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Wind-Solar Hybrid System for Domestic Utility

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Abstract. Wind-Solar Hybrid System is one of the major growing industries that can change the way using of electricity. In this era of emerging technologies, it is safe to say that the idea of Wind Solar Hybrid system technologies and to use the renewable energy sources for various tasks are some of the areas where there is a lot of scope and innovation is going on. Because wind and solar energy complement one another, the system can generate electricity almost all year long. The wind aero generator and tower, solar photovoltaic panels, batteries, wires, charge controller, and inverter are the essential elements of the wind solar hybrid system. The electricity produced by the wind-solar hybrid system can be utilised to run AC appliances as well as charge batteries. This project majorly deals with the consistent power supply, reliable energy provision and backup power. This project can also reduce the usage of energy from the grid, this may cause reducing the production of thermal energy.

1 Introduction

Many are looking at sustainable energy alternatives to protect the planet for future generations as worry over global warming and the depletion of fossil fuel supplies grows. Other than hydropower, photovoltaic and wind energy have the greatest potential to satiate our energy needs. Large amounts of power can be generated by wind energy alone, but it is highly unpredictable because it might appear one second and disappear the next. Similar to this, solar energy is available all day long, but the amount of solar irradiation varies due to the sun's intensity and the unpredictably shaped shadows created by clouds, birds, trees, etc. Both wind and photovoltaic systems have the inherent flaw of being intermittent, which renders them unstable. Nevertheless, by combining these two sporadic sources.

The alternative energy source can make up the difference if a source is unavailable or not enough to fulfil the demands of the load. In development, a number of hybrid wind/PV power systems with control have been suggested. To execute the control for each of the renewable energy power sources, the majority of the systems described in the literature employ a separate DC/DC boost converter coupled in parallel in the rectifier step. A more straightforward multi-input structure that combines the sources from the DC-end while still

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attaining for each renewable source has been proposed. The structure suggested by combines the buck converter with the buck-boost converter. To eliminate the high frequency current harmonics introduced into wind turbine generators using the technologies described in the literature, passive input filters are needed. The generator current's harmonic content shortens its life and increases power loss from heating. For hybrid wind/solar energy systems, a different multi-input rectifier structure is suggested in this research.

1.1. Renewable Energy

Globally important issues now include the energy problem and the need for sustainable energy sources. Fossil fuel use has contribue to Environmental issues like pollution, global warming, and climate change. The usage of wind and solar energy is expanding considerably as the need for sustainable energy sources has become more pressing. A wind-solar hybrid system combines solar and wind energy to produce electricity for use in home utilities. This study paper's goal is to examine how a wind-solar hybrid system is designed, installed, and operated for household utility.

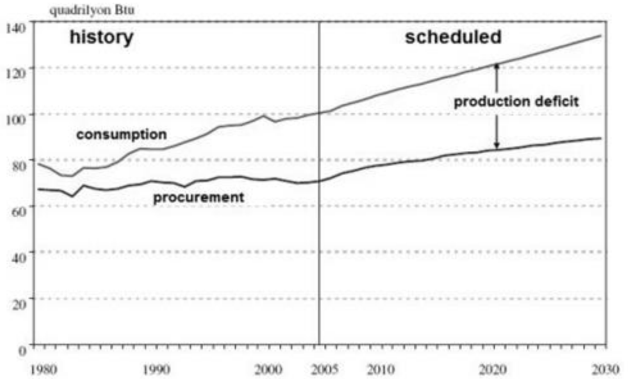

Fig. 1 *World Energy Production/consumption*

1.1.1.Hybrid system

When two or more renewable energy sources, such as solar and wind, are combined to produce power, this is referred to as hybrid energy. By maximizing each energy source's advantages while minimizing its disadvantages, hybrid energy systems aim to create a more dependable and effective energy system. Hybrid power plants that use both solar and wind energy are gaining popularity. Combining wind and solar energy can reduce unpredictability because solar energy is more powerful during the day and in the summer while wind energy is often stronger at night and in the winter. A hybrid system can generate a more constant flow of energy throughout the day and year by combining the two.

