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Solar-wind-power Hybrid Power Generation System

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In comparison to traditional power generation techniques, renewable energy is reliable as well as efficient, clean, and environmentally friendly. Switching to renewable energy sources is the only way to alleviate the resource shortages that the world is now experiencing, particularly the lack of fuel resources. More and more people are turning to renewable energy sources like solar and wind power. The project's goal is to utilize the programming language MATLAB/Simulink to design a hybrid power producing system that is connected to the grid and uses both solar and wind energy. The geography, solar irradiance, daylight hours, temperature, wind speed, and wind direction were all considered during the model's creation. The grid-connected hybrid model includes photovoltaic cells, a maximum power point tracker (P&O), a boost converter, an inverter, a wind turbine, and a permanent magnet synchronous generator (PMSG). In addition, the hybrid system is what powers the grid. The output is measured under a range of irradiance and temperature conditions. To examine the hybrid model, simulations are done in MATLAB.

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1. INTRODUCTION

With its support for economic expansion, welfare, and quality of life, energy is essential for human advancement and world prosperity. The ecological balance and safety of conventional energy sources are seriously compromised on a local and global scale. Renewable energy sources are a superior choice because they are clean, non-polluting, and environmentally beneficial in today's energy-demanding world. Natural energy is abundant, carbon-free and can replace fossil fuels while protecting resources for future generations. Examples of such sources are sunshine, wind, rain, waves, geothermal heat, and tides. The excessive consumption of traditional energy sources like coal, petroleum, and oil, which has resulted in resource depletion and environmental imbalances, is what is causing the rising need for electrical energy. Renewable energy sources including biomass, solar, wind, and hydroelectricity are safe, dependable, and environmentally benign. These renewable energy sources, however, are susceptible to climatic and seasonal changes, which reduces their efficiency in the summer and winter [1-3]. Hybrid power generation using renewable energy is more efficient since it combines two or more renewable energy sources to satisfy load demands. This system costs less and is more dependable, effective, and eco-friendly. The most popular renewable energy sources for generating electricity are solar and wind power. These sources have several advantages over other energy sources, including a decrease in peak demand, a reduction in reliance on a sole source, and an improvement in power quality [4,5,6,7].

2. MOTIVATION

The overuse of conventional energy sources has resulted in environmental problems and resource depletion. Alternative options that are abundant and frequently used for power generation, like solar and wind energy, rely on these natural resources to overcome these issues. With continued research and study, solar and wind power have a lot of promise and are widely available. A potential option for a consistent and dependable power supply is hybrid power generation. To meet the world's energy needs without endangering people or the environment, it is essential to use these resources properly Conventional energy sources are running out while also exploiting future needs and having a severe influence on the ecosystem. Although there is a lot of renewable energy available and it can be utilized to generate electricity, it cannot be used efficiently unless it is properly controlled and integrated. The performance of unconventional energy sources is constrained since they are weather-dependent. High potential, yet unstable owing to difficulty of access and climatic changes, include solar and wind power. Harmonics, power fluctuations, transients, voltage sag, and voltage dip are some of the power quality problems that arise with integrating renewable energy sources.

3. SCOPE OF THE PROJECT

The hybrid system, which combines solar and wind energy for power generation in both rural and urban locations, aims to provide a continuous supply of power without endangering people or the environment. This renewable energy option solves environmental problems such as pollution, fossil fuel degradation, and global warming. The project aims to develop a sustainable replacement for current power-producing infrastructure by assessing the availability of solar and wind energy, creating a hybrid model connected to the grid, and applying controlling mechanisms to generate the most energy possible. The system includes solar, wind, power converters, and a battery, with five possible renewable energy sources and their usage and charging methods. It aims to maintain a stable and reliable power supply with desired ratings for charging the battery and powering the load. Maximum power tracking is achieved using the perturb and observe method for both solar and wind power sources. The wind energy system includes a generator and a turbine for converting mechanical power to electrical energy. The maximum speed is obtained under maximum rotor speed by the MPP. The supervisory control system sets the DC and maintains the power sources and storage system, charging and discharges the battery in accordance with setting the voltage at specified range. The hybrid system is mainly adopted for domestic purposes and uses photovoltaic cells to convert solar energy into electrical or heat energy. There are two types of systems: line dependent and line independent. Line dependent systems do not require batteries for storing energy, while wind energy is based on the capacity for producing power, with sun beams producing power during summer and wind velocity sufficient during winter [8,4,9,10].

