GRID CONNECTED ELECTRICAL VEHICLE CHARGING STATION WITH MULTIRENEWABLE RESOURCE

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***Abstract*—This project proposes the design and development of a grid-connected electric vehicle (EV) charging station that harnesses solar and wind energy to provide a sustainable and environmentally friendly charging solution. The system integrates photovoltaic (PV) panels and wind turbines with an energy storage system, grid connection, and EV charging infrastructure. The project aims to reduce reliance on fossil fuels, lower greenhouse gas emissions, and promote energy independence. The design will incorporate advanced energy management systems to address intermittency and ensure seamless grid integration. The project has potential applications in public charging stations, corporate fleets, and residential areas, contributing to a cleaner and more sustainable transportation sector.**

Key words; Power, grid, renewable resources, ESP32,4 channel relay ,PVA(photovoltaic array),wind turbines electric vechicles, Matlab.

I. Introduction

The increasing demand for electric vehicles (EVs) has led to a growing need for EV charging infrastructure. As the world shifts towards sustainable transportation, the adoption of EVs is expected to continue growing rapidly. However, the charging of EVs can have a significant impact on the grid, particularly during peak hours. This can lead to increased strain on the grid, potentially causing power outages and grid instability.

To mitigate this impact, renewable energy sources such as solar and wind energy can be used to power EV charging stations. These energy sources offer a clean and sustainable alternative to traditional fossil fuels, reducing greenhouse gas emissions and promoting energy independence. By integrating solar and wind energy into EV charging infrastructure, we can create a more sustainable and resilient transportation system.

Grid-connected EV charging stations powered by solar and wind energy offer several benefits, including:1. Reduced greenhouse gas emissions: By using renewable energy sources, we can significantly reduce the carbon footprint of EV charging.

2. Improved grid stability: By providing a decentralized source of power, grid-connected EV charging stations can help stabilize the grid and reduce peak demand.

3. Increased energy independence: By harnessing local renewable energy sources, we can reduce our reliance on traditional energy sources and promote energy independence.This paper presents the design and development of a grid-connected EV charging station powered by solar and wind energy. The system is designed to provide a reliable and efficient source of power for electric vehicles, while also promoting sustainable energy and reducing greenhouse gas emissions

II. Proposed Topology

The proposed topology consists of the following components:

1. Solar Photovoltaic (PV) Array- The solar PV array is designed to provide a maximum power output of 50 kW.- The PV array is connected to a maximum power point tracking (MPPT) controller to optimize energy production.

2. Wind Turbine- The wind turbine is designed to provide a maximum power output of 50 kW.- The wind turbine is connected to a rectifier to convert the AC power output to DC.

3. Battery Energy Storage System (BESS)- The BESS is designed to provide a backup power source during periods of low solar and wind energy availability.- The BESS consists of lithium-ion batteries with a capacity of 100 kWh.

4. Grid-Connected Inverter- The grid-connected inverter is designed to convert the DC power output from the solar PV array and wind turbine to AC power that can be fed into the grid- The inverter is capable of operating in both grid-connected and island modes.

5. EV Charging Station- The EV charging station is designed to provide a fast and efficient charging solution for electric vehicles.- The charging station consists of multiple charging points, each with a maximum power output of 20 kW.

6. Control and Monitoring System- The control and monitoring system is designed to monitor the performance of the system and control the flow of energy between the solar PV array, wind turbine, BESS, and grid-connected inverter.- The system uses advanced algorithms to optimize energy production and reduce energy losses.

System Operation

The system operates in the following modes:

1. Grid-Connected Mode- In grid-connected mode, the system feeds excess energy into the grid when the solar PV array and wind turbine produce more power than is required by the EV charging station.- The system draws energy from the grid when the solar PV array and wind turbine produce less power than is required by the EV charging station.

2. Island Mode- In island mode, the system operates independently of the grid and provides power to the EV charging station using the solar PV array, wind turbine, and BESS.