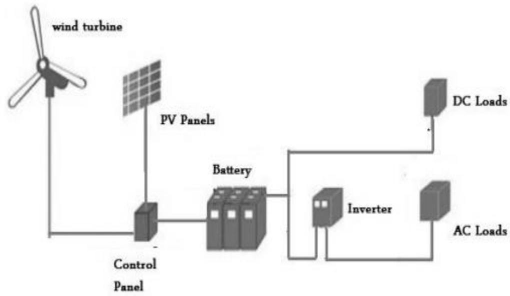

Fig. 2 *Hybrid system.*

A battery storage system is frequently connected to solar panels and wind turbines in a wind-solar hybrid system, allowing excess energy to be stored for use when there is less wind or sunlight. The system is made more dependable and adaptable by the ability to power homes, companies, and other facilities with the energy stored in the battery.

1.1.1.1. Solar Energy

Solar energy is defined as the renewable energy produced by utilising the sun's rays. As a sustainable and eco-friendly substitute for conventional energy sources like fossil fuels, solar energy is gaining popularity. Solar energy is typically produced through the use of photovoltaic (PV) cells found in solar panels, which transform sunlight into direct current (DC) electricity. An inverter converts the direct current (DC) electricity into alternating current (AC) electricity, which is then usable to power residences, commercial buildings, and other structures. Compared to conventional energy sources, solar energy has a number of benefits. First, because the sun is a limitless resource that is accessible throughout the majority of the planet, solar energy is abundant and renewable. Second, solar energy is clean and does not produce harmful emissions like greenhouse gases that contribute to climate change. Third, solar energy is cost-effective, as the cost of generating solar energy has decreased significantly over the years.

1.1.1.2. Wind Energy

The term "wind energy" refers to the clean energy produced by wind turbines, which use the kinetic energy of the wind to produce electricity. As a sustainable and eco-friendly substitute for conventional energy sources like fossil fuels, wind energy is gaining popularity. Large blades that are attached to a rotor and a generator make up a wind turbine. The rotor transforms the wind's kinetic energy into rotational energy after being captured by the blades. The rotational energy is then transformed by the generator into electrical energy, which can be used to run buildings such as residences and businesses. Compared to conventional energy sources, wind energy has a number of benefits. First off, as wind is an unlimited resource that is accessible in the majority of the world, wind energy is abundant and renewable. Second, using wind energy is safe and produces no hazardous emissions like those from greenhouse gases that cause climate change. Third, wind energy is economical since it is now much cheaper to produce wind energy than it was in the past.

2 BLOCK DIAGRAM

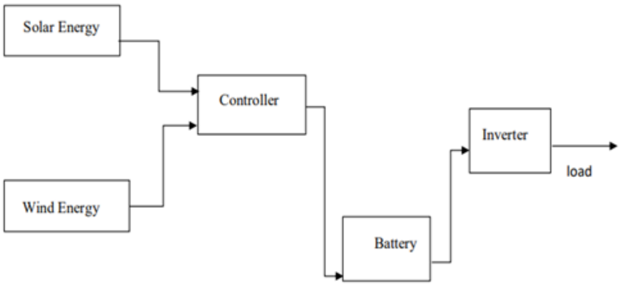

Fig. 3 *Block diagram*

This Block diagram represents that Solar energy and wind energy generated by the wind generator are integrated on the condition of currents equals, and given to the converter i.e. Boost converter. This boost converter increments the input voltage and gives 12V as output voltage. The output is a continuous DC supply, that will be stored in a battery bank of capacity 12000mah. Then the DC power can be converted into AC through the Inverter circuit. It is a square wave Inverter with two IRF Z44N MOSFET's and CD4047 IC. That AC output is given to the loads.

The components details used in this project is given below:

A solar panel, usually referred to as a photovoltaic (PV) panel, is a machine that uses sunlight to create electricity. Multiple solar cells made of silicon or other materials that can absorb light photons and release electrons to create an electric current make up solar panels. Typically, solar panels are installed on roofs or in other locations that receive sunlight. They are connected to an inverter, which transforms the electricity produced by the solar panels from direct current (DC) to alternating current (AC), which can be used to power buildings such as residences and businesses. Solar panel overproduction can either be stored in a battery storage system or redirected back into the power grid.

Table. 1 *Solar panel specifications*

Parameter	Value
Maximum Power	10 W
Vmax	18Volts
Imax	0.56Amps
Voc	21.6Volts
Vsc	0.64Amps
Rechargeable Battery	12Volts
Dimension	280*54*22
Weight	1.5kg

This solar charging circuit keeps the DC output voltage from the solar panel constant. Battery overcharging or overdischarge will be avoided.