4. EQUIPMENT

a. PV Energy System

Solar power is a cost-effective, pollution-free type of energy that is produced by collecting solar radiation. Utilizing semiconductor materials such as silicon, PV panels utilize solar energy to produce electricity. With a PN junction, these cells operate similarly to diodes, enabling free electron movement to produce an electric current. Solar energy is converted into electrical energy using the photoelectric effect as a guiding principle [11-19]. PV cells that are joined to create a PV module are combined to create solar panels. Depending on the load requirements, the cells are often set up in series or parallel configurations. The cells are set up either in parallel or in series depending on the output voltage or current that is desired. Solar panels directly transfer the energy from the sun through their photoelectric effect. Solar panels' DC output is delivered into converters' inputs where it is used to track the sun's maximum power point. By altering voltage levels, the converters produce regulated DC output while turning the input signal into AC output, which is subsequently sent to the grid or a load. For large-scale applications, conductance methods are more popular, although they cost money and need parameter tweaking. The P&O method is employed in a variety of climatic situations, such as when the sun's radiation is shifting, however it could produce inaccurate results. In a variety of environmental situations, the incremental conductance approach performs better and is applicable in digital contexts. However, because of its complicated structure, it is mostly employed for large-scale applications, including satellite applications [20,21,22,23].

b. DC Convertor

A DC-DC converter converts voltage into controlled outputs, categorized into boost, buck, and buck-boost converters. They produce regulated DC output based on switching frequency and duty cycle, with a high step-up boost circuit diagram. The feedback loop supplies output error signal and constant DC, and PWM pulses are produced and sent to the converter switch [24,25].

c. Inverter

Inverters are electrical power electronics that convert DC outputs into AC outputs at a predetermined frequency. They are divided into current source inverters with high impedance and voltage source inverters with low impedance. There are two types: half bridge and full bridge, and single-phase and three- phase inverters. Single-phase inverters convert DC inputs into AC outputs at predetermined frequencies and magnitudes. The inverter switch is a universal bridge that transforms DC power into AC and feeds it through a three-phase series RLC branch, resulting in a sinusoidal waveform [26].

d. Wind Energy System

Wind energy is a promising renewable energy source that can meet the world's growing energy demands. It comes from air movement and is safe and clean. Wind turbines convert wind's kinetic energy into mechanical energy, which is then transformed into electrical energy by generators. Two popular types of generators are permanent magnet synchronous generators (PMSG) and induction generators (IG). IG generators use synchronous generators, which are less expensive, easier to operate, and more efficient than PMSGs. Wind turbines consist of a rotor, blades, gearbox, nacelle, generator, and tower. Wind energy can be characterized as constant or variable, with variable speed turbines being most effective. The most widely used technique for converting wind energy is the direct driven permanent magnet synchronous generator. The Simulink model of a wind energy system uses three inputs: generator speed, pitch angle, and wind speed. The mechanical energy generated by the wind turbine is transformed into electrical energy by the permanent magnet synchronous generator (PMSG). The electrical output is delivered to the grid or load through a three- phase V-I measuring block. The synchronous generator has an input voltage of 400V, a 60kVA rating, and a frequency of 50Hz [25,27].

e. Hybrid energy system

Hybrid power production systems combine solar and wind energy to produce electricity, meeting future demands by combining them during the day and night. These systems offer superior performance and consistent output compared to independent systems. The goal is to integrate grid-connected solar and wind energy with controlling strategies to provide the most power possible. During shutdowns, the grid can serve as a source or backup system, storing excess energy generation and supplying it when needed to fulfill load demand. This strategy may be particularly helpful in addressing seasonal changes in the sun and wind while enhancing output quality. The hybrid system uses Perturb and Observe (P&O) tracking to maximize available power from energy resources. The energy is passed through a boost converter, which steps up the solar panel's DC output power before being supplied to the inverter. A three-phase inverter converts DC power to AC power in the inverter. The wind turbine captures the spinning wind speed and converts it into mechanical energy, converting wind energy from electrical energy to mechanical energy. The generated power is then fed into the grid to meet energy demands.

f. PV System

Simulink blocks are used in MATLAB/Simulink software to model the PV and wind energy systems. A new Simulink file is first created, then blocks from the library are added, connected, and given values. After that, the model is updated and simulated, and the simulation output is examined. A second diode has been added to the PV MATLAB model to improve the I-V characteristics, which is based on the fundamental equivalent circuit diagram for a solar cell. Equations for theoretical equivalent circuits are used to create the model [28,29,30,31,32].

