

# Solar Wind Hybrid Microgrid System

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**Abstract:** *The increasing demand for electricity and the environmental impact of conventional fossil-fuel-based power generation have led to the development of renewable energy systems. This project presents the design and analysis of a solar-wind hybrid microgrid system that integrates solar photovoltaic (PV) panels and wind turbines to generate sustainable electrical power. The main objective of the system is to provide a reliable and continuous power supply by utilizing multiple renewable energy sources.*

*In this system, solar panels generate electricity during daytime using sunlight, while wind turbines produce power when sufficient wind energy is available. A hybrid controller and power conditioning unit manage the energy generated from both sources and regulate the power flow to the load and battery storage system. The battery bank stores excess energy and supplies power during periods of low solar radiation or insufficient wind speed.*

*The proposed hybrid microgrid improves system reliability, reduces dependency on fossil fuels, and minimizes greenhouse gas emissions. It is particularly suitable for remote or rural areas where grid connectivity is limited or unavailable. The system demonstrates an efficient and environmentally friendly solution for decentralized power generation.*

**Keywords:** Solar energy, Wind energy, Hybrid microgrid, Renewable energy, Battery storage, Power generation

## I. INTRODUCTION

The rapid increase in global energy demand has created serious challenges for conventional power generation systems. Traditional energy sources such as coal, oil, and natural gas are not only limited but also cause environmental pollution and global warming. As a result, there is a growing need to develop alternative energy sources that are renewable, clean, and sustainable. Solar energy is one of the most abundant renewable energy resources available on earth. It is captured using photovoltaic (PV) panels which convert sunlight directly into electrical energy. Solar power generation is simple and environmentally friendly, but its availability is limited to daylight hours. Wind energy is another important renewable energy source that is produced by converting the kinetic energy of moving air into electrical energy using wind turbines. Wind power is widely used in many countries, but it also depends on weather conditions and wind speed variations. A microgrid is a small-scale power system that can operate independently or in connection with the main power grid. Microgrids are commonly used in rural or isolated areas where extending the main grid is difficult. By integrating renewable energy sources into a microgrid system, it is possible to provide reliable electricity while reducing environmental impact. The Solar-Wind Hybrid Microgrid System combines both solar and wind energy sources in order to improve reliability and efficiency of power generation. This hybrid approach ensures continuous electricity supply by utilizing the strengths of both renewable energy resources. Energy demand is increasing rapidly while conventional fossil fuel resources are decreasing. Renewable energy sources such as solar and wind energy provide a clean and sustainable alternative. However, solar energy depends on sunlight availability and wind energy depends on wind speed. Combining both sources in a hybrid microgrid improves power reliability and efficiency. A



microgrid is a localized energy system capable of operating independently or connected to the main grid. Solar–wind hybrid microgrids are particularly useful for rural and remote areas

An inverter is a power electronic device that converts direct current (DC) into alternating current (AC) and is widely used in domestic, commercial, and industrial applications. In recent years, the use of inverters and backup power supplies has increased significantly. During grid failure or maintenance conditions, these inverter systems can feed electrical power back into the distribution line, even when the main supply is disconnected. This phenomenon is known as inverter reverse current.

Inverter reverse current refers to the flow of current from the consumer side or inverter system back into the grid or distribution line. This reverse feeding can occur due to grid faults, low load conditions, or improper isolation of inverter systems. Such backfeeding energizes the power lines unexpectedly, creating extremely dangerous conditions for linemen who assume the line is de-energized. As a result, linemen are exposed to severe electric shock hazards, which can lead to serious injuries or fatal

## **II. LITERATURE REVIEW**

Researchers around the world have studied hybrid renewable energy systems to improve the reliability and efficiency of power generation. In one research study on hybrid renewable energy systems for microgrid applications, solar photovoltaic panels were combined with wind turbines to create a reliable power generation system. The research showed that hybrid systems provide better energy stability compared to single-source renewable systems. Another research paper focused on the design and analysis of solar-wind hybrid power generation systems. The study explained how combining solar and wind energy can reduce power fluctuations and improve system performance. The researchers also highlighted the importance of battery storage and power electronic converters in maintaining stable power output. A third study discussed renewable energy microgrids used for rural electrification. The study concluded that hybrid renewable energy systems are particularly suitable for remote areas where grid electricity is not available. These systems help reduce dependency on fossil fuels and promote sustainable energy development. Although hybrid renewable systems offer many advantages, there are still challenges such as high initial installation cost, energy storage limitations, and the need for efficient energy management systems. Future research focuses on improving these areas to make hybrid systems more affordable and efficient.

### **Problem Statement**

Despite the advantages of renewable energy sources, several problems exist when they are used individually. Solar energy generation depends entirely on sunlight availability. During nighttime or cloudy weather conditions, solar panels cannot generate sufficient electricity. Similarly, wind energy generation depends on wind speed. If wind speed is low, the wind turbine cannot generate sufficient electrical power. This variation in renewable energy sources creates a challenge in maintaining continuous electricity supply. Another issue is that rural and remote areas often lack reliable electricity supply due to distance from the main power grid. Extending grid infrastructure to these locations can be expensive and technically difficult. Because of these challenges, there is a need for an efficient and reliable hybrid renewable energy system that combines multiple energy sources. By integrating solar and wind energy, the system can ensure continuous power generation even when one energy source is not available.