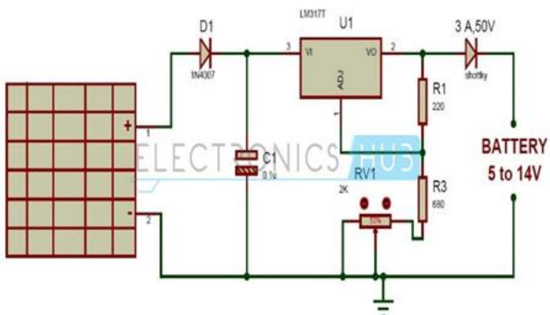

Fig. 4. Solar charging circuit block diagram

An apparatus that transforms wind energy into electrical energy is a wind turbine. A tower, rotor blades, a nacelle (which houses the generator, gearbox, and other components), and a foundation make up a wind turbine in most cases. Wind forces the rotor blades to revolve as it passes over them, which powers the generator in the nacelle to generate electricity. The electricity produced by the wind turbine can be put back into the electrical grid or used to power buildings such as residences, businesses, and other establishments. Wind turbines come in a variety of sizes, from tiny ones used to power one or two homes to massive ones found in wind farms that produce electricity on a far bigger scale. Depending on the availability of wind resources, wind turbines can also be erected onshore or offshore.

A device that transforms wind kinetic energy into electrical energy is referred to as a wind generator, wind turbine, or wind power plant. Typically, a wind turbine consists of a rotor with blades attached on it that spins in response to wind, and a generator that turns the rotational energy of the rotor into electrical energy. Vertical-axis wind turbines (VAWT) and horizontal-axis wind turbines (HAWT) are two different types of wind turbines. The most popular kind of wind turbines, HAWTs, have blades that revolve around a horizontal axis. In contrast, the blades of VAWTs revolve about a vertical axis. Instead of employing an alternator, the DC generator acts as a wind generator. in order to avoid dealing with AC voltage. The mechanical energy is transformed into electrical energy by this generator. DC output is produced by a DC generator when a turbine turns.

Table. 2. specifications

Parameter	**Value**
Type	PMDC
Material	Metal
Voltage	12v
Current	5A
Power	60W
Speed	1500 rpm

A DC-to-DC converter called a boost converter, often referred to as a step-up converter, raises the voltage of a DC power source. When the input voltage is high, a boost converter stores energy in an inductor, and when the input voltage is low, it releases that energy to the output.

The input voltage is connected to the switch, which is commonly a transistor or a MOSFET, in a boost converter's basic operation. When the switch is closed, current passes through the inductor, causing the magnetic field surrounding it to accumulate energy. The magnetic field collapses when the switch is opened, releasing energy to the output capacitor and load. The ratio of the inductor and capacitor values determines the boost converter's output voltage, which is greater than the input voltage. The switch's duty cycle, or how long it is closed relative to its overall period, can be changed to manage the output voltage.

1.1.2. Specifications:

Table. 3. Boost converter specifications

Parameter	**value**
Type	LM2577
Input voltage range	3v - 32v
Output voltage range	5v – 35v
Switching frequency	400KHz
MOSFET enable efficiency	94%

A lead acid battery was utilised in this project for energy storage. We made adjustments to two sets of series batteries in parallel and three batteries in series. Each battery has a 4v voltage and a 2A current. They are both rechargeable and re-usable. The capacity of each battery is 2000 milliamp hours.

An electrical circuit known as an inverter transforms direct current (DC) to alternating current (AC). Applications for inverter circuits include solar power systems, battery backup systems, and electronic gadgets that need AC power. An inverter circuit's fundamental operation is as follows: The circuit's input is linked with DC power, which the inverter circuit subsequently transforms into an AC waveform. The inverter can produce an AC waveform that is sinusoidal, square, or modified square, among other waveform types.

The primary component of this project is integration. Integrated both sources under an equal current situation. The output of the solar panel is sent to the solar panel charging circuit, while the output of the wind generator is sent to the dc generator charging circuit.

