INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)
VOLUME: 10 ISSUE: 04 | APRIL - 2026 SJIF RATING: 8.659 ISSN: 2582-3930

Dual Power Generation Using Solar Energy and Wind Energy

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Abstract: Dual power generation systems combine solar and wind energy to produce electricity in a more reliable and efficient manner compared to single-source systems. Solar panels generate power during daytime by converting sunlight into electrical energy, while wind turbines produce electricity from wind energy, which can be available during both day and night. By integrating these two renewable energy sources, the system ensures continuous power generation despite environmental variations.

This hybrid approach reduces dependence on conventional fossil fuels, minimizes power interruptions, and improves overall energy efficiency. The system typically includes photovoltaic panels, a wind turbine, charge controllers, a battery storage unit, and an inverter to supply consistent power to loads. Energy storage plays a crucial role in balancing supply and demand, ensuring electricity availability during low sunlight or wind conditions.

Dual power generation systems are especially beneficial in remote and rural areas where grid connectivity is limited. They offer a sustainable, eco-friendly, and cost-effective solution for meeting growing energy demands while reducing carbon emissions. The integration of solar and wind energy thus represents a promising step toward a cleaner and more resilient energy future.

Key Words - Renewable energy, Wind energy, Windmill, Electricity, Atmega328 microcontroller, Battery charging, Eco-friendly

INTRODUCTION

With increasing concerns about global warming and the depletion of fossil fuels, there is a growing demand for sustainable energy solutions. Renewable sources like wind and solar energy have significant potential to meet future energy needs. However, wind energy is highly unpredictable, as its availability fluctuates rapidly. Similarly, solar energy varies throughout the day due to changes in sunlight intensity and environmental factors. This intermittent nature makes both sources individually unreliable for continuous power supply.

To overcome this limitation, hybrid wind and solar systems are developed to improve reliability and efficiency. When one energy source is insufficient, the other can compensate for the power demand. The integration of Maximum Power Point Tracking (MPPT) algorithms further enhances energy extraction and system performance. Many existing systems use separate DC/DC converters for each source to achieve MPPT control. However, newer approaches propose simpler multi-input converter structures that combine both sources effectively. Additionally, reducing harmonic content and improving system design can increase efficiency and extend the lifespan of the overall system.

LITERATURE REVIEW

S. Rehman and L.M. Al-Hadhrami (2010),[1] who analyzed hybrid solar-wind power generation systems in *Renewable and Sustainable Energy Reviews*. Their study highlighted that combining solar and wind energy sources significantly improves system reliability and reduces fluctuations in power output compared to

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standalone systems. This work established the fundamental importance of hybridization in renewable energy systems.

N. N. Nema and R. K. Nema (2009) [2]in the *Renewable Energy Journal*, where they conducted a feasibility study on hybrid solar-wind systems. Their research demonstrated that such systems are economically viable, especially for rural and remote areas. The study emphasized cost-effectiveness, reduced dependency on conventional fuels, and suitability for decentralized energy generation.

H. Yang et al. (2008),[3] through their IEEE publication, explored grid-connected hybrid solar-wind systems. Their work showed that integrating hybrid systems with the electrical grid enhances overall system stability, improves energy efficiency, and ensures continuous power supply even during fluctuations in renewable energy availability.

A. Chauhan and R. P. Saini (2014) [4] *Energy Conversion and Management*. Their study focused on the operational characteristics of hybrid systems and concluded that the complementary nature of solar and wind energy ensures continuous energy generation. For example, solar energy is abundant during the day, while wind energy can be available during night or cloudy conditions, thus balancing overall power output.

A. Elhadidy (2002) [5] *Applied Energy* emphasized the importance of hybrid renewable systems for rural electrification. The study concluded that hybrid solar-wind systems are highly suitable for remote locations where grid connectivity is unavailable or unreliable. This work laid the foundation for using hybrid systems in off-grid applications

METHODOLOGY

The block diagram of the system contains a solar panel, buck converter and battery. The solar
panel is used to convert the solar energy to electrical energy. The normal voltage rating of the
solar panel used is 12V.The principle used is PHOTOELECTRIC EFFECT for the
conversion of solar energy to electrical energy. When light is incident upon a material
surface; the electrons present in the valence band absorb energy and get excited. They jump
to the conduction band and become free.

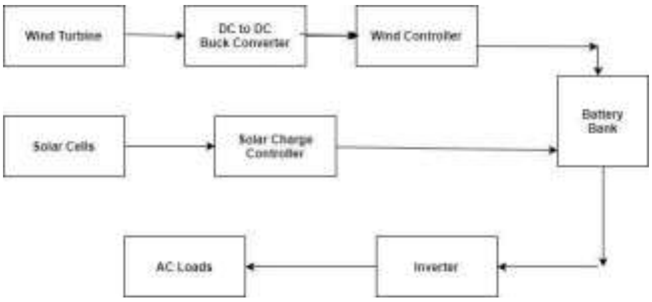

Fig: 1 Block diagram of the system

COMPONENTS USED:

I.SOLAR PANEL

A solar panel is a set of solar photovoltaic modules electrically connected and
mounted on a supporting structure. A photovoltaic module is a packaged, connected
assembly of solar cells. The solar panel can be used as a component of a larger
photovoltaic system to generate and supply electricity in commercial and residential
applications.