5. RESULTS AND ANALYSIS

The simulation output for an inverter circuit shows the conversion of a PV module's DC input into AC output. The graph shows the voltage and current in volts and amperes, representing the time and voltage/current components. The inverter circuit converts DC power from a PV panel to AC power.

5.1 Simulation Result of Inverter Output of PV

Simulation Results of PV Module

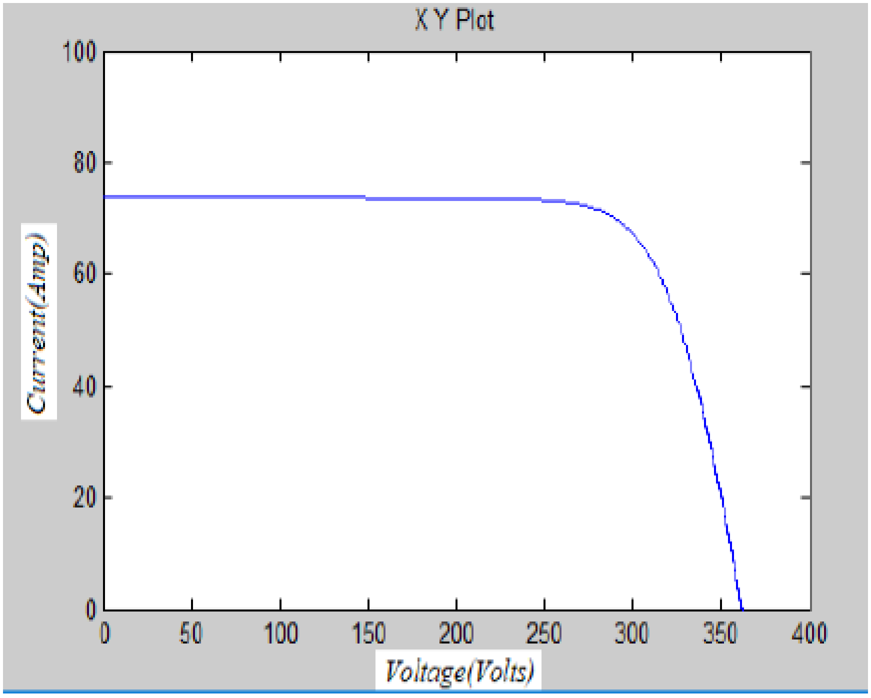

Fig. 1. P. V. curve of the P. V. mode

Here X axis show that Current value and Y axis show that voltage value. Here we show that Amp-Volt frequently increased by PV module.

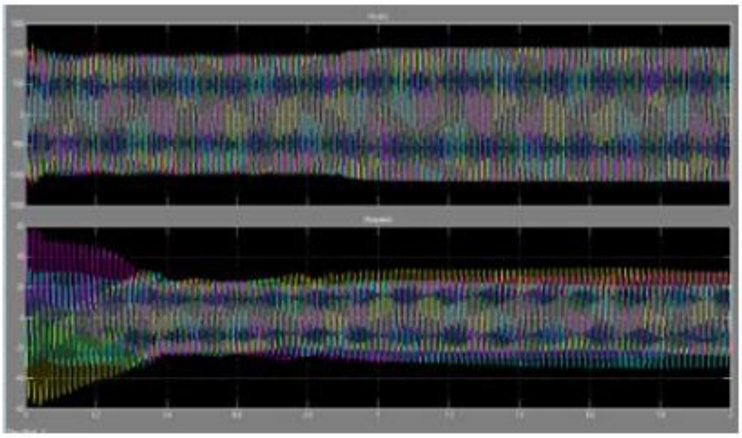

Fig. 2. Simulation results of Inverter Output of PV

Here is X axis show that Current and Y axis show that Volt.

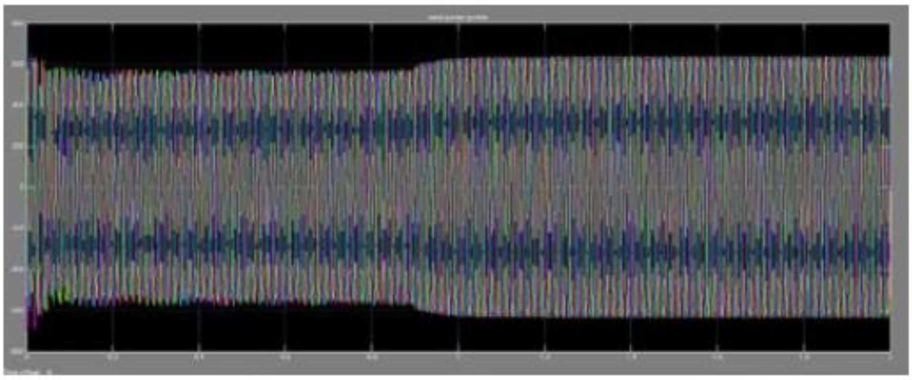

Fig. 3. Output Voltage of Wind Power System

Here X axis is Wind energy and Y axis is Volt that is frequently increased depends on wind velocity.

