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The Capstone Design of Hybrid Power Plant for the Renewable Energy in the Airport

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Abstract. Currently, renewable energy sources are needed as a substitute for conventional energy sources because conventional energy sources will become decades in recent years. Renewable energy sources such as wind and solar have gained popularity and demand over the last decade. However, the output of this source depends on weather conditions. With these two sources, then we can produce the desired electric power. This project designs a hybrid power generation system model using wind and solar resources. This system can be implemented in areas around airports where large amounts of wind energy can be collected due to the high-speed movement of aircraft. At the same time, solar energy from the sun will also be collected. Eventually, the two energies will be collected simultaneously to charge the battery and be used for everyday life. The designed wind turbines are Savonius wind turbines which produce an average of 33.2-33.5 watts of electricity, and a Polycrystalline type solar panel with 200 WP.

Keyword: Wind, Solar, Hybrid Power Plant, and Airport.

1. Introduction

With very high population, economic, and energy consumption growth, energy needs are increasing daily. More than 86% of the world's energy comes from fossil fuels, while the demand for global energy needs is overgrowing. Given the negative impact of fossil fuels, switching to alternative renewable energy sources, especially wind and solar energy or geothermal energy, is necessary. Wind and solar energy are one of the uses of renewable energy currently having excellent development potential (Ismail et al., 2017).

The combination of wind and solar energy is a renewable energy source that can be used as an alternative energy source because wind and solar energy do not require fuel to produce electrical energy. Sources of wind energy obtained from the surrounding environment and the absorption of solar energy can help supply electrical energy to solar panels. If it relies on one source, it will be consistent because the individual solar and wind energy sources are stable.

Hybridization of wind power plants and solar energy sources with batteries as storage is needed to overcome periods without a supply of wind or solar energy so that electricity generation is stable and constant. Many compare the use of solar and wind power as alternative power plants. However, this comparison is generally carried out in sub-tropical countries whose geographical conditions differ from Indonesia's (Purwoto et al., 2018).

Therefore, this research design and build a hybrid solar and wind turbine system for day and night operations. This study aims to determine which New Renewable Energy power generation technology is best for use in specific environments and urban areas in the tropics by considering the geographical conditions and characteristics of urban areas. This research is also expected to be a benchmark for similar commercial buildings in locations that have similar characteristics. The suitability of the technology used is measured based on high levels of reliability and efficiency, low pollution, and the lowest environmental impact.

2. Methods

The research begins with conducting a literature search to learn the basics of a topic to be discussed. The second step that needs to be done is to collect data on potential renewable energy and electricity load income. After the first and second stages have been carried out, the third stage is to carry out an analysis of the potential for renewable energy; if the third stage is appropriate, it will move to the model; apart from analyzing the potential for renewable energy, load calculations, and power generation are also carried out. After data collection, data analysis, and report preparation, the study was completed.

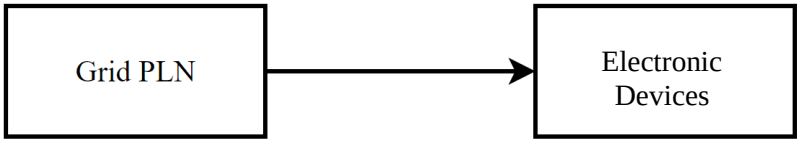

Figure 1 Diagram block 1st scenario

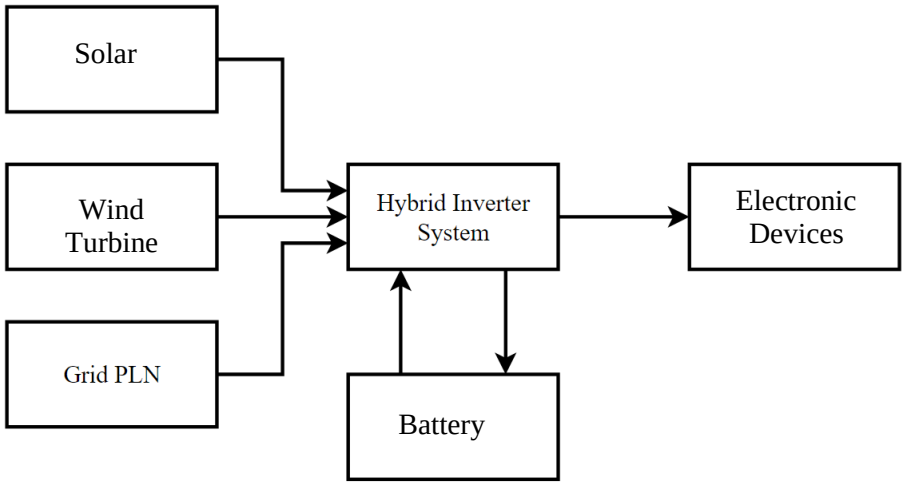

Figure 2 Diagram block 2rd scenario

3. Result and Discussion

3.1 Component Systems

In the design of a hybrid power plant there are system components such as:

1. *Grid Tie Inverter (GTI)*

Grid Tie Inverter (GTI) is an inverter used to convert the energy produced by solar panels in the form of direct current (DC) into alternating current (AC). The output from GTI is in the form of a sinusoidal waveform which is still not ideal and has a Total Harmonic Distortion (THD) value above 3%, and the efficiency value has not reached 90% (Arpino, et al., 2018).

