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Modeling Solar-Wind Hybrid Energy System Using MATLAB Simulink

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Abstract: Renewable energy sources like solar and wind can be used to generate electricity. As indicated in the 9th Malaysian Plan, the Malaysian government has stated its interests in and commitment to expanding the renewable energy sector. Intermittent energy sources include solar and wind. Implementing a hybrid system, in which the solar and wind plants complement one another to further improve their ability to capture energy, can increase the dependability and overall performance of solar and wind power plants. This presents a model of a hybrid solar-wind energy system using MATLAB Simulink. The main goal of this project is to model the wind and solar energy system using MATLAB Simulink and evaluate the performance of the solar wind system. To further enhance the hybrid system's overall performance, elements affecting solar-powered systems' efficiency were researched in addition to combining both power sources. The location of the project is Kuala Terengganu as Kuala Terengganu has the potential to develop a hybrid solar-wind energy system. The first development of the modeling equations for sizing simulations took place during the theoretical development stage. From the simulation, the result for solar energy based on the number of solar panels is 52 solar panels and the wind energy based on the area of blades for wind turbines is 284.9 m2. In conclusion, the findings of this study contain manual calculations performed for wind energy and solar energy to get the system size of the solar system and wind turbine.

Keywords: Solar Energy, Wind Energy, Hybrid Energy System, MATLAB

1. Introduction

GCPV systems can be implemented as centralized generators or as distributed generators. It is versability combined with advanced technology, relative ease of installation and various other factors has proliferated the growth of GCPV systems in many regions around the globe. The total solar energy incident on Earth is far greater than the global energy needs at the moment and in the future and gain popularity as a sustainable energy source in the twenty-first century due to its limitless supply and lack of pollution [1]. Hybrid solar PV and wind generation systems become very attractive solutions in particular for stand-alone applications. The hybrid system becomes more cost-effective to operate when

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solar energy and wind energy are combined since the weaknesses of each system can be made up for by the advantages of the other. Natural intermittent power sources like solar and wind can provide technical problems for the system's ability to produce electricity, particularly if their integration becomes more widespread or the grid is unable to cope with sudden fluctuations in generation levels [2]. Due to the instability and regular inconsistency of the sources of both individual solar and wind energy. To overcome this issue, it is necessary to hybrid the power generation from wind and solar energy sources with batteries as storage. Current renewable energy methods include wind energy as one of the least expensive alternatives [3]. Therefore, the purpose of this research is to examine if it is feasible to produce local electricity using a wind-PV hybrid system in rural areas, as well as to identify the conditions under which such a system would be financially viable [4-6].

Thus, in this research, a system that integrated a hybrid solar-wind energy system, which is more likely to be simulated using MATLAB Simulink, will be implemented. This research aims to evaluate the performance of a hybrid solar-wind energy system based on the sizing of the hybrid solar-wind system, a wind turbine with a speed of 3 m/s, solar specification number of solar panels, and 10 kW load for the potential location at Kuala Terengganu.

2. Materials and Methods

This chapter describes the methods and flow process of the project. The aim is to model a solar-wind hybrid energy system using MATLAB Simulink. The components and software used in this project will be explained. All these components will be used to model the circuit using MATLAB Simulink.

A. Methodology

Figure 1 shows the block diagram of the project and the setup of the hybrid system. This project is simulated and consists of a wind turbine, solar panel, grid utility, battery, and load.

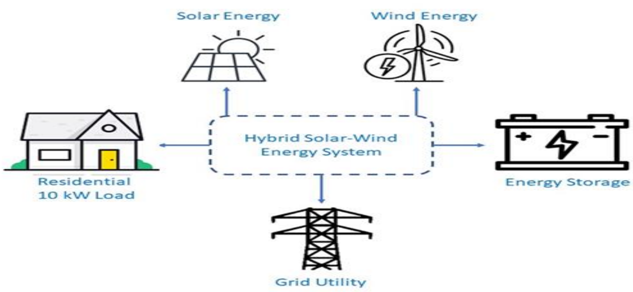

Figure 1: Block diagram of the project

B. Main components of project

i. Solar energy system

In this scenario with a buck-boost connected the power is increased in each scenario because the buck-boost converter could increase or decrease the operating voltage as shown in Figure 2. In real applications a boost converter is sufficient because most loads are much higher than in this simulated case:

