PROCEEDINGS

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PREFACE

On behalf of the Organizing, Steering and Technical Program Committee, I sincerely welcome you to the 2nd IEEE Conference on Power Engineering and Renewable Energy (ICPERE 2014). ICPERE 2014 is an international scientific conference that held by School of Electrical Engineering and Informatics ITB and the Institute of Electrical and Electronics Engineers (IEEE), technical co-sponsored by the IEEE Indonesia Section Signal Processing / Education / Electron Devices / Power Electronics Society Joint Chapter and also in cooperation with the Institution of Engineers Indonesia (IEI).

This conference is expected to be the place for the academics, industries and government to exchange information on progress and plans for the electricity development programs. Speakers for various countries are expected to attend in this seminar. In addition to regular speakers, guest speakers from within and abroad the country are also invited to this seminar.

As the conference venue, Bali is peacefully seated in the eastern part of the tropical country, Indonesia. By the motto of "*Bali Dwipa Jaya*" (Glorious Bali Island), Bali gives high values to nature, culture and spiritual life, which are all in synergy to create harmony and peace in the island. We are sure that all participants will have a memorable and enjoyable time in Bali. If you need any help during the conference, please let us know. We would be very happy to serve and help you for enjoying the conference.

Dr. Pekik A. Dahono

ICPERE 2014, General Chairman
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The 2nd IEEE Conference on Power Engineering and Renewable Energy
ICPERE 2014

Feasibility and Optimal Design of Micro-hydro and Photovoltaic Hybrid System in Support to Energy Independent Village

(Study case in Pesawaran Indah Village, Pesawaran Regency, Lampung Province)

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Abstract

A hybrid system utilizes several energy sources to generate electricity. This paper proposes combination of two renewable energies i.e. micro-hydro and photovoltaic for energy independent village application in Dusun Mergosari, Pesawaran Indah Village, Pesawaran Regency, Lampung Province. Previously, the village was only supplied by one micro-hydro generator through a long feeder line with high voltage drop along the line. In this work, an optimal placement and size of photovoltaic system is identified and studied through software simulation. The obtained results show that installation of a PV system improves grid's performances in terms of lower voltage drop and power losses. About 9.5% to 31% voltage improvements were observed in accordance with PV System installation.

Keywords: hybrid system, micro-hydro, photovoltaic, voltage drop

1. INTRODUCTION

Dusun Margosari, Pesawaran Indah Village, Pesawaran Regency, Lampung Province achieves energy independent by utilizing renewable energy like micro-hydro generator to meet its electricity demands. However, this has not satisfied quality of supplied voltage due to large variations in water level from its river. The long feeder line has worsened this voltage profile, especially for end nodes far from the generator which becomes the main cause of damage of customer's appliances[1]. From reliability of operation, a single supply system like this is also not a reliable system, considering electricity cut-offs when this generator is under maintenance or faulted.

A solution of this problem is by utilizing a hybrid system which combines several renewable energy sources available locally to improve both quality and reliability of electricity supply[2]-[6]. Furthermore, this strategy of utilizing another renewable energy is considered to be environmentally friendly. Owing to the availability of solar energy at the village, it is beneficial to utilize this type of energy in combination with the existing micro-hydro generation.

In this work, several alternatives of different photovoltaic capacity are studied to obtain the most optimal solution to the problem. Simulations are carried out for installation of PV System at various different locations and capacities. Because the main concern is to improve voltage profile of the existing micro grid at this village, several power flow analysis with Newton-Raphson method were conducted to find the optimal location and size of the photovoltaic system.

2. MICRO-HYDRO AND PHOTOVOLTAIC HYBRID SYSTEM

The most popular way of generating electricity in the remote and rural area of developing countries with the availability of hydro energy is through micro-hydro generating scheme. The electricity generated is usually transmitted to houses in the village for lighting purposes via an isolated micro grid. Choice of this technology is mainly due to its inexpensive capital cost and ease of built. However, this technology relies highly on water source and hence cannot be built far from the source.

This problem is worsened by long feeder line from the generating unit to houses which are located aside of main road across the village where the overhead lines are built. In

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Pesawaran Indah village where it is located, water availability during dry season is scarce and mainly used to water the farming land. This limited water volume results in poor performance of the micro-hydro generating unit both in terms of voltage profile which violates the 0.90 p.u. to 1.05 p.u. and frequency of less than 50 Hz.

In order to overcome these problems, at least there are three strategies that can be carried out:

1. Active power injection at buses with the lowest voltage by installing a generation unit known as dispersed generation.In this work, a photovoltaic system is used for active power injection. This is the strategy chosen in this work.
2. Reducing active power demand from the system. However, this strategy will result in load cut-offs and limit the amount of power consumed by consumers. This is clearly not a preferable solution.
3. Network reconfiguration and re-conductor. This is also difficult to perform since the cost of implementation will be quite high for people in the village with minimum income.