2. Baterry

An accumulator (accu, accumulator) is a device that can store energy (generally electrical energy) in the form of chemical energy (Darsan et al., 2020). The capacity of a battery shows how long the battery is capable of delivering electricity at a specific voltage expressed in amp-hours (Ah) (Green, 2006). The following equation can determine battery capacity:

$$C = \frac{E_M}{V_B \times D0D \times \eta_{total}}$$

Dimana:

C = battery capacity (Ah)
E_M = the total energy that must be supplied by the photovoltaic module (Wh)
VB = Battery voltage (volt)
DOD = battery discharge depth (%)
η_{total} = Efficiency of photovoltaic (%)

3. Inverter

Inverter is a power electronics circuit used to convert direct voltage (DC) into alternating voltage (AC). To determine the capacity of the inverter to be used at the load by adding up all the power. With specifications, namely - Capacity: 1,200 W, dimensions: 37.5 x 31.5 x 15 cm, the maximum solar panel that can be installed is 1000 WP, the controller inside the engine is Inverter Hybrid: 1500VA.

3.1. Capstone Design

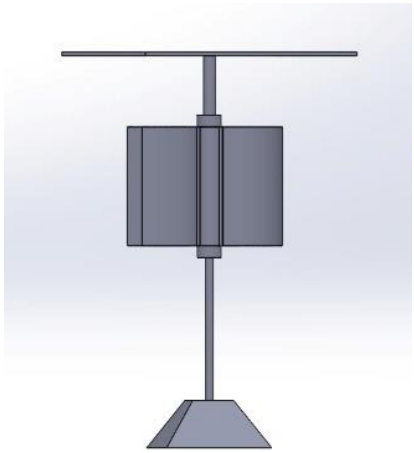

Figure 3 Design of VAWT and *Solar Cell*

In determining the type of turbine to be used in research, it is necessary to know the power generated by the wind turbine. To find out the power generated, it can use the equation:

$$Power\,(P) = \frac{1}{2} \times \rho \times V^3 \times A$$

Where :

P : Daya/power (Watt)
ρ : density (1,225 kg/m3)
V : wind speed (m/s)
A : Areas (m^2)

The type of wind turbine used is a Savonius wind turbine which produces an average of 33.2-33.5 watts of electricity. The highest performance at a load of 100 W with an efficiency of 64.72%. Although the lowest efficiency is found at 25 W load with an efficiency of 63.68%.

The type of solar panel used is Polycristaline with 200 WP (Watt Peak). Then with specifications (Pm): 200W; Tolerances: ±3%; Voltage at Pmax (Vmp); 35.8V - Current at Pmax (Imp): 5.59A; Open Circuit Voltage (Voc): 44V; Short et al. (ISC): 6.08A; Normal et al. (NOCT): 47±2°C; Maximum System Voltage: 1000VDC; Operating Temperature: -40°C to +85°C; Cell Technology: poly – Dimension (mm): 1330x986x35mm.

3.2. The Weather of Airport Analysis

Sun and wind can be used as alternative energy sources. Airports located in Indonesia have great potential to harness wind and solar energy. Potential solar and wind energy data from NASA Surface Meteorology and Solar Energy support this data. The data obtained as follows:

