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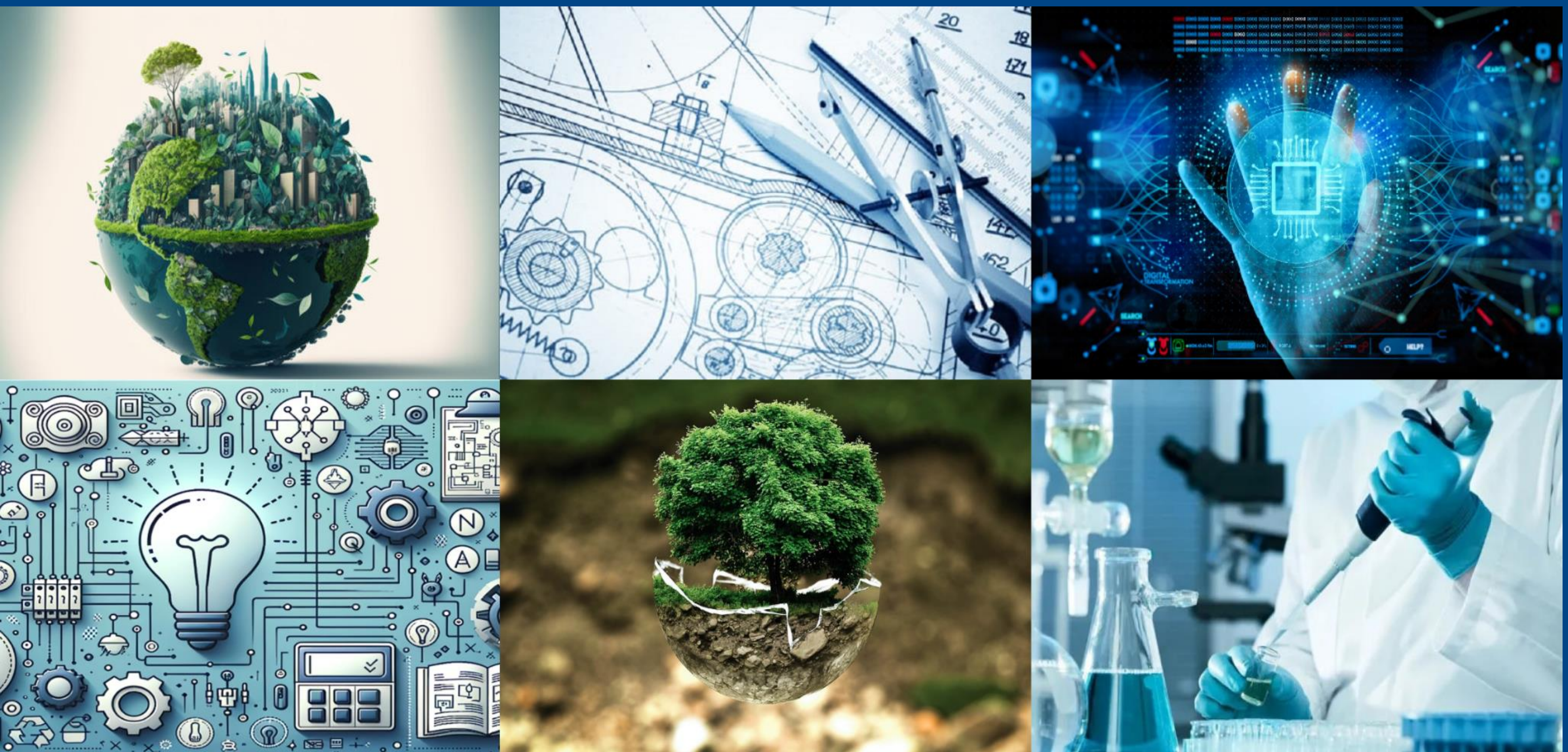

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www.ijmrset.com ijmrset@gmail.com +91 6381 907 438 +91 63819 07438