Fig :2 Solar panel

II.DC motor

A DC motor is an electromechanical device that converts direct current (DC) electrical energy into mechanical rotation. It consists of essential components such as the armature, commutator, brushes, and field magnets, which work together to produce motion. When electric current flows through the armature, a magnetic field is generated that interacts with the external magnetic field, causing the rotor to spin. DC motors are commonly used in applications like fans, pumps, robotics, and small machines due to their versatility. They are preferred for their simple construction, ease of speed control, and reliable performance.

Fig: *3* DC Motor

mineral, the manufacture of solar cells
(As with computer chips) has to be in a very clean environment.

III.Boost Converter

Although motor gives 60 RPM at 12V but motor runs smoothly from 4V to 12V and gives wide range of RPM, and torque, 60RPM Centre Shaft

Fig: 4 Boost Converter

Economy Series DC Motor is high-quality low-cost DC geared motor.
A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter). Battery power systems often stack cells in series to achieve higher voltage.

IV.Micro controller board (Arduino nano)

A charge controller or charge regulator is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the

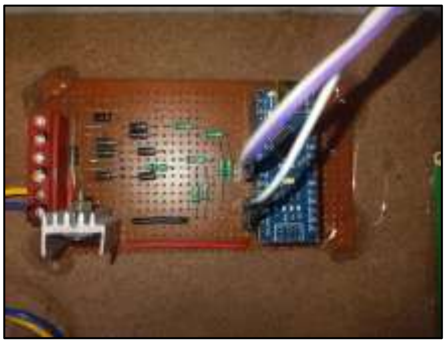

Fig: 5 Micro controller board (Arduino nano)

Voltage and current coming from the solar panels going to the battery. Most "12 volt" panels put out about 16 to 20 volts, so if there is no regulation the batteries will be damaged from overcharging. Most batteries need around 14 to 14.5 volts to get fully charged.

V.7805 Voltage Regulator

The 7805 is an adjustable 3-terminal positive voltage regulator capable of supplying different
DC voltage outputs other than the fixed voltage power supply of +5 or +12 volts, or as a

variable output voltage from a few volts up to some maximum value all with currents of about 1.5 amperes.

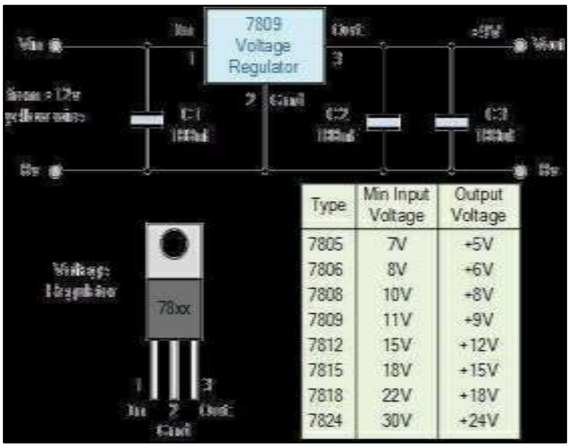

Fig. 6:7805 Voltage Regulator

The electrical energy produced by the system is need to be either utilized completely or stored. Complete utilization of all the energy produced by the system for all the time is not possible. So, it should be store rather than useless wasting it. Electrical batteries is the most relevant, low cost, maximum efficient storage of electrical energy in the form of chemical reaction.

VI.LCD Display (16*2)

The 16×2 LCD display is a widely used output device capable of displaying 16 characters in each of its two lines. It is commonly used in embedded systems to show text, numerical data, and system status messages. The display operates based on the HD44780 controller and can be easily interfaced with microcontrollers such as Arduino. It supports both 4-bit and 8-bit communication modes, which helps in reducing the number of required input/output pins. Due to its low power consumption, simplicity, and ease of use, it is widely preferred in various electronic projects.

Fig: 7 LCD Display (16*2)

VII.Lead acid Battery

A lead-acid battery is a rechargeable energy storage device widely used in automobiles, backup power systems, and solar applications. It consists of lead dioxide as the positive plate, sponge lead as the negative plate, and sulfuric acid as the electrolyte.

Fig;8 Lead acid Battery

When the battery discharges, a chemical reaction occurs to produce electrical energy, and this process is reversed during charging. Lead-acid batteries are known for their low cost, reliability, and ability to deliver high surge currents. Due to these advantages, they are commonly used in various electrical and electronic systems.

VIII.INVERTER

An inverter is a motor control that adjusts the speed of an AC induction motor. It does this by varying the frequency of the AC power to the motor.

Fig: 9 Inverter

An inverter also adjusts the voltage to the motor. This process takes place by using some intricate electronic circuitry that controls six separate power devices. They switch on and off to produce a simulated three phase AC voltage.

IX.Vertical axis wind mill (savonius blades)

A vertical axis wind turbine with Savonius blades is a simple device used to convert wind energy into mechanical energy, rotating on a vertical axis. It uses curved blades that capture wind through drag force, allowing it to operate efficiently even at low wind speeds.