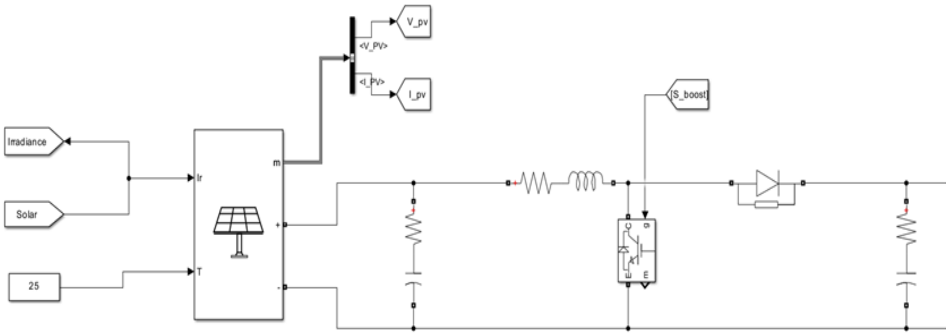

Figure 2: Model of PV connected Buck-Boost converter in Simulink

ii. Wind energy system

Aerodynamic forces occurring on the wind turbine's blades allow for the extraction of wind energy. The driving shaft that rotates through a generator to produce variable AC electricity is attached to the blades. The electricity is typically converted from AC to DC and back to AC at a certain frequency since the blades rotate at a variable speed to collect the most power from the wind resource. In comparison to the solar resource, the wind speeds are often in the range of 3-6 m/s, which may not be high enough to make wind turbines feasible for the microgrid. Wind speeds are the key component of wind power generation as shown in Figure 3.

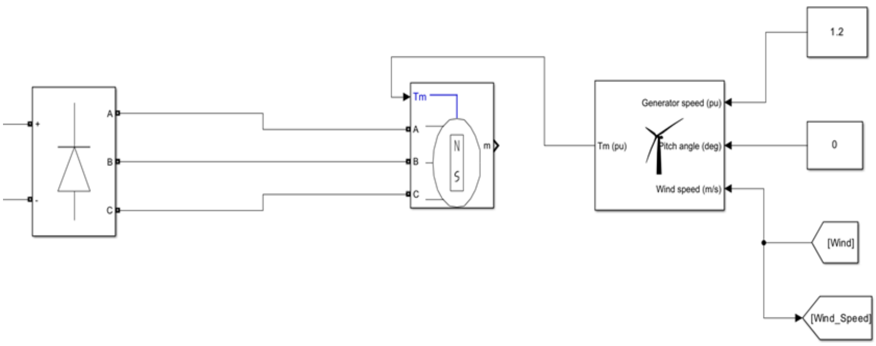

Figure 3: Model of a wind turbine in Simulink

iii. Grid connection system

A three-phase source operating at 11 kV and a three-phase step-down transformer stepping it down to 220V are both used in Simulink to simulate the grid as shown in Figure 4.

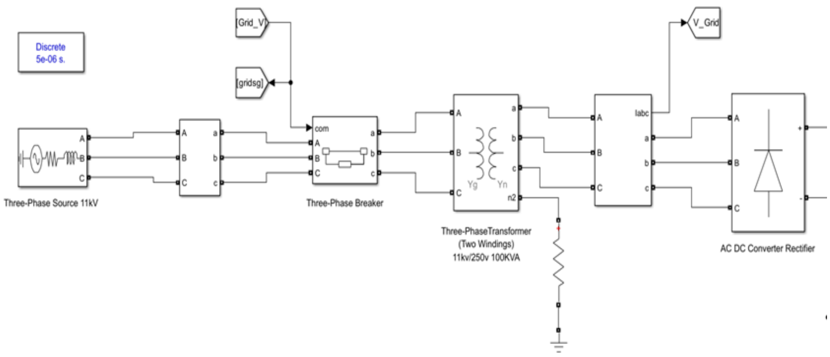

Figure 4: Model of grid connection in Simulink

iv. Battery storage

An essential part of a microgrid powered by renewable energy is energy storage. Energy storage will assist in preserving voltage stability and reducing the variations caused by the production of renewable energy. The energy storage component in this system will be batteries, which use a reversible chemical process to store energy and transform chemical energy into electrical energy. It is possible to describe a battery as a non-linear voltage source in which the output voltage is dependent on the current and the state of charge (SOC) of the battery. The SOC is not a linear function of time or current. Battery SOC affects internal resistance and voltage. The remaining ampere-hour in the battery divided by the total ampere-hour of the battery is known as the SOC. A battery's internal resistance is almost constant until the SOC approaches 90%, at which point it exponentially increases as shown in Figure 5.