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Dual Power Generation Solar + Windmill System

Vikram Kamble[1], Sanskar Zagade[2], Kshitij Chavan[3], Vedant Biramane[4], Prof.Gaurav Modak[5]

Diploma Student, Department of Electrical Engineering, Zeal Polytechnic, Pune, India[1-4]

Lecturer, Department of Electrical Engineering, Zeal Polytechnic, Pune, India[5]

ABSTRACT: This project presents a sustainable and innovative approach to harnessing renewable energy sources, aligning with Sustainable Development Goal 7 (SDG7) for affordable and clean energy by 2030. The increasing demand for renewable energy has led to the development of a dual power generation system that combines solar and windmill energy to efficiently charge a 12V battery using an Arduino Uno microcontroller. The system optimizes energy production by utilizing both solar and wind resources simultaneously, reducing reliance on non-renewable energy sources and mitigating climate change. By harnessing the power of nature, this project demonstrates a cost-effective and reliable solution for electricity generation, contributing to a sustainable future. The system's ability to smartly sense and charge the battery while displaying the voltage on an LCD screen enhances its efficiency and user-friendliness. Furthermore, the project showcases the potential for renewable energy to provide energy access to underserved communities, promoting energy equity and social justice. Overall, this project highlights the importance of transitioning to renewable energy sources and provides a viable solution for achieving a sustainable energy future.

KEYWORDS: DUAL POWER GENERATION, SOLAR, WINDMILL

I. INTRODUCTION

The world is witnessing a significant shift towards renewable energy sources as concern over climate change, energy security, and sustainable development continues to grow, prompting a global response to reduce dependence on non-renewable energy resources, which are not only depleting at an alarming rate but also contributing to environmental degradation and escalating costs, thereby necessitating the exploration of alternative energy sources that are clean, sustainable, and abundant, such as solar and wind energy, which have emerged as promising solutions to the global energy challenge, and in response to this challenge, this project aims to design and develop a dual power generation system that harnesses the power of solar and wind energy to generate electricity, thereby providing a reliable, efficient, and cost-effective solution for electricity generation, aligning with the United Nations' Sustainable Development Goal 7 (SDG7) of ensuring affordable, reliable, sustainable, and modern energy for all by 2030, and demonstrating the potential of renewable energy to mitigate climate change, promote energy security, and foster sustainable development, while also showcasing the importance of innovation and technological advancements in addressing the global energy challenge and creating a sustainable energy future.

II. LITERATURE REVIEW

The world is witnessing a significant shift towards renewable energy sources as concern over climate change, energy security, and sustainable development continues to grow, prompting a global response to reduce dependence on non-renewable energy resources, which are not only depleting at an alarming rate but also contributing to environmental degradation and escalating costs, thereby necessitating the exploration of alternative energy sources that are clean, sustainable, and abundant, such as solar and wind energy, which have emerged as promising solutions to the global energy challenge, and in response to this challenge, this project aims to design and develop a dual power generation system that harnesses the power of solar and wind energy to generate electricity, thereby providing a reliable, efficient, and cost-effective solution for electricity generation, aligning with the United Nations' Sustainable Development Goal 7 (SDG7) of ensuring affordable, reliable, sustainable, and modern energy for all by 2030, and demonstrating the potential of renewable energy to mitigate climate change, promote energy security, and foster sustainable development, while also showcasing the importance of innovation and technological advancements in addressing the global energy challenge and creating a sustainable energy future.

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III. METHODOLOGY

1. Windmill: Design and develop a horizontally rotating windmill prototype to generate electricity.
2. Solar Panel: Use silicon-based wafers cascaded together to form a solar panel for electricity generation.
3. Arduino Uno Microcontroller: Utilize Arduino Uno to smartly sense and charge the battery while displaying voltage on the LCD.
4. 12V Battery: Employ a 12V battery to store energy generated by the windmill and solar panel.
5. LCD Display: Use an LCD display to show the voltage level of the battery.
6. Rotating Panel: Design a rotating panel to mount the solar panel, allowing it to adjust to maximum daylight exposure.