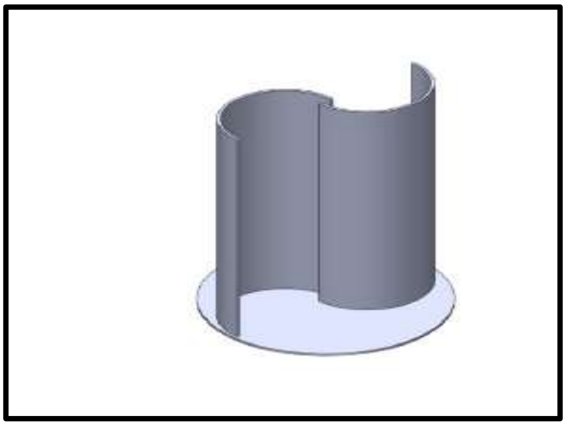

Fig: 10 **Vertical axis wind mills (savonius blades)**

The Savonius design is easy to construct, cost-effective, and does not require alignment with wind direction. It is suitable for small-scale power generation in both urban and rural areas. Due to its simple structure, durability, and low maintenance, it is widely used in renewable energy projects.

X.Gears

Gears are mechanical components consisting of toothed wheels used to transmit motion and power between rotating shafts.

Fig: 11 Gears

They work by meshing with one another to change the speed, torque, or direction of rotation. Gears can be made from materials such as metal or plastic depending on the application and required strength. There are various types of gears, including spur, helical, bevel, and worm gears, each designed for specific functions. They are widely used in machines like automobiles, clocks, and industrial equipment for efficient power transmission.

XI.**Pillow block bearing**

A pillow block bearing is a type of mounted bearing used to support and guide a rotating shaft. It consists of a bearing enclosed within a housing block, which is securely mounted on a base or

Fig.12 **Pillow block bearing**

surface. The housing is typically made of cast iron, providing strength, stability, and durability. It helps reduce friction between moving parts and ensures smooth and efficient rotation. Pillow block bearings are

VOLUME: 10 ISSUE: 04 | APRIL - 2026 SJIF RATING: 8.659 ISSN: 2582-3930

commonly used in conveyors, agricultural equipment, and various industrial machines.

WORKING

The dual power generation system using solar and wind energy is designed to generate electricity from two renewable sources for improved efficiency and reliability. The system consists of main components such as a solar panel, vertical axis wind turbine (Savonius type), charge controller, battery, generator, and necessary electrical connections. The solar panel is installed at an appropriate angle to capture maximum sunlight, while the wind turbine is placed in an open area to utilize wind energy effectively. The turbine rotates due to wind force and drives a generator to produce electrical energy, whereas the solar panel converts sunlight directly into electricity using photovoltaic cells. Both energy outputs are fed into a charge controller, which regulates voltage and current, preventing overcharging and ensuring safe battery operation. The generated energy is stored in a rechargeable lead-acid battery for later use. Proper wiring, switches, and protection devices are included to ensure safe and efficient operation. During daytime, the solar panel generates power, while the wind turbine produces energy whenever wind is available, allowing both sources to work simultaneously. This hybrid system ensures continuous power supply even when one source is unavailable. It reduces dependence on conventional energy, is environmentally friendly, and is suitable for small-scale applications such as homes and agricultural fields. Thus, the system enhances overall efficiency, reliability, and sustainability of power generation.

RESULT
Solar Panel Output (15V)

Depends on sunlight intensity

Typical results:

Bright sunlight → ~15V, good current

Cloudy weather → 8–12V
Wind Generator Output (15V)

Depends on wind speed

Typical results:

High wind → ~12–15V

Low wind → 5–10V
Wind Generator Output (15V)

- Depends on wind speed
- Typical results:
- High wind → ~12–15V
- Low wind → 5–10V

Combined Output (Hybrid Result)

Case 1: Only Solar Available

- Output: ~12–15V
- Battery charges normally

Case 2: Only Wind Available

- Output: ~8–15V
- Battery charges depending on wind speed

Case 3: Both Solar + Wind Available

- Voltage: ~30— 40V (regulated by battery)
- Current: Increased (sum of both sources)
- Faster battery charging
- Better efficiency Battery Charging Result
- Charging is:
- Slow → single source
- Fast → both sources

Fig.12: DUAL POWER GENARATION USING SOLAR ENERGY AND WIND ENERGY

CONCLUSION

The dual power generation system successfully demonstrates the effective use of solar
and wind energy to produce electricity. By combining two renewable sources, the
system ensures a continuous and reliable power supply under different environmental
conditions.

• Solar energy generates power during the daytime, while wind energy can generate
power both day and night depending on wind availability. This complementary nature
improves the overall efficiency and performance of the system compared to single source
generation.

• The integration of components such as solar panels, wind turbines, rectifiers, batteries, and control units enables efficient energy conversion, storage, and
utilization. The use of a microcontroller and LCD display also helps in monitoring
system performance.

• Overall, this system is:

o Eco-friendly and reduces pollution

o Cost-effective in the long run

o Suitable for rural and remote areas

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