### **Objective**

- \* To generate electrical power using solar and wind energy.
- \* To design a hybrid renewable energy system.
- \* To improve reliability of power supply.
- \* To store excess energy using battery storage.
- \* To reduce dependence on fossil fuels.
- \* To provide clean and sustainable energy.



### III. METHODOLOGY

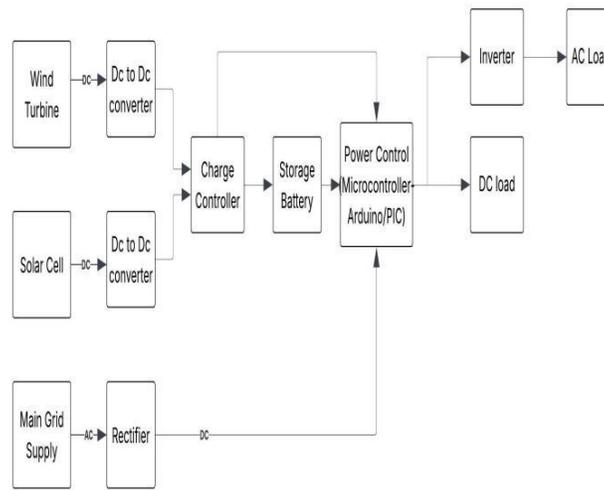


Fig. block diagram

The methodology describes the step-by-step process used to design, develop, and analyze the solar-wind hybrid microgrid system.

#### 1. Resource Assessment

The first step is to study the availability of solar radiation and wind speed in the selected area. Data about sunlight intensity and average wind speed is collected to determine whether the location is suitable for generating power using solar panels and wind turbines.

#### 2. System Design

Based on the resource assessment, a hybrid system is designed that combines solar photovoltaic (PV) panels and a wind turbine. The design includes components such as:

- Solar PV panels
- Wind turbine generator
- Charge controller
- Battery storage system
- Inverter
- Load (electrical devices)

The design ensures that both energy sources can operate together efficiently.

#### 3. Power Generation

Solar panels convert sunlight into electrical energy during the daytime, while the wind turbine generates electricity when wind flows through the blades. Both sources produce DC power, which is regulated through controllers.

#### 4. Energy Management and Control

A hybrid charge controller manages the power produced by both solar and wind sources. It regulates the charging and discharging of the battery and protects the system from overcharging or voltage fluctuations.

#### 5. Energy Storage

The generated energy is stored in battery banks. When renewable sources generate excess power, it is stored in the batteries. During periods of low sunlight or wind, the stored energy is used to supply power to the load.

#### 6. Power Conversion

An inverter converts the stored DC power into AC power so that it can be used by household appliances or other electrical loads.



### **7. System Testing and Performance Analysis**

Finally, the system is tested to evaluate its performance. Parameters such as power output, efficiency, battery charging levels, and system reliability are analyzed to ensure the hybrid microgrid operates effectively

Implementation of the System :-

1. Solar panels are installed to generate electricity from sunlight.
2. Wind turbines are installed to generate electricity from wind.
3. The output from both sources is connected to a charge controller.
4. The charge controller regulates power flow to the battery.
5. Batteries store excess electrical energy.
6. An inverter converts DC power into AC power.
7. The AC output is supplied to the electrical load.
8. The system automatically switches between solar and wind sources.
9. The hybrid system provides reliable and continuous power supply.

### **Implementation Summary**

The implementation of the solar-wind hybrid microgrid system involves integrating solar photovoltaic panels and a wind turbine to generate renewable electrical power. In this project, solar panels are installed to capture sunlight and convert it into direct current (DC) electricity, while a wind turbine is used to generate electricity from wind energy. Both energy sources are connected to a hybrid charge controller that regulates the power flow and ensures efficient energy management.

The generated power is stored in a battery bank for later use. The battery plays an important role in providing continuous electricity when solar radiation is low or when wind speed is insufficient. A charge controller protects the battery from overcharging and maintains stable voltage levels within the system.

An inverter is used to convert the stored DC power into alternating current (AC), which can be used to operate household appliances or other electrical loads. The system is tested under different environmental conditions to evaluate its efficiency, reliability, and performance.

### **Result**

The Solar-Wind Hybrid Microgrid System provides reliable electricity generation using renewable energy sources.

The combination of solar and wind energy improves the efficiency and reliability of the system. When solar energy generation decreases during cloudy weather or night time, wind energy can supply the load. Similarly, when wind energy is low, solar energy can generate power.

The battery storage system helps in storing excess energy and supplying it when generation is low. This ensures continuous power supply.

The system is environmentally friendly and reduces carbon emissions.

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