Hardware Methodology Components

IV. WORKING PRINCIPLE

The *Dual Power Generation Solar Plus Windmill System* works by harnessing renewable energy from two natural sources: solar and wind. The system uses a solar panel, mounted on a rotating servo motor controlled by an Arduino Uno, to track and maximize sunlight exposure throughout the day. The solar panel generates DC electricity, which charges a 12V battery through a blocking diode to prevent reverse current flow. Simultaneously, a horizontally rotating wind turbine generates AC electricity when wind is present. This AC power is converted to DC using a full-bridge rectifier and regulated to 12V to charge the same battery. The Arduino Uno acts as the brain of the system, monitoring the voltage levels from both sources and the battery. The measured voltage is displayed on an LCD screen for real-time monitoring. Additionally, the battery powers a connected load, such as a lamp or LED, through a relay controlled by the Arduino. This intelligent system ensures efficient energy utilization by combining two renewable sources, enabling faster charging and uninterrupted power supply, while promoting sustainability and aligning with *SDG7* for modern, reliable, and sustainable energy access.

V. CIRCUIT DIAGRAM

This circuit diagram represents the interfacing of an ESP8266 NodeMCU with an L298N motor driver to control two DC motors using a 12V DC power supply.

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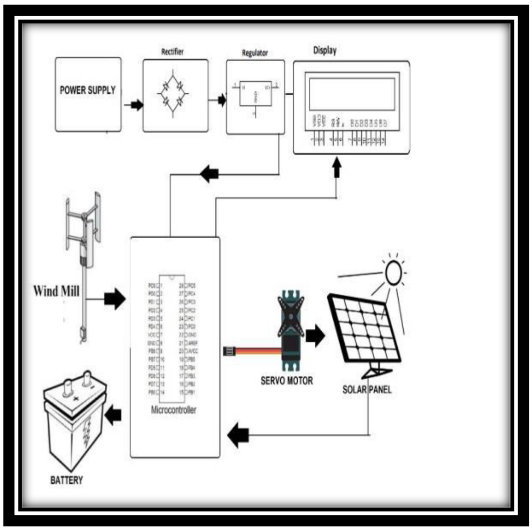

1. Arduino Uno:
The Arduino Uno is a microcontroller board based on the ATmega328P. It's one of the most popular and widely used Arduino boards.
2. DC Bulb:
DC lights such as LED fixtures should have DC supplied to them via a DC power source. Unfortunately, alternating current (AC) power is usually what they get (because power grids distribute AC power). This means that LED fixtures, and other DC lighting, need to convert the AC power they get, into the DC power they need
3.Voltage Regulator:
A Voltage Regulator (VTG Regulator) is an electrical circuit that regulates the output voltage to a specific value, despite changes in the input voltage or load conditions. It is commonly used in electronic devices to provide a stable and reliable voltage supply.

VI. FUTURE SCOPE

1. **Renewable Energy Integration**
Hybrid Systems (Solar + Wind + Battery Storage): The combination of solar and wind with battery storage systems can provide a more stable and reliable power supply. As renewables are intermittent, having multiple energy sources working together helps to mitigate issues related to the variability of solar and wind.
Solar + Biomass: In rural and off-grid areas, combining solar power with biomass generators (such as biogas or agricultural waste) can create a continuous energy supply. Solar can generate during the day, while biomass can provide power at night or during cloudy days.
2. Smart Grids and Microgrids
Dual power generation systems can be integrated into **smart grids** and **microgrids** for localized, decentralized energy distribution. For example, a microgrid could use both solar and diesel generators as a backup during periods of low renewable output. As energy storage and grid management technologies improve, these hybrid setups will become more efficient, reducing reliance on fossil fuels.
Grid Flexibility: Dual generation systems can be used to maintain grid stability by switching between different power sources as needed. This could help utilities manage the transition to 100% renewable grids.
3. Energy Storage Systems
Combining **energy storage** (such as batteries) with power generation can be very effective in ensuring a continuous power supply. For example, a dual system of wind energy and storage allows for energy production when the wind is strong, while storing energy for use when it slows down.