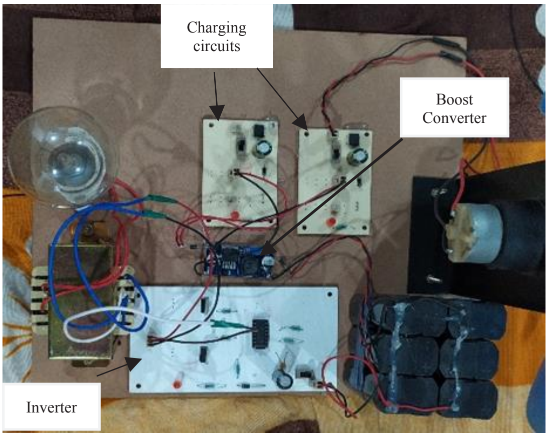

Fig.5. *Integrated circuit*

The boost converter receives the outputs from both charging circuits. The energy is amplified and sent to the battery bank via this boost converter. Energy will be stored in the battery bank, and the inverter circuit will receive the stored energy. Step-up transformer receives Dc to Ac conversion from the inverter circuit. The supplied 12V voltage will be increased to 230V using this step-up transformer.

3 Result

Following, the hardware results and the MATLAB results are roughly equal. The integration is successful, and it provides 220 volts constantly for three hours. Results from MATLAB for wind turbine output at various wind speeds and solar panel output at various irradiance.

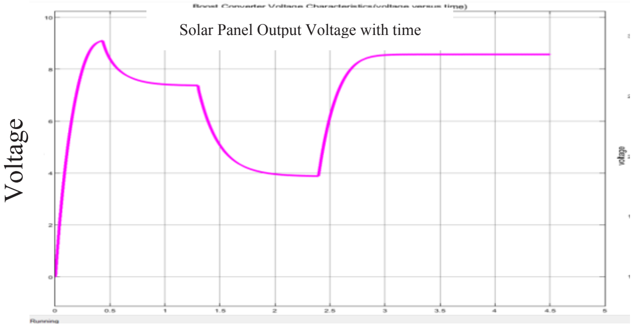

Fig.6. Solar output voltage (MATLAB)

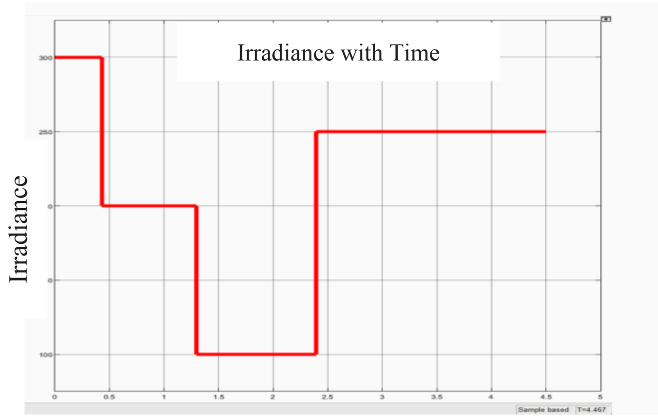

Fig.7. Irradiance (MATLAB)

This is the output voltage we are getting from solar array with respect to the irradiance. The maximum amplitude of our simulation is about 12.3v at 300 irradiance. With this we observed that output of the solar voltage depends on irradiance and temperature.

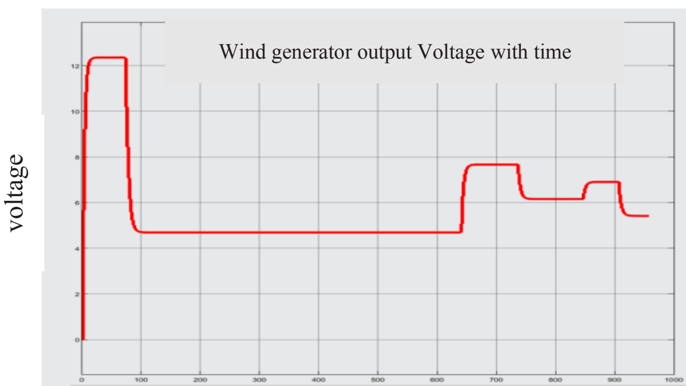

Fig.8. Wind output voltage (MATLAB)