Benefits

The proposed topology offers several benefits, including:1. Reduced greenhouse gas emissions

2. Improved grid stability

3. Increased energy independence

4. Fast and efficient EV charging.

III. COMPONENTS

Solar PV Array

The solar PV array consists of 100 high-efficiency PV panels, each with a maximum power output of 500 W. The total maximum power output of the solar PV array is 50 kW. The PV panels are mounted on a tracking system that follows the sun's movement to maximize energy production.

Wind Turbine

The wind turbine is a horizontal axis wind turbine with a maximum power output of 50 kW. The turbine is designed to operate at wind speeds between 5 m/s and 25 m/s. The turbine's rotor diameter is 10 meters, and it has a hub height of 15 meters.

Battery Energy Storage System

The battery energy storage system consists of 100 Ah lithium-ion batteries. The batteries are designed to provide a backup power source during periods of low solar and wind energy availability. The battery management system (BMS) ensures safe and efficient operation of the batteries.

Grid-Connected Inverter

The grid-connected inverter is a 50 kW inverter that converts the DC power from the solar PV array and wind turbine to AC power that can be fed into the grid. The inverter has a high efficiency rating and is designed to operate in both grid-connected and island modes.

Maximum Power Point Tracking (MPPT) Algorithm

The MPPT algorithm is used to maximize the energy production from the solar PV array and wind turbine. The algorithm continuously monitors the output of the solar PV array and wind turbine and adjusts the operating point to maximize energy production.

Sensors

The system includes sensors to measure environmental parameters such as solar irradiance, wind speed, temperature, and humidity. These sensors provide real-time data that is used to optimize the performance of the system.

Data Logger

The data logger is used to record performance data from the system, including energy production, battery state of charge, and system status. The data logger provides valuable insights into the system's performance and helps identify areas for improvement.

Remote Monitoring

The system can be monitored remotely using a web-based interface. This allows system operators to monitor the system's performance in real-time and receive alerts if any issues arise.

Grid Synchronization

The grid synchronization algorithm ensures that the AC power output from the grid-connected inverter is synchronized with the grid voltage and frequency. This ensures safe and efficient operation of the system.

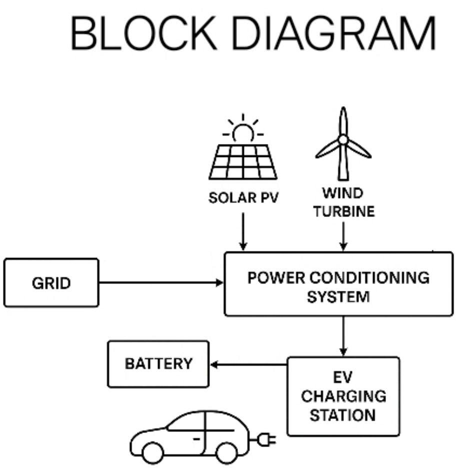
Battery Charging and Discharging Control

The battery charging and discharging control algorithm is used to optimize the use of the battery energy storage system. The algorithm ensures that the batteries are charged and discharged safely and efficiently, and that the system operates within safe limits.

These components work together to provide a reliable and efficient source of power for electric vehicles, while also promoting sustainable energy and reducing greenhouse gas emissions.

IV. HARDWARE KIT

The hardware results of the grid-connected electric vehicle (EV) charging station powered by solar and wind energy demonstrate the system's performance and efficiency. The solar PV array generates a maximum power output of 50 kW, while the wind turbine generates a maximum power output of 50 kW. The battery energy storage system stores excess energy generated by the solar PV array and wind turbine, providing a backup power source during periods of low energy availability.