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Hydropower + Solar: In some regions, hydropower can act as a storage reservoir for solar energy. Excess solar power can be used to pump water into higher altitudes for later use in generating hydroelectric power when solar output is low.

4. Electric Vehicles (EV) and Charging Stations

The integration of dual power systems into EV charging stations, where solar panels power the station during the day, and the grid (or another power source) takes over at night, can create self-sustaining charging infrastructure. This can support a growing EV market and help reduce the demand on the main grid.

5. Combined Heat and Power (CHP) Systems

Dual generation in the form of **combined heat and power (CHP)** systems, where heat and electricity are produced simultaneously, has significant potential. By using both natural gas and renewable sources like biomass or solar thermal, CHP systems can be highly efficient, reducing waste and improving energy output.

6. Industrial Applications

Many industrial applications require continuous and reliable energy. **Dual-fuel power plants** (e.g., natural gas + biomass or solar + diesel) can be used to ensure reliability in case one source is unavailable. Such systems would be especially useful in remote or off-grid locations where energy demand is high but renewable resources may not be consistently available.

7. Hydrogen Production and Storage

Hydrogen as an energy carrier could play a major role in dual power generation. Solar or wind power can be used to generate electricity that splits water into hydrogen and oxygen (via electrolysis). The hydrogen can be stored and used as a fuel for power generation when demand is high or renewable resources are low.

8. Off-Grid and Remote Applications

For off-grid or remote locations, dual power generation is particularly valuable. A combination of solar or wind with backup generators (diesel, biomass, etc.) can provide uninterrupted power supply. Innovations in **mini-grids** and **stand-alone power systems** that integrate these technologies will enable energy access in areas without a centralized grid.

9. Global Decarbonization

As countries push toward **carbon neutrality**, dual power generation systems can contribute to reducing emissions. For instance, combining clean energy sources (like wind, solar, and hydro) with cleaner fossil fuels (like natural gas) or hydrogen can help ease the transition from traditional fossil fuels toward a fully renewable-based energy system.

10. Carbon Capture and Storage (CCS) Integration

For regions still relying on fossil fuels, dual power systems that combine **carbon capture and storage (CCS)** with renewable power generation could significantly reduce emissions. A dual approach, such as integrating CCS with gas turbines that use renewable energy for auxiliary power, can help achieve low-emission power production.

VII. RESULT

The project yielded a fully functional Dual Power Generation Solar + Windmill System with a 16x2 LCD Display Module, a VTG Regulator, a Servomotor, and a Vertical Wind Mill. The system successfully integrates solar and wind energy to generate electricity, providing a reliable and efficient power supply.

VIII. CONCLUSION

Dual Power Generation holds immense promise for the future, offering an effective and sustainable way to integrate multiple energy sources for more reliable, efficient, and resilient power systems. The combination of renewable energy sources like solar, wind, and biomass with traditional or emerging technologies such as energy storage, hydrogen, or backup generators can address the intermittency of renewable power and meet the growing global energy demands.

As the world moves towards cleaner energy, dual generation systems are poised to play a critical role in enhancing grid stability, facilitating the transition to low-carbon energy systems, and supporting industrial and off-grid applications. Additionally, they offer potential for reduced emissions, improved efficiency, and cost savings in the long term.

While challenges such as high initial costs, energy storage solutions, and regulatory adaptation need to be addressed, the ongoing advancements in technology and policy frameworks will make dual power generation increasingly viable and essential. Ultimately, it is a key component in the journey toward a sustainable, resilient, and decarbonized energy future.

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