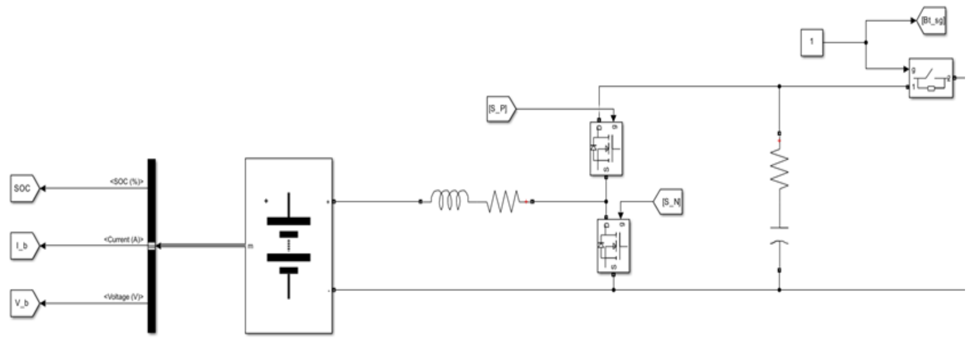

Figure 5: Model of grid connection in Simulink

v. Hybrid solar-wind energy system

A hybrid solar-wind energy system was modeled using MATLAB Simulink as shown in Figure 7. The system has three sources of energy: the grid, solar PV, and wind energy. The controller ensures that the sources are switched over smoothly to maintain a constant load voltage and current. The results of the simulation show that the system can meet the load demand reliably.

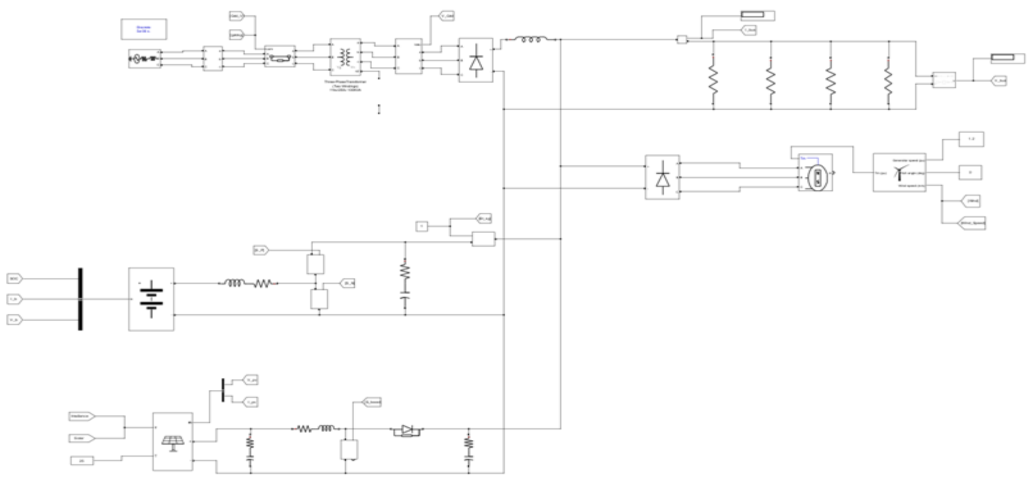

Figure 7: Model of a solar-wind energy system in Simulink

3. Results and Discussion

This section discusses the results and design model of the solar wind energy system. The circuit was simulated using MATLAB Simulink software. A solar wind energy system is a renewable energy system that uses both solar and wind power to generate electricity. The results of the simulation showed that the solar-wind energy system was able to generate enough electricity to meet the load demand. The design model was also validated by the simulation results. The development of the solar wind energy system is a promising step towards the use of renewable energy sources. This type of system has the potential to provide reliable and sustainable electricity to homes, businesses, and other applications.

A. Hybrid solar-wind energy system

The system starts with the grid-connected and charging the battery. Solar and wind power are not yet contributing to the system. The system can support a 10 kW load when connected to the grid. After 1.5 seconds, the grid starts to disconnect. The solar irradiance increases to 1000 watts per square meter, but the wind energy is still zero. The battery continues to charge and can still support a 10 kW load. After 3 seconds, the grid and solar energy drop to zero. The wind energy increases to 3 m/s, but this is not enough to meet the system's power demand. The battery starts to discharge at a rate of 10 kW to meet the system's power demand. The system can only support a 10 kW load when the grid is connected or when the solar and wind power are both contributing to the system. If either the grid or the solar and wind power are not available, the battery will start to discharge to meet the system's power demand as shown in Figure 8.

