# A Review Paper on Intelligent IoT Platform for Performance Analysis of Solar-Wind Hybrid Systems

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***Abstract*—The Intelligent IoT Platform for Performance Analysis of Solar–Wind Hybrid Systems integrates smart sensors, cloud connectivity, and real-time data analytics to evaluate and optimize the combined performance of solar and wind energy sources. By enabling continuous monitoring, fault detection, and efficiency assessment, the platform enhances system reliability, energy output, and overall operational sustainability. The rapid growth of renewable energy has increased the adoption of hybrid solar–wind systems to ensure reliable and sustainable power generation. However, managing and optimizing the performance of these systems remains challenging due to the intermittent nature of solar and wind resources. This study presents an Intelligent IoT Platform for Performance Analysis of Solar–Wind Hybrid Systems, which integrates real-time monitoring, data analytics, and predictive control. The platform collects operational data including voltage, current, power output, irradiance, wind speed, and battery state of charge through IoT-enabled sensors and transmits it to a cloud-based analytics framework. Using advanced algorithms, the system performs performance evaluation, fault detection, and energy optimization, enabling proactive maintenance and improved reliability.**

***Index Terms*—Cloud Monitoring, Data Analytics, ESP32, Hybrid Renewable Energy System, Internet of Things (IoT), Performance Analysis, Remote Monitoring, Solar-Wind Hybrid System, Smart Energy Management, Wireless Sensor Network.**

## I. INTRODUCTION

The growing demand for clean and sustainable energy has accelerated the adoption of hybrid renewable energy systems that combine solar and wind power. While these systems offer improved reliability and higher energy generation compared to standalone sources, their performance is significantly influenced by varying environmental and operational conditions. To ensure maximum efficiency, stability, and real-time control, there is a need for advanced monitoring and intelligent analysis tools.

An Intelligent IoT Platform provides a modern solution by integrating smart sensors, communication technologies, cloud computing, and data analytics to continuously assess the performance of Solar–Wind Hybrid Systems. Through real-time data acquisition and intelligent processing, the platform enables accurate performance evaluation, prediction of power generation, and early detection of system faults. This enhances operational reliability, minimizes downtime, and supports predictive maintenance.

Furthermore, the IoT-driven approach offers remote accessibility, scalability, and automation, allowing operators to make informed decisions for optimizing energy output.

## II. LITEATURE SURVEY

1. A Smart Monitoring of Hybrid Mini Wind-Solar System Using IoT Application.
Author: Ahmad Syahid Kamaluddin, Siti Amely Jumaat
Publication: Evolution in Electrical and Electronic Engineering
Publication Year: 2022
Finding:
This paper presented a smart monitoring system for a hybrid mini wind-solar setup using Node MCU

ESP8266 and the Blynk IoT platform. Sensors were used to monitor current, voltage, and power generated by the renewable system. The study showed that IoT applications enable automatic data collection and remote monitoring, thereby improving operational efficiency and reducing manual supervision requirements.

2. Monitoring of IoT-based Wind and Solar Hybrid Power Plants for Agricultural Irrigation Systems.
Author: Budhi Prasetiyo, Wiwik Purwati Widyaningsih, Yusuf Dewantoro H, Suwarti
Publication: Eksergi Journal
Publication Year: 2022
Finding:
The authors designed an IoT-based monitoring system for wind and solar hybrid power plants used in agricultural irrigation systems. The system used ESP32, voltage sensors, current sensors, wind speed sensors, and water flow sensors for data collection. The research concluded that IoT-based monitoring improves reliability, performance tracking, and fault identification in renewable energy applications.

3. Unified Environment for Real Time Control of Hybrid Energy System Using Digital Twin and IoT Approach
Author: Lamine Chalal, Allal Saadane, Ahmed Rachid
Publication: Sensors (MDPI)
Publication Year: 2023
Finding:
This research introduced a digital twin and IoT-based framework for real-time monitoring and control of hybrid energy systems. The system collected operational data from renewable sources and processed it through cloud-based platforms. The study highlighted that digital twin technology combined with IoT improves predictive maintenance, system optimization, and operational reliability in renewable energy systems.

