

Optimal Smart Grid Management System in Campus Building

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Abstract— The utilization of well-managed electrical energy sources will result in high energy efficiency and reliability. Smart grid uses electricity management with 2-way communication that allows loads and sources to cooperate each other. Campus is a place that requires priority in the availability of energy and it requires smart grid management. This research will contain smart grid management systems on campus that use multisource to fulfil dynamic loads conditions so as to produce optimal smart grid management. The method that use to analysis the system is conventional method. The optimal smart grid achieved by analysis the sources and loads energy needed and then create a management system that have substantial impact on campus electrical system. The results of this research that smart grid system ensures electrical conditions for the needs of these dynamic loads can be fulfilled which is without a smart grid there is lack of energy for 3 days, whereas with a smart grid there is no lack of energy in the campus building.

Keywords : Smart Grid, Campus, Management

1. Introduction

The use of electricity on campus is related to campus development which causes an increase in electricity usage. The ability of electricity resources available in Indonesia through the National Electricity Company or also called PLN is limited by frequently power outages then there is a need to increase electricity through new renewable electricity sources so that the academic process in campus can run well. Several ways that have been done by the previous researchers are the addition of new renewable energy with the aim of adding energy sources in addition to the presence of electricity provided by the government such as the use of wind energy [1,2], Solar PV [3,4,5], micro hydro [5], and hybrid [6,7].

By the addition of more than one source of electrical energy, it is necessary to have management in electrical energy to anticipate the use of more than one source of electrical energy to the user or load based on needs. Some researchers have investigated the management of this energy to produce a grid system that is smart like energy management of the load [6,8,9] makes a strategy of managing energy between source and load [10], maintaining a balance between source and load [11] management centrally coordinated [12].

To get energy management in a smart grid system, an investigation is needed optimally.

Other investigators have tried to make an evaluation of the optimal grid system that is smart based on the system it formed by using several methods including: the Robust Algorithm method for optimization by implementing the program on action requirements [13], artificial intelligence which aims to carry out active demand side management for households on smart networks [14].

The objective of this paper is to achieve an optimal system; communication between sources and loads is needed to ensure that energy management is managed optimally. In this communication and organization there are four things that need to be considered as follows:

1. Ensure sufficient energy from the source in all loads;
2. If there is a lack of energy through PLN (Ps1), communication will request PV Solar System (Ps2) to fulfil electricity;
3. If there is a lack of energy through Ps1 and Ps2, communication will ask Power Option (Po) to provide energy for the load;

If there is excess energy in the load, communication will respond to Po to save the energy in battery.

In this system Po is a battery which has two tasks, that is as a source and as a load. Po is a source when there is a lack of energy in the smart grid system and Po is a load when there is excess

energy in the smart grid system so that excess energy saved in battery.

2. Methodology

The system investigated is as shown in figure 1

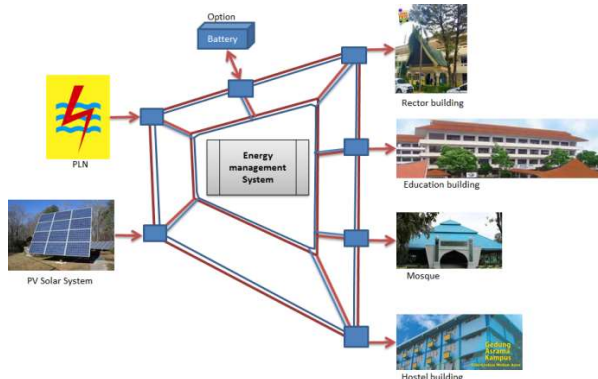


Figure 1. Smart grid system on campus building

If the power supplied through PLN is P_{s1} , the power supplied through the solar PV system is P_{s2} , the power supplied by the Battery is P_o , and for each load uses electric power such as the rector building is P_{L1} , building education is P_{L2} , mosque building is P_{L3} and hostel building is P_{L4} . In addition, here the battery is added as an option to save energy if there is an excess of electrical energy from PLN.

In this case, if there is a lack of electrical energy through PLN, the Solar PV system will provide an electric power supply. But if there is an excess of electricity from the PLN that may be caused by reduced power consumption, the excess electricity can be supplied to another load or battery.