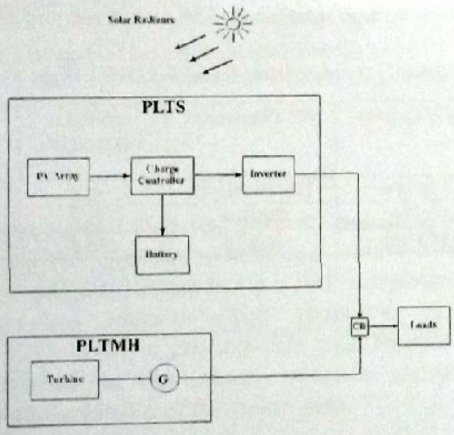

Figure 1.Conceptual Diagram of Hybrid System Combining Micro-hydro and Photovoltaic

Proposed solution in this research is conceptually supplying base load from the largest available renewable energy sources, in this case a micro-hydro system, and a photovoltaic system to make up the rest of the load. This concept is shown in figure 1. There are two models of hybrid systems, i.e. series and parallel connection. In this research, the parallel scheme is selected.

3. MODEL AND SIMULATION

Stand-alone units are already in operation at many plantations/colonies though the availability of solar, hydro or wind energy is not continuous. Isolated operation of these power units may not be effective in terms of cost, efficiency and reliability. A viable alternative solution is by combining these different renewable energy sources to form a hybrid energy system [3].

Figure 2 and figure 3 shows schematic of the hybrid system under simulation with ETAP Software for power flow analysis using Newton-Raphson method. Subsystem micro-hydro comprises of a three-phase generator with G mark, with installed capacity of 16 kW for all three phases. This generator is operated in an unusual way where only one phase is utilized to supply the load. The overhead line uses AAC conductor or twisted cable 10 mm^2, with resistance of 3.691 ohm/km. Total length of overhead line is 1.2 km of radial type network to supply 16 load buses where each load point is 30 watt.

Photovoltaic system consists of a solar panel, inverter, battery and charging controller. PV is modeled as an active power injection. Different size of active power generations were injected at the end nodes.

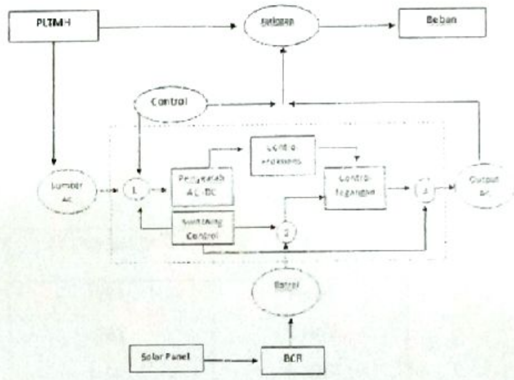

Figure 2. Schematic Diagram of the Proposed Hybrid System

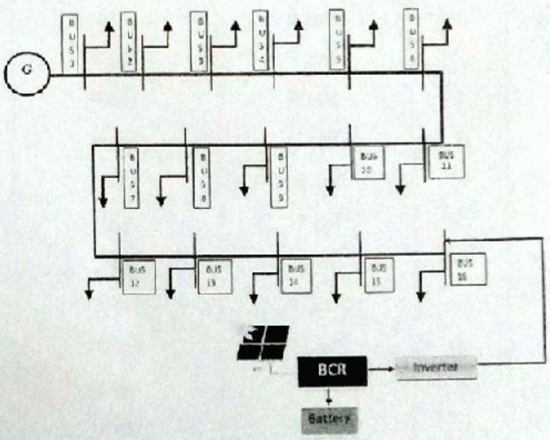

Figure 3. Planning Design of the Proposed Hybrid System

4. RESULTS AND DISCUSSIONS

Generating capacity of the existing micro-hydro generation unit is 3.2 kW per phase. This capacity cannot be

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utilized at maximum because the turbine was not properly designed. Moreover, during dry season, volumetric flow rate is minimal and only one phase output of the generator is utilized. Therefore, only 0.9 kW of power can be generated. Table 1 shows measurements on May 14, 2014, 19:00 – 01:00 WIB.

From this table, output voltage of generator was only 159 volt. The lowest voltage is observed to be at Bus 16 of 119.1 volt. Bus 16 is the most end node of the overhead line, and the drop of voltage experienced by this bus is due to voltage drop along the line. Therefore, an increase of voltage is required by injection of active power from photovoltaic system at the end node. Having 4 solar panels of 50 Wp, the amount of energy supplied by the PV System is 2880 Wh from two batteries of 12 volt, 70 Ah. Figure 4 shows simulation result from ETAP Software package prior to PV installation. Output power from generator is 0.9 kW and load is distributed at each bus of 0.03 kW. In this simulation, load is lumped. This assumption is made because each house consumes 30 watts of lighting load. Table 2 shows simulation results for different capacity of 100 Wp, 200 Wp, and 350 Wp.