4. A Hybrid Solar Photovoltaic and Wind Turbine Power Generation for Stand-Alone System with IoT-Based Monitoring and MPPT Control
Authors: R. Priyadharsini and R. Kanimozhi
Publication: A Hybrid Solar Photovoltaic and Wind Turbine Power Generation for Stand-Alone System with IoT-Based Monitoring and MPPT Control
Publication Year: 2024
Finding:
The authors proposed an IoT-based hybrid solar and wind energy system for stand-alone applications. The system used Maximum Power Point Tracking (MPPT) techniques to improve power extraction efficiency from renewable sources. IoT technology enabled real-time monitoring of voltage, current, and power parameters through cloud platforms.

## III. OBJECTIVES

To achieve the above aim, the following objectives have been identified:

I. Real-Time Data Acquisition: To design a robust sensor network (using voltage, current, anemometers, and pyranometers) capable of capturing high-frequency data from both solar and wind components simultaneously.
II. Edge-to-Cloud Connectivity: To establish a seamless communication architecture using protocols like MQTT or LoRa WAN to transmit field data to a centralized cloud platform with minimal latency.
III. Performance Analytics & Visualization: To develop an interactive dashboard that visualizes real-time performance metrics, such as Total Energy Yield, Capacity Utilization Factor (CUF), and Performance Ratio (PR).
IV. Implementation of Machine Learning Models: To integrate AI algorithms for Predictive Maintenance (identifying potential hardware failures before they occur) and Energy Forecasting (predicting future power output based on weather patterns).
V. Hybrid Power Management: To design an intelligent switching logic that automatically balances the load between solar, wind, and battery storage based on real-time availability and demand.
VI. Fault Detection and Alerting: To create an automated notification system that alerts operators via SMS, Email, or App notifications regarding system anomalies, critical faults, or efficiency drops.
VII. Efficiency Optimization: To implement "Maximum Power Point Tracking" (MPPT) logic within the IoT framework to ensure the system operates at its peak power curve under varying environmental conditions.

## IV. METHODOLOGY

Block Diagram

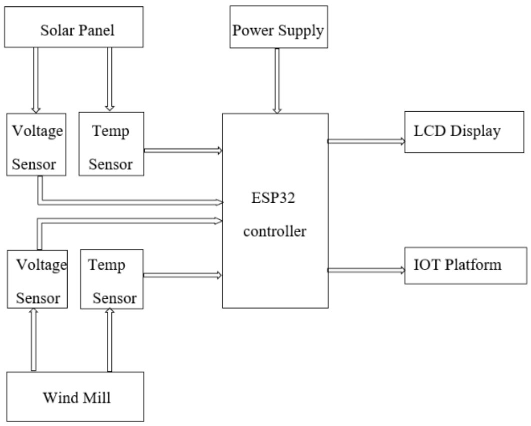


Fig. Block Diagram

The system consists of the following main modules:

Solar Panel
A solar panel converts sunlight into electrical energy using photovoltaic cells. It acts as the primary renewable energy source in the hybrid system.

Voltage Sensor (Solar Side)
The voltage sensor measures the output voltage generated by the solar panel. It sends voltage data to the ESP32 controller for monitoring and analysis.

Temperature Sensor (Solar Side)
The temperature sensor measures the temperature of the solar panel and surrounding environment. It helps analyse the effect of temperature on solar panel efficiency.

Wind Mill
The wind mill converts wind energy into electrical energy through a turbine-generator mechanism. It serves as the second renewable energy source in the hybrid system.

Power Supply
The power supply provides the required electrical power to the ESP32 controller and other electronic components. It ensures stable and continuous system operation.

ESP32 Controller
expressive Systems ESP32 is a microcontroller with built-in Wi-Fi and Bluetooth used for data processing and communication. It collects sensor data, performs analysis, and sends information to the display and IoT platform.

LCD Display
The LCD display shows real-time system parameters such as voltage and temperature readings. It provides local monitoring of the hybrid energy system.

IoT Platform
The IoT platform stores and displays real-time data collected from the hybrid system over the internet. It enables remote monitoring, analysis, and control from mobile or web applications.

## V. CONCLUSION

The proposed system stores the voltage and current parameters and keeps updating the new values. By tracking the solar photovoltaic system continuously, the daily or monthly analysis also becomes simple and easy. It is also possible to detect any errors occurring in the system if there is any uncertainty in the generated data by tracking the solar panels that are operated at the maximum capability. In this project, we have proposed the architecture how solar power system is implemented using Lcd and how solar power is monitored using Lcd. There is a large future scope in the solar power monitoring system using Lcd. Also, it consists of various application and advantages of the system.

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