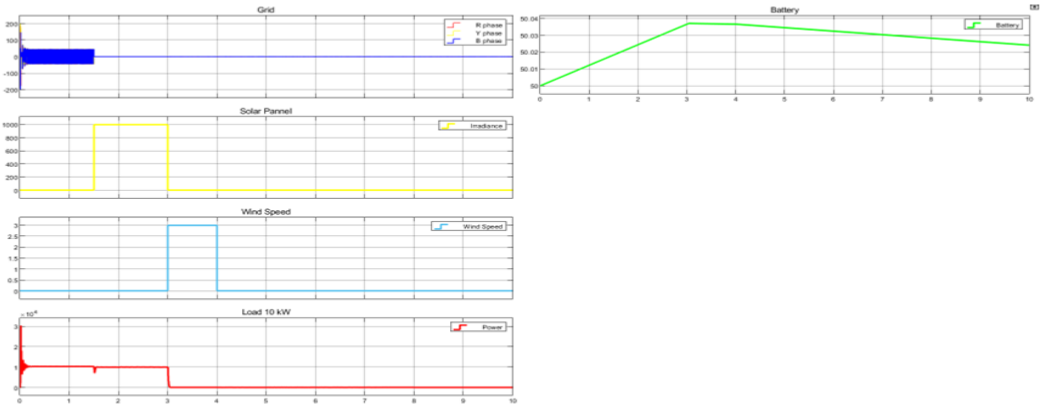

Figure 8: Graph of the hybrid solar-wind energy system

B. Solar energy system

The solar panels can supply 10 kW when there are 1000 watts of solar irradiation per square meter. The battery charges slowly when there is no wind or grid electricity. The load can go up to 10 kW as solar irradiation increases. If solar irradiation falls below 1000 watts per square meter, the battery will discharge to meet the load. The system can handle a load of up to 10 kW even if solar irradiation is not always at 1000 watts per square meter as shown in Figure 9.

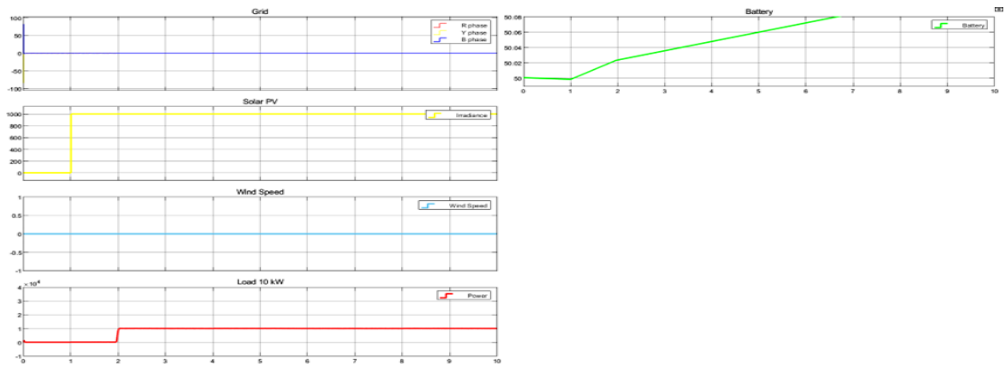

Figure 9: Graph of the solar energy system

C. Wind energy system

The wind turbines are operating at 3 m/s, but the grid and solar energy are not available, the battery will discharge to support a 10 kW load. The battery will act as a backup power source until renewable energy generation is restored or alternative power sources are available. The amount of time the battery can support the load will depend on the battery size and the amount of power being drawn as shown in Figure 10.