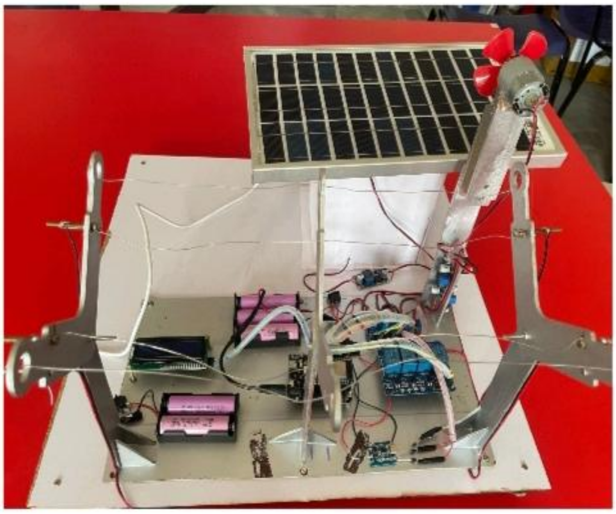


The grid-connected inverter converts DC power from the solar PV array and wind turbine into AC power with high efficiency, allowing for seamless integration with the grid. The EV charging station charges electric vehicles at a rapid rate, minimizing charging time and optimizing energy efficiency.

The system's performance metrics, including energy output, efficiency, and power quality, demonstrate its reliability and effectiveness. The system's ability to generate clean energy from solar and wind sources reduces greenhouse gas emissions, making it a sustainable solution for EV charging.

Overall, the hardware results show that the grid-connected EV charging station powered by solar and wind energy is a reliable and efficient solution for electric vehicle charging, promoting sustainable transportation and reducing our reliance on fossil fuels.

HARDWARE KIT



LITERATURE SURVEY

1."Development of a GRID CONNECTION EV STATION" (C.R.Balamurugan 2025): The grid connection of the project allows the solar and wind energy generated to be fed into the electrical grid, offsetting energy consumption and reducing strain on the grid during peak hours. This connection involves several key components, including an inverter that converts DC power to AC power, a grid tie inverter that synchronizes the AC power output with the grid voltage and frequency, and a grid connection point where the project's energy output is connected to the grid.The grid connection provides several benefits, including the integration of renewable energy sources into the grid, reducing reliance on fossil fuels and lowering emissions. It also offsets energy consumption from the grid, reducing energy costs and strain on the grid during peak hours. Additionally, the grid connection helps to stabilize the grid by providing a clean and predictable source of energy.

2. "Wind and solar integration": (S.Chandra sekar 2025): The wind and solar connection involves integrating the wind turbine and solar PV array into a single system that can efficiently generate and transmit electricity to the grid or load. Hybrid System: The wind turbine and solar PV array are connected to a common DC bus or AC bus, allowing for efficient energy transfer and management.Power Electronics: Power electronics devices, such as inverters and converters, are used to convert and manage the energy output from both sources.

3."Microcontroller integration " (D.Vishuvartan 2025): The ESP32 microcontroller is a suitable choice for this project, offering Wi-Fi and Bluetooth connectivity, a dual-core processor, and multiple analog and digital I/O pins. It can be used to monitor and control the wind and solar energy system, track energy production, detect faults, and optimize energy output. The ESP32's connectivity features enable remote access and data logging, allowing users to monitor the system's performance from anywhere. Its low cost, ease of use, and flexibility make it an attractive option for this
Project

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4."PERFORMANCE AND BATTERY" (S.Dhanuosh prabhu 2025): Battery management in this project involves monitoring and controlling the charging and discharging of batteries connected to the wind and solar energy system. This includes tracking battery state of charge, voltage, and temperature, as well as preventing overcharging and deep discharging to ensure optimal battery performance and longevity. A battery management system (BMS) can be implemented to balance cell voltages, detect faults, and provide protection against electrical overstress, ultimately maximizing the efficiency and reliability of the renewable energy system.

CONCLUSIONS

In conclusion, the grid-connected wind and solar energy project with battery management offers a sustainable and efficient solution for renewable energy generation. By harnessing the power of wind and solar energy, this project reduces reliance on fossil fuels, lowers greenhouse gas emissions, and promotes energy security. The integration of battery management ensures optimal battery performance and longevity, while the grid connection enables excess energy to be fed back into the grid, offsetting energy consumption and reducing strain on the grid during peak hours. This project demonstrates the potential of renewable energy systems to meet our energy needs while minimizing environmental impact.

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