Prototype of Pico Hydro – Solar Photovoltaic Hybrid System

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Abstract. In this research will be developed a prototype of Hybrid Power Plants (HPP) which integrates pico-hydro power and Solar Photovoltaic (SPV) system. This HPP prototype will be developed in two stages; the first stage or prototype-1 has a capacity 100 - 200 watts (W) and the second stage or prototype-2 with a capacity of 500-1000 watts. Prototype-1 was used as a study and evaluation object for the development of prototype-2 in hopes of producing better output. From the development of prototype-1 it is known that pico-hydro generates a maximum power 86 W (from a capacity 100 W) and the SPV produces a maximum power 30 W in sunny weather and 23 W in cloudy weather (from capacity 100 W). In this prototype-1, the electric energy of pico-hydro in the form of alternating current electric energy, after being converted into direct current electric energy, then combined with the output of the SPV (in the form of direct current electric energy) and stored in the battery (accumulator). At this combination, the input voltage to the battery is in the range 12-13 V and the current 2-3 A.

1. Introduction

According to 2015 Electricity Statistics [1], up to the end of 2015 the installed capacity of power plants in Indonesia reaches 55,528.10 MW consisting of PLN power plants amounting to 38,314.23 MW and Non-PLN of 17,213.87 MW; compared to 2014 of 53,065.50 MW, the installed capacity of power plants increased by 2,462.60 MW or 4.64%. The installed capacity of national power plants based on the type of power plants in 2015 can be seen in Figure 1.

**Figure 1.** National installed capacities by type of power plant 2015 (MW).

Based on the data in Figure 1, it can be seen that the dependence of power plants in Indonesia on fossil fuels (such as coal, petroleum, and natural gas) is enormous. By 2015, the installed capacity of...
fossil fuel-based power plants is 48,779.87 MW or 87.85% of total installed capacity. In fact, as is known, fossil fuels are so limited that at some point they will run out, and their effects can contaminate and even damage the environment. Based on the above, it is necessary to think about alternative energy supply that has character:
- Can reduce dependence on the use of fossil energy, especially coal and oil;
- Can provide electrical energy in a regional local scale;
- Able to exploit the potential of local / local energy resources, as well as
- Environmentally friendly, in terms of production processes and disposal of its products do not damage the surrounding environment.

An electrical energy supply system that can meet the above criteria is an energy conversion system that utilizes new and renewable energy (NRE) resources [2]. Renewable energy resources such as geothermal energy, water, bioenergy, solar, wind, and currents/ocean waves; while those including new energy include liquefied coal, coal methane gas, depressed coal, nuclear, and hydrogen. Up to 2015, the installed capacity of new NRE-based power plants is about 6,748.23 MW or 12.15% of total installed capacity [1].

To meet the electricity needs of the people of Indonesia from Sabang to Merauke, the government has committed to realize the supply of electricity amounting to 35000 Megawatts (MW) within 5 years (2014-2019). In that time period, the government together with PLN and the private sector will build 109 plants; each comprising 35 projects by PLN with a total capacity of 10,681 MW and 74 projects by private/Independent Power Producer (IPP) with a total capacity of 25,904 MW. In 2015, PLN will sign a power plant contract of 10,000 MW as the first phase of a total of 35,000 MW. In this 35,000 MW program, the share of NRE-based power generation is 25% or 8,750 MW, with details: 1.751 MW geothermal (20%), hydro 2,438 MW (28%), biofuels 1,156 MW (13%), and solar, wind, sea and other NRE 3,405 MW (39%). The required budget is USD 29.8 billion or approximately Rp.402 trillion.

In relation with new and renewable energy source, just behind the Electricity Engineering Laboratory, the Department of Electrical Engineering Education, Indonesia University of Education, there is a small river in which according to the observation, potency the flow of water can be utilized for power plants with the power output of tens to hundreds of watts. Based on this, in this research will be conducted a study and trial to develop a power plant by utilizing potency of the river water flow, in the form of pico-hydro power plant. Furthermore, this power plant will be combined with solar power plant or Solar Photovoltaic (SPV) which will also be developed at the site to form a prototype of Hybrid Power Plants (HPP).

2. Literature review
The hydro power plant is a power plant that uses water energy as its original energy source. The mechanical energy contained in the water energy is used to rotate the turbine; this rotating turbine is connected to the generator to produce electrical energy [3],[4].