From the information above, mathematical equations can be made as follows:

$$SG = \begin{cases} 0 & P_{s1} = P_{L1} + P_{L2} + P_{L3} + P_{L4} \\ P_{s2} & P_{s1} < P_{L1} + P_{L2} + P_{L3} + P_{L4} \\ P_o & P_{s1} > P_{L1} + P_{L2} + P_{L3} + P_{L4} \end{cases} \quad (1)$$

Where SG is sources possibility from the smart grid system.

If it is assumed:

$$P_{s1} = a \quad (2)$$

$$P_{L1} + P_{L2} + P_{L3} + P_{L4} = b$$

Then equation 1 becomes:

$$a = b \text{ Or } \frac{a}{b} = 1 \quad (3)$$

Where electrical energy supplied through PLN is sufficient for all loads. Then:

$$a < b \text{ Or } \frac{a}{b} < 1 \quad (4)$$

While the condition of the electrical energy supplied through the PLN is not enough for all loads to be divided into 2 conditions, the situation when the lack of energies are fulfilled by P_{s2} so that equation 3 becomes:

$$\frac{a + P_{s2}}{b} = 1 \quad (5)$$

However, the situation when PLN and P_{s2} cannot be fulfilled the energy shortage so that equation 4 becomes:

$$\frac{a + P_{s2} + P_o}{b} = 1 \quad (6)$$

Then:

$$a > b \text{ Or } \frac{a}{b} > 1 \quad (7)$$

Where electrical energy supplied through PLN is excessive for all loads, then P_o will work as load (battery) and equation 5 becomes:

$$\frac{a}{b + P_o} = 1 \quad (8)$$

If the system works in a steady state there will be no problems in managing electrical energy through the network.

If there are problems in the system, surely undesirable things can happen as follows:

Case 1; The PV solar system does not respond to communication calls so equation 4 is not reached.

Case 2; P_o is not functioning, so if there is a lack of energy then equation 5 is not achieved and if there is excess energy through the PLN then equation 7 is not achieved.

Case 3; If there is lack of energy, but the PV solar system is not functioning and P_o is also not functioning then equations 4 and 7 are not achieved.

To determine the system, the network can be done by performed optimally from the mathematical equations made before with the conventional method. And the simulation results in the results and discussion section.

3. Result and Discussion

The simulation results show the relationship between sources and loads can be managed properly in order to achieve optimal use of electrical energy.

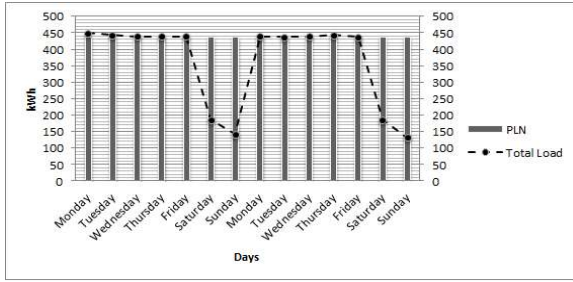


Figure 2. The power source from PLN only and the used of total load

In the condition of the system without using a smart grid, (see figure 2) there will be excess and lack of energy to fulfill the load requirements which shows the dynamic loads.

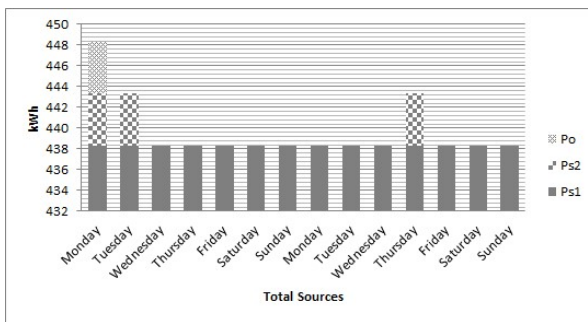


Figure 3. Total Sources

To optimize these conditions, a smart grid system is formed, so that the source consists of 3 that work with dynamic load conditions. P_{S1} is PLN, P_{S2} is PV Solar, and P_0 is battery.

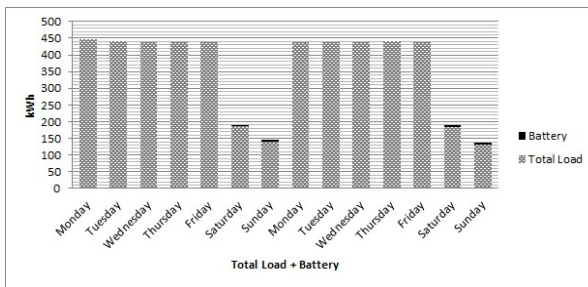


Figure 4. Total Load + Battery

In addition to fulfill the load needed, the excess energies can be used to charge the battery which can then be used when damage to the smart grid system. See picture 4, on Saturday and Sunday, the network can save power on the battery.

