electricity usage.

Researchers [25] used a linear programming computation based method to minimize electricity payments and waiting times. However, this method does not take into account the reduction of peak loads. [26] uses the Water-Filling scheduling algorithm that considers the reduction of the peak-to-average ratio from the overall demand. Researchers [27] used the user-friendship DSM algorithm (UDSM) which considered not only minimizing billing and peak loads but also customer convenience based on previous electricity usage patterns. The researcher [28] uses heuristic algorithms in scheduling electricity usage to obtain optimal solutions in decreasing billing, peak load and maximizing consumer convenience. In this paper, the discussion is still limited to the integration of solar energy sources and existing electricity.

3. Smart Home Micro Grid
Smart grid enables integration between conventional power plants that rely on fossil fuels (coal and oil) and non-fossil power plants that utilize renewable energy (solar, wind, water, etc.). Through this smart grid, coordination and automation in generating energy will occur. For example, when a solar power plant whose electricity production depends on sunlight conditions, the smart grid must be able to respond to meet supply shortages from solar power plants from other sources.

3.1. Overview Smart Home Grid Architecture
Smart grid in Indonesia has begun to be applied to the state electricity provider by utilizing renewable energy sources, namely geothermal, water, solar and wind with the aim of increasing the supply of electricity in Indonesia which has increased needs. The use of renewable energy sources aims to reduce the use of fossil fuels and the amount of electricity subsidies that are increasingly swollen.
The following figure 1 shows the architecture of the smart home micro grid that is used for household areas. Renewable energy sources use solar energy and are integrated with the PLN electricity network. Solar energy is converted into electrical energy using solar panels (photovoltaic) in the form of direct current (DC). Furthermore, it is converted into AC (alternating current) using an inverter to be used directly by the load. The energy management system is used to regulate and coordinate the energy supply process both from the supply of PLN electricity and electricity from solar energy. Through analysis of electrical data obtained from smart meters and data concentrators monitoring and management can be done scheduling the use of electricity supply from solar energy and PLN.

3.2. Physical Design
The following figure 2 shows a solar energy grid consisting of solar panels, MPPT, data loggers, batteries and inverters. Solar panels convert solar energy into DC electrical energy. This DC electrical energy is stored in a battery that has previously been regulated by the dynamics of the electric current using MPPT. Each solar panel produces DC electricity from sunlight of 100Wp / 12V, which is stored on a battery with a capacity of 100Ah. MPPT as a controller of electricity storage from solar panels to batteries has a capacity of 60A / 150 VDC. The Off Grid inverter is used to convert the DC current from the battery to the AC so that it can be used by the load. In addition, the On Grid inverter is also
used so that the DC electricity generated by solar panels can be used directly by the load without having to take electricity from the battery.

Photovoltaic (PV) solar panels are placed on the roof top of a building when exposed to sunlight will convert to electricity. The electricity produced at this stage is direct current. The dynamics of sunlight throughout the daytime cause the electric current from PV to vary in size. Maximum Power Point Tracking (MPPT) controls the dynamics of electric current from PV to batteries to be stored as electrical energy. The inverter on the micro grid system converts electricity (Direct Current) from the Battery to AC (Alternating Current) to be integrated into the network system (Grid). Through the network (Grid) electrical energy is channeled to the user (electrical load). The role of the Grid in this system is not only to send or distribute electrical energy to the user. But it also carries information on the demand for electrical energy from several channels connected in one system. To support the operating needs of the system, it is equipped with data logger and Gateway. Data logger as an instrument to monitor and record electrical parameters while the Gateway acts as a medium for communicating in the system. The mitigation potential or transfer of CO2 in the presence of electrical energy from the sun can be informed through data logger.

3.3. Smart Micro grid

The integration between electricity sourced from PLN and electricity sourced from solar energy needs to be managed so that the use of solar energy in supporting household electricity needs is more effective. In order for its utilization to be effective, it is necessary to develop a control system that regulates time or detects events so that it can properly control the use of PLN electricity and solar energy.

Figure 3. Smart micro grid controller

The following figure 3 is a design of a smart micro grid controller consisting of several sensors to detect the state of the surrounding environment, the condition of the battery and the condition of the electrical load in the area of the house. Actuators in the form of relays are used to activate the use of a power source. Microcontrollers are used to process conditions detected by sensors so that the right time and event are obtained in using a power source. The working principle of the smart micro grid controller is as follows: 1) good weather conditions (temperature and heat from the sun) then the inverter ON grid works and simultaneously charging on the battery if it is low. Conversely, if the weather is not good, the OFF Grid inverter works and supplies the load from the battery and then supplies the load from the PLN if the battery is low; 2) When the battery is low, the panel directly charges the battery, the load can be sourced from the PLN, the inverter on the grid does not work; 3) When the battery is full, the energy from the solar panel goes directly to the ON Grid inverter to help
supply to the PLN; 4) When electricity fails, it will automatically load and get the source from the inverter; 5) When the battery is full and PLN load (experiencing peak load, it can be seen from the PLN voltage decreasing), then the inverter off grid turns on then relay A moves the load source to the inverter; 6) When the battery is low, relay A moves to the PLN source again.

4. Experimental and Result
Integration of solar energy with PLN electricity is carried out in the household area. Installation of solar panels is placed on the roof of the house to get better heat and sunlight. The solar panel will convert the sunlight into DC electricity. Each solar panel will produce DC electricity of 100Wp / 12V and then stored on a battery with a capacity of 100Ah. In this study, 6 solar panels were installed and 6 batteries for DC electricity storage. Figure 4 below is the installation of solar panels placed on the roof of the household.

MPPT as a controller of electricity storage from solar panels to batteries has a capacity of 60A / 150 VDC. This MPPT will control the dynamics of electric current from PV to batteries to be stored as electrical energy. The use of solar electricity can be done on grid and off grid. The use of on grid allows the load to be able to use electricity sources from solar panels directly without going through the battery. While off the grid, electricity from solar panels cannot be used directly by the load. Electricity sources from solar panels must be stored first into the battery and can then be used by the load by first being converted by an inverter. In this study, the load will use an electricity source from solar energy stored in the battery, so it requires an off grid type inverter to convert DC electricity to AC. Figure 5 below is a battery installation that is used to store solar electricity. Measurements are made on one solar panel with observations on inputs and outputs of current, voltage and power. Figure
6 shows a graph of the input current value obtained from the conversion of solar light to DC current and output current obtained from the inverter after being converted to AC current. Furthermore, the input / output voltage and the Power input / output.

Figure 6. Micro grid steady state of Current, Voltage and Power

5. Conclusion

Based on the results of the research that has been carried out by the micro grid installation in the area of the house by utilizing renewable energy from the sun, it can produce electricity that can be used to meet the electricity needs of the household. The installed micro grid can be used for electricity needs both off-grid, which is only during the daytime with sunlight and on grid conditions that can be used as long as the electricity stored in the battery is still sufficient. It is necessary to develop smart or smart methods on the micro grid to coordinate and automation on the micro grid so that the grid is able to respond to supply from connected power plants that are adapted to the conditions of electricity use.

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