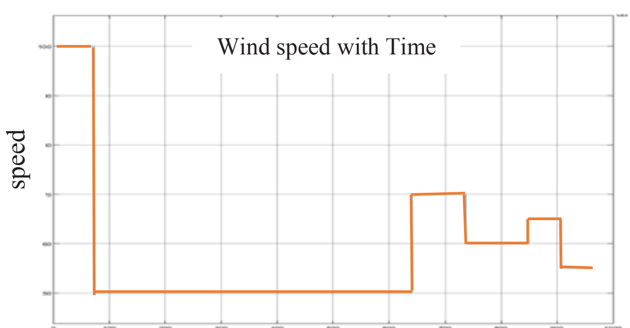

Fig.9. Wind speed (MATLAB*)*

According to the wind speed, this is the DC output voltage that the wind turbine generator is producing. At a wind speed of 100 m/s, the output voltage's maximum amplitude is 12.5 v. As a result, we saw that the output voltage rose as the wind speed rose.

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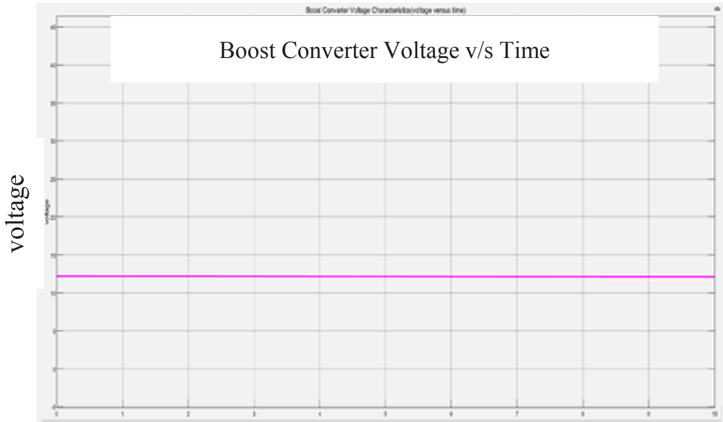

Fig.10. Boost converter output voltage

This is the constant DC output voltage that the boost converter provides. The battery stores the 12v continuous DC voltage that we get.

Table. 4. Solar voltage with respect to irradiance

Irradiance	**Voltage**
300	12.5
200	7.8
150	5.7
100	3.9
250	8.8
270	9.9

Table. 5. Wind generator voltage with respect to wind speed

Wind speed	**Voltage**
100	12
50	5.2
70	7.9
60	6.1
65	7
55	5.6

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When researching and designing a wind-solar hybrid system for domestic utility, the output is an important factor to consider. Understanding the system's predicted production can help establish the suitable system size and capacity, the kind and quantity of wind turbines and solar panels required, and the energy storage requirements.The output of wind-solar hybrid systems can also be used to find the best locations for such systems depending on the available wind and solar resources. This can be assessed by the analysis of historical wind and solar data, as well as the use of instruments such as wind and solar maps and software models. Furthermore, research can be directed towards optimising the output of wind-solar hybrid systems through the use of advanced control strategies and energy management techniques. This can involve using smart inverters to manage the output of the wind turbine and solar panels to fit the load demand, as well as using energy storage devices to balance the variable production.

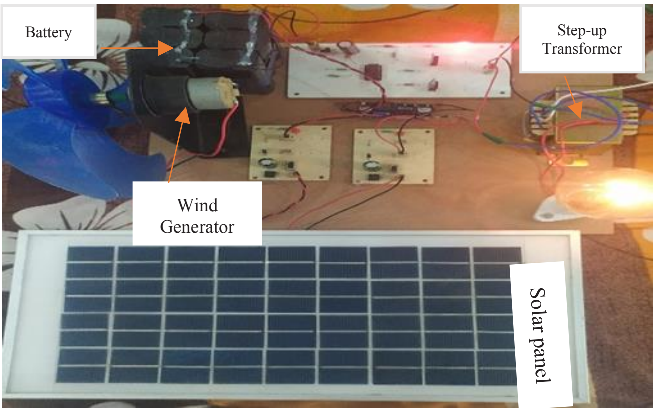

Fig.11. *Hardware output*

3 Conclusion

A wind-solar hybrid system for home utilities is an environmentally friendly and dependable source of energy. Despite its challenges and limitations, the system's advantages outweigh its disadvantages. The system's installation and operation require careful design, consideration, and routine maintenance. This project is very beneficial for home power backup. Solar and wind energy are both environmentally benign, renewable, and widely available. This reduces the cost of operation and maintenance.

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