IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, June 2025
Impact Factor: 7.67

Wind and Solar Mobile Charging Stations

[1]Prof. Mayur Devdhe ,[2]Adityaraj Kawale, [3]Pranav Barawkar, [4]Komal Hinge
[1]Professor, Department of Mechanical Engineering
[2,3,4]Student, Department of Mechanical Engineering
JSPM's Bhivarabi Sawant Institute of Technology & Research ,Wagholi, Pune

Abstract: *This paper focuses on the development of a wind and solar mobile charging station that utilizes renewable energy sources to provide portable and sustainable power for electronic devices. The system integrates solar panels and a compact wind turbine to ensure continuous energy generation under varying weather conditions. A battery storage unit is used to store the generated energy, making it available for use when sunlight or wind is not present. The mobile design allows the station to be easily transported and deployed in remote areas, during emergencies, at outdoor events, or in locations lacking reliable access to the electrical grid. By harnessing clean energy, this solution not only reduces dependency on conventional power sources but also promotes environmental sustainability and energy independence. The project demonstrates the feasibility and practicality of hybrid renewable energy systems in real-world mobile applications. The increasing reliance on mobile electronic devices necessitates the development of sustainable and efficient charging solutions. This paper presents the design and implementation of a hybrid mobile charging station powered by both wind and solar energy. The system integrates photovoltaic (PV) panels and a wind turbine to harness renewable energy, which is stored in batteries and used to charge mobile devices. A charge controller regulates the power flow, ensuring safe and efficient charging. The station is equipped with multiple charging ports, including USB and AC outlets, to accommodate various devices. This hybrid approach enhances the reliability and availability of the charging station, especially in remote or off-grid locations. The design emphasizes modularity, allowing for easy scalability and adaptability to different environments. Preliminary tests demonstrate the system's capability to provide consistent power output, even under variable weather conditions, making it a viable solution for sustainable mobile device charging.*

Keywords: *integrates photovoltaic.*

I. INTRODUCTION

In today's world, the demand for clean and portable energy solutions is growing rapidly due to increasing reliance on electronic devices and the need for sustainable alternatives to fossil fuels. Wind and solar mobile charging stations present an innovative and eco-friendly solution to this challenge by utilizing renewable energy sources to generate electricity for mobile charging needs. These systems combine the power of the sun and wind through solar panels and small wind turbines, allowing them to operate efficiently in various environmental conditions. Designed for portability and ease of use, these stations are especially useful in remote areas, during natural disasters, at outdoor events, or in situations where grid power is unavailable. The integration of renewable energy in mobile infrastructure not only helps reduce