Solar power plant is a power plant that converts solar energy into electrical energy. Power plants can be done in two ways, namely directly using photovoltaic and indirectly with the concentration of solar energy. Photovoltaics directly converts light energy into electricity using the photoelectric effect. The concentration of solar energy using a lens or mirror system is combined with a tracking system to focus solar energy to a point to move the engine of heat [5].

Hybrid Power Plants (HPP) is a power plant system that combines several types of power plants, in general between fuel-based power plants and renewable energy-based power plants. Generally, power generating systems that are widely used for HPP are diesel generators, solar photovoltaic (SPV), microhydro, and power plant. HPP is a solution to overcome the fuel crisis and the lack of electricity in remote areas, small islands and also in urban areas [6]. The illustration of hybrid photovoltaic-wind energy system is shown in Figure 2.
3. Research Methods
This research is a descriptive study that discusses the provision of renewable electric energy through the manufacture of prototype of Pico Hydro-Solar Photovoltaic hybrid power plant, at the Electrical Engineering Laboratory, Indonesia University of Education. This research was conducted through making of prototype of Pico Hydro-Solar Photovoltaic power plant by utilizing small river water flow around the laboratory. Solar Photovoltaic is installed on the roof of the laboratory building, where the existing area is sufficient for the installation of photovoltaic electrical panels.

The research related to the manufacture of prototype of PLTPH-PLTS hybrid power plant is done with the following steps:

- Literature review, potential analysis and feasibility study of pico-hydro power plant;
- Literature review, potential analysis and feasibility study of solar power plant;
- Collection of relevant data and information;
- Making lay out of hybrid power plant: Pico-Hydro – Solar Photovoltaic;
- Civil construction for turbine open flume 100 watts and 600 watts;
- Procurement of 100 watt and 600 watt electricity generators and their control systems;
- Pico-hydro Power Plant trial;
- Civil construction for the installation of solar cell;
- Procurement of solar cells, control systems and batteries;
- Solar Power plant trial;
- Analysis of energy forecasts to be generated from HPP system;
- Supply transformer and AC to DC converter (rectifier), as well as DC to AC converter (inverter);
- Installation of HPP: Pico-Hydro – Solar Photovoltaic;
- Testing and Commissioning test;
- Preparation of reports.

4. Results and discussion
Currently it has been made prototype Hybrid Power Plants (HPP) which combines Pico-Hydro Power Plants and Solar Photovoltaic (SPV) as diagramed in Figure 3. This prototype is a prototype-1, which uses generators and solar panels with a small capacity. The performance of Prototype-1 afterward measured and evaluated as input to develop prototype-2 with greater capacity.

In this prototype-1, pico-hydro power plant is built using an open flume turbine with a capacity 100 W, while solar photovoltaic uses solar cells with a capacity 2 x 50 WP (watt peak). Currently, pico-hydro power plant produces a maximum power of 86 W, while the solar photovoltaic generate a maximum power of 30 W in sunny weather and 23 W in cloudy weather.
Electrical energy sourced from pico-hydro, once set through Auto Load Control (ALC) then rectified using rectifier, and then stored in battery (accumulator). Electrical energy derived from the solar photovoltaic, firstly stabilized through the regulator, directly stored in the accumulator. For use of loads requiring an alternating current (ac) power source, the electrical energy stored in the accumulator is first converted through the inverter; while for direct current (dc) electric load can directly use electrical energy from accumulator. Figure 4 shows the wiring diagram of solar power plant in this study.

5. Conclusions

- Utilization of small river water flows behind the Electrical Engineering Laboratory, Indonesia University of Education using open flume turbine TC-60 with a capacity 100 W produces electricity with a maximum power of 86 W. Muddy water and a lot of waste is an obstacle in the utilization of river water.
- The muddy water causes turbine rotation decreases and effect on generator rotation as well and can causes decreasing of the power produced by generator become roughly 66 W; even impact the waste or rubbish disruption could result in the generator not operating at all.
- Utilization of solar energy into electrical energy using solar cells 2 x 50 WP in this study has not yet been optimal. The total maximum power generated is 30 W in sunny weather and only 23 W in cloudy weather.
In this study, the electrical energy generated from the utilization of water flow around electrical engineering lab in the form of pico-hydro power and the utilization of solar energy in the form of Solar Photovoltaic (SPV) System is integrated into a Hybrid Power Plant (HPP). After going through several settings and conversions, the energy from both sources is stored in the battery. At this combination, the input voltage to the battery is in the range of 12-13 V and the current of 2-3 A.

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