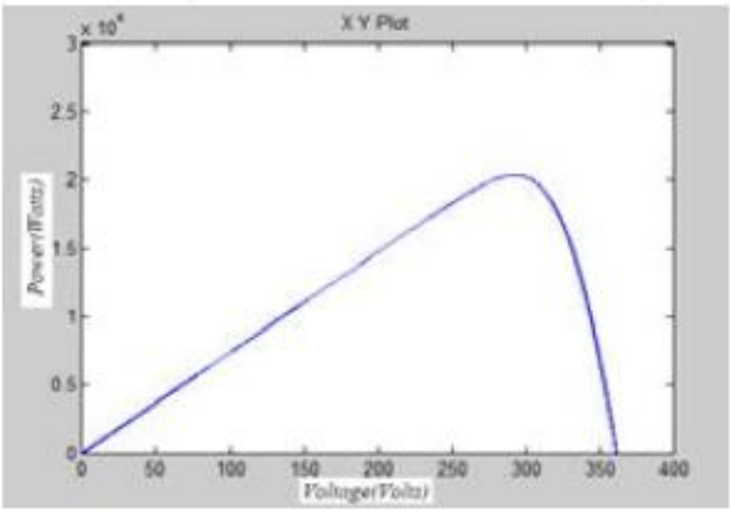

Fig. 4. I-V curve of PV Module

Here is P-V module depends on wind energy.

Simulation Result of Hybrid Energy System

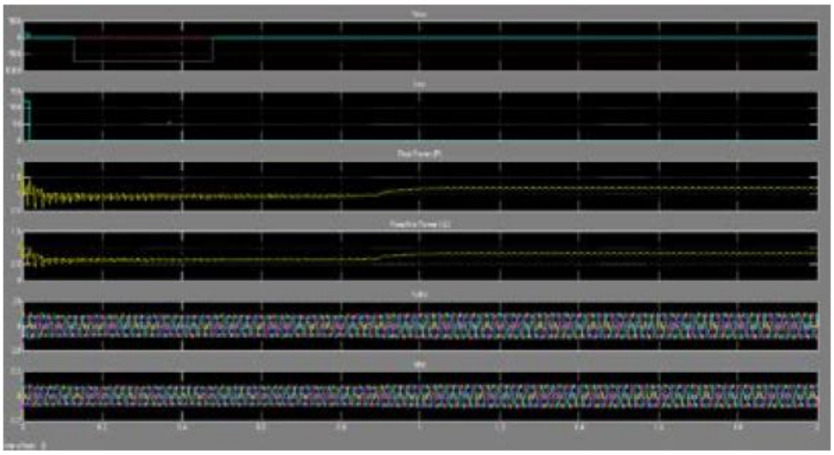

Fig. 5. Output of Hybrid Energy System

Here is total energy of Hybrid module that is show that voltage is increased by following hybrid energy.

6. CONCLUSION

The study of a hybrid PV-Wind power generating system for a grid-connected application is the main objective of the thesis, which makes use of MATLAB/Simulink software. The hybrid PV-Wind model is suggested to account for the effects of climate changes and environmental variables on energy production. Solar energy is efficiently tracked using the Perturb and Observe (P&O) MPPT technique, and inverter fluctuations are eliminated using a boost converter. Sinusoidal AC power generated by a permanent magnet synchronous generator is combined to power the grid. The MATLAB/Simulink modeling program was used to create the hybrid model, and the results were checked. The system's output was found to be influenced by solar radiation, temperature, and wind speed fluctuations. Sinusoidal AC power was produced with some minor variations. The hybrid system's overall output is roughly 1.5 MW, and it provides clean energy. However, problems with power quality including voltage sag, voltage swell, harmonics, and transients have a detrimental effect on the system's performance [33,34,35]. To get around these problems, methods including static compensators, series type LC filters, UPQC, DSTATCOM, and STATCOM are suggested. To estimate power for a continuous energy supply, advanced techniques for recording solar and wind data are required. There are various MPPT methods available for tracking resources.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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