Table 1. Voltage Measurements of the Existing Micro-hydro

No	Bus	Tegangan (V)
1	Bus 1	159
2	Bus 2	139
3	Bus 3	134.4
4	Bus 4	134.7
5	Bus 5	134.9
6	Bus 6	134
7	Bus 7	133.4
8	Bus 8	130.9
9	Bus 9	130.9
10	Bus 10	129.6
11	Bus 11	123
12	Bus 12	123
13	Bus 13	121.3
14	Bus 14	122.3
15	Bus 15	120.5
16	Bus 16	119.1

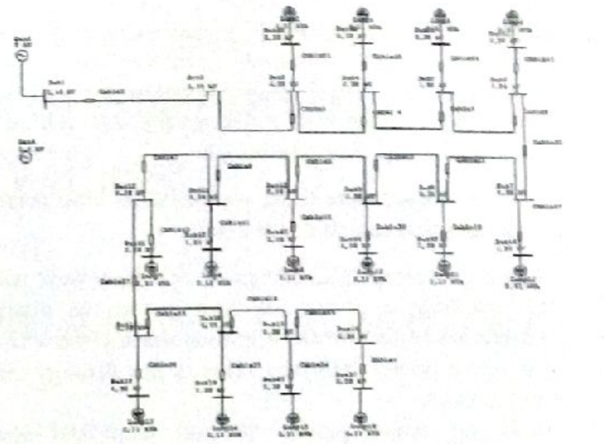

Figure 4. Existing Micro-hydro System from ETAP Simulation

Figure 5 shows changes of line to neutral voltage prior to and after installation of 100 Wp photovoltaic system. Green line indicates voltage profile before PV installation. PV installation is simulated to be at Bus 14, 15 and 16 respectively. It is shown that PV installation improves voltage profile to 136.1 volt for end bus.

Table 2. Hybrid System Simulated during Night Time Load

PV Capacity	PV Placement	Average Voltage (V)	Voltage Increase (%)
100 Wp	Bus 14 and 15	140.4	9.5
200 Wp	Bus 14	146.4	14.3
350 Wp	Bus 14	155.6	31

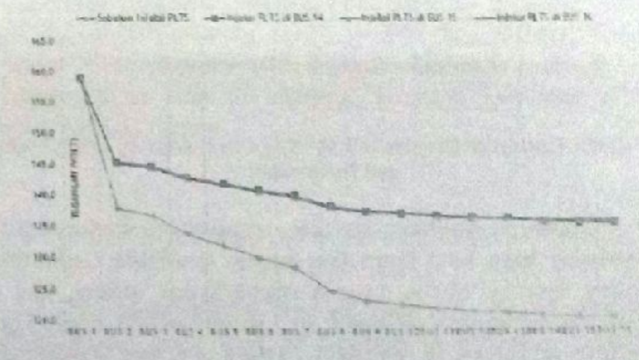

Figure 5. Line-to-Neutral Voltage before and after installation of 100 Wp PV System

Figure 6 and 7 show voltage increase before and after PV installation of 200 Wp and 350 Wp respectively. Optimal placement of PV System is at Bus 14. After injection of 200 Wp PV System, end node voltage is 146.4 volt and 155.6 volt for 350 Wp PV installation. The proposed hybrid system can supply the entire village population with improves voltage profile.

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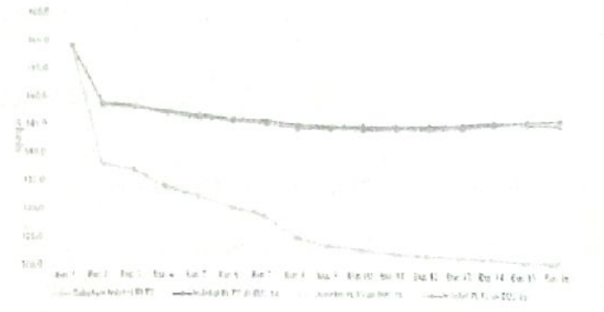

Figure 6. Voltage Profile before and after installation of 200 Wp photovoltaic

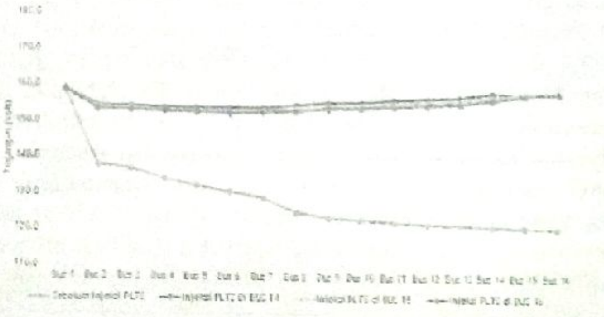

Figure 7. Voltage profile before and after installation of 350 Wp photovoltaic

5. CONCLUSIONS

Modeling, simulation and performance analysis of the proposed hybrid system combining micro-hydro and photovoltaic was carried out using ETAP software based on Newton-Raphson method. The proposed system is implemented for rural or country-side area. Results validate previous assumption that power injection at end nodes improves voltage profile of the micro grid.

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