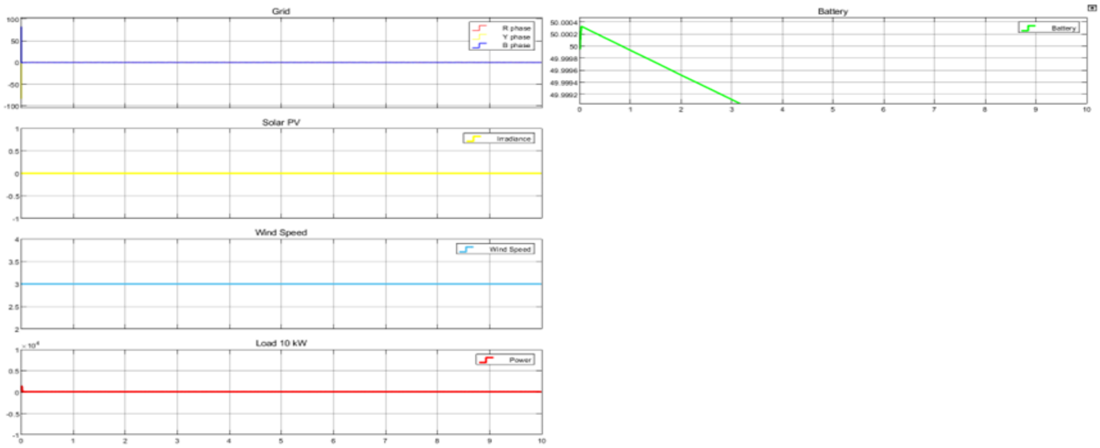

Figure 10: Graph of the wind energy system

3.4 Grid connection system

The system can support a 10 kW load and charge the battery when the grid is operational. The battery will gradually charge even when the system is not using solar or wind power. This is so that the battery can provide backup power in the event of a grid failure. The battery can keep the system running for a short period after a grid failure. The battery's runtime depends on its capacity and the load being drawn. It is important to use power sparingly after a grid failure so that the battery does not run out of power before the grid is restored as shown in Figure 11.

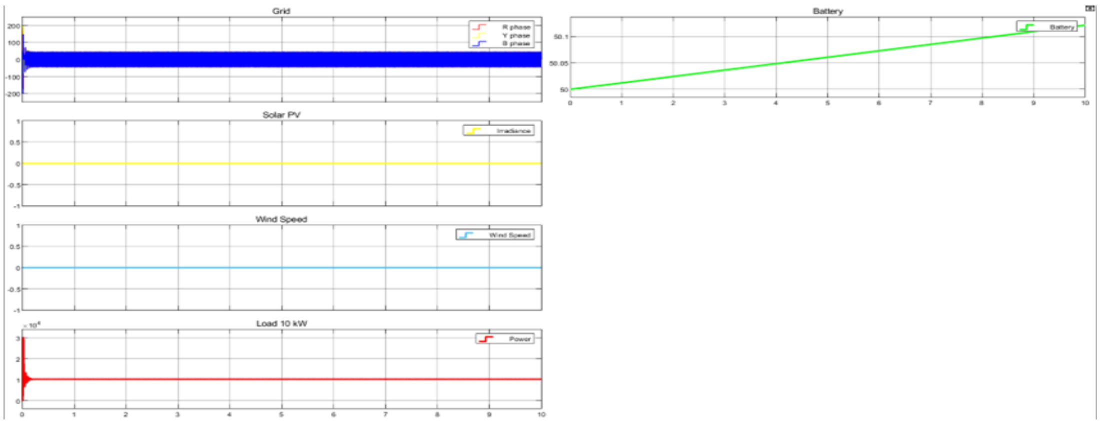

Figure 11: Graph of grid connection system

4. Conclusion

This project's goal is to model the wind and solar energy system using MATLAB Simulink and evaluate the performance of the solar wind system. The project focused on analyzing the technical feasibility of prospective renewable energy sources based on the prospects of solar energy and wind energy in the state of Kuala Terengganu, Malaysia. As a result, a hybrid power system can switch between various energy sources, such as solar energy on sunny days and wind power on cloudy days, ensuring a stable and efficient power supply. The results showed that a hybrid system was significantly more cost-effective and reliable than a standalone solar or wind system. A hybrid system could provide a stable and efficient power supply, even when solar or wind power is not available with the help of grid utility. To overcome the times when neither wind nor solar energy is available, it is necessary to hybridize the power generation from wind and solar energy sources with batteries as the storage. Renewable energy methods include wind energy as one of the least expensive alternatives. The use of solar energy has many benefits over other renewable energy sources, including minimal periodic maintenance requirements and no noise pollution throughout the power generation process. This project can be improved in the future by determining the ideal system size, the arrangement of the solar and wind components in the hybrid, availability, load demand, and cost optimization. In summary, it can be concluded that the objectives established at the beginning of the project were met. As a result, the project was a success.

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