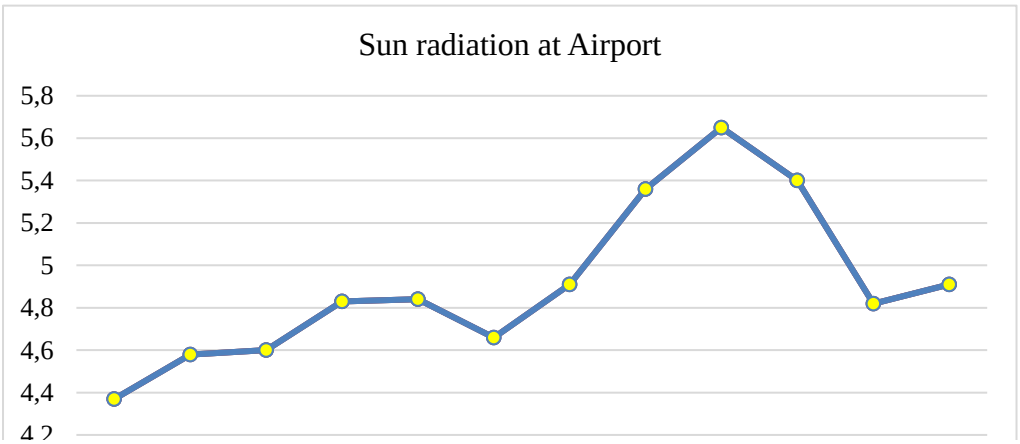

Figure 3.2 Graphic of Sun radiation at Airport

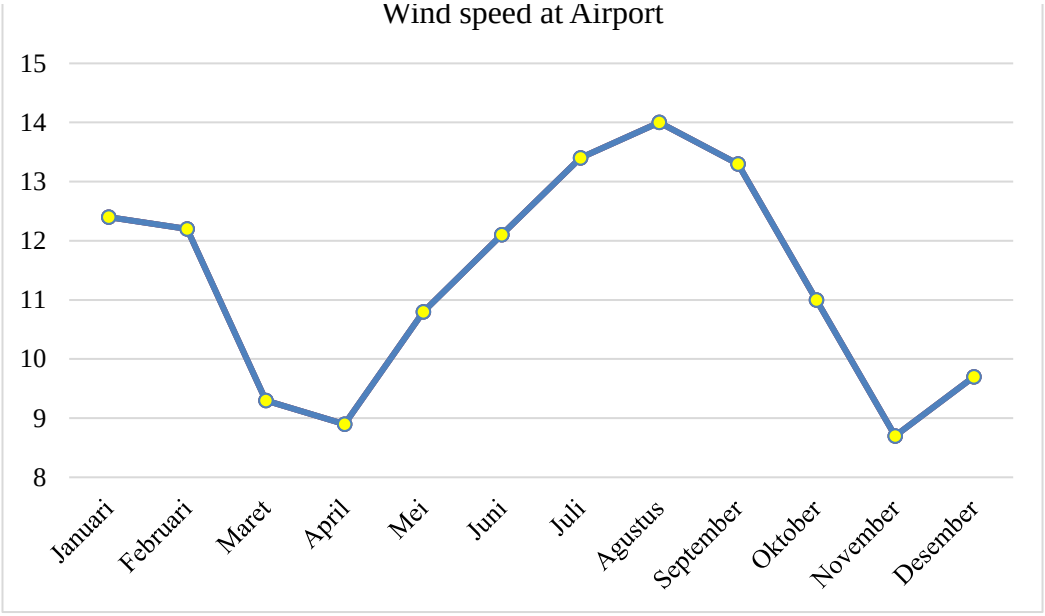

Figure 3.3 Graphic of Wind speed at Airport

3.3. Wind and Solar Energy Conversion System into Electrical Energy

Solar energy can generate electrical energy through photovoltaic (PV). Photovoltaic cells are made of semiconductor material in the form of silicon, to which some unique materials are added. When sunlight hits the PV, electrons are released from the silicon atoms and flow to form an electric circuit to

generate electrical energy. Solar cells' performance depends on the intensity of sunlight received by solar cells. The greater the light intensity received by the solar cell, the greater the power generated, whereas if the received, light intensity is small, the resulting power will also be small (Alit et al., 2016). Meanwhile, wind energy is alternative energy with excellent prospects because it is always available in nature and is a clean and renewable energy source (Arpino et al., 2018). Wind conditions and speed can be used to determine the type and size of the rotor. The process of utilizing wind energy goes through two stages of transformation, namely:

a. The wind flow will drive the rotor (propeller), which will cause the rotor to rotate in sync with the wind.
b. Rotor rotation is connected to a generator so that electricity can be generated. Thus, the kinetic energy or wind energy generated by the wind speed is used to rotate the windmill blades.

4. Conclusion

The Savonius model Vertical Axis Wind Turbine (VAWT) is designed to use three blades that produce an average of 33.2-33.5 watts of electricity. The type of solar panel used is Polycristaline with 200 WP (Watt Peak). Then with specifications (Pm): 200W; Tolerances: ±3%; Voltage at Pmax (Vmp); 35.8V - Current at Pmax (Imp): 5.59A; Open-Circuit Voltage (Voc): 44V; Short et al. (ISC): 6.08A; Normal et al. (NOCT): 47±2°C; Maximum System Voltage: 1000VDC; Operating Temperature: -40°C to +85°C; Cell Technology: poly – Dimension (mm): 1330x986x35mm. Using an inverter with specifications, namely - Capacity: 1,200 W, dimensions: 37.5 x 31.5 x 15 cm, maximum Solar panels that can be installed 1000 WP, Controller inside the Inverter Hybrid engine: 1500VA.

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