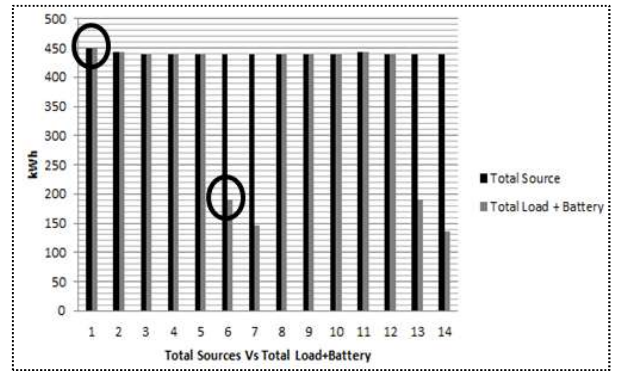


Figure 5. Comparison Total Sources vs. Total Load + Battery

In figure 5, shows that if the smart grid works in normal conditions, then the smart grid system will work to fulfil load requirements optimally. In first day, the network can fulfill the loads requirement, and in sixth day, the network can save the excess power in battery.

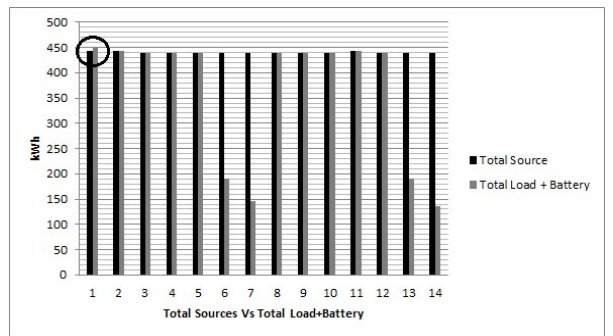


Figure 6. Case 1

However, in the realization of smart grid management there can be several cases that cause the system to not work optimally. The first case is equation 4 is not reached or P_{S2} is not active, so P_0 will fulfil energy needs. But if the energy needs over P_0 , a trip will occur and the smart grid system is not optimal (first day in figure 6).

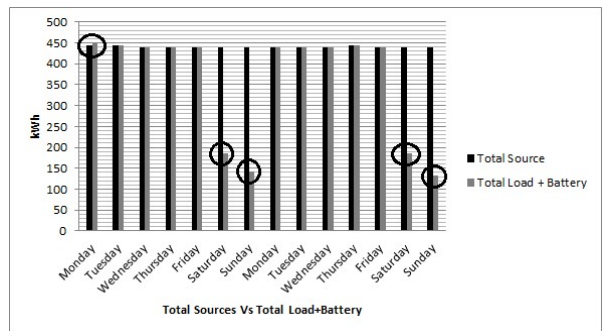


Figure 7. Case 2

The second case is Po is not active which causes shortages and excess energy. The lack of energies are caused by PLN and Ps2 unable to fulfil load requirements, while excess energy is caused by the load < PLN and excess energy cannot be given to Po (Battery). See figure 7.

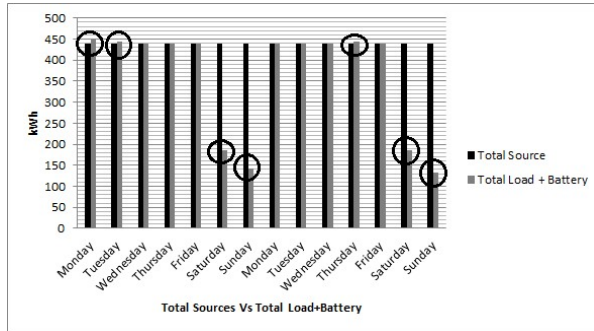


Figure 8. Case 3

The third case is that if PS2 and Po are inactive, there will be more energy shortages and excesses. This is caused by PLN, Ps2 and Po not being able to work together to fulfil load requirements and use the excess energy optimally to produce energy efficiency. See figure 8.

In a smart grid system, the case must be eliminated by using a strategy, that is communicating with other smart grid system networks to request or provide energy to other smart grid system networks [15][16].

4. Conclusion

Based on system analysing obtain that cooperate between sources and load will produce optimal smart grid management. It is known that without a smart grid there is lack of energy for 3 days, whereas with a smart grid there is no lack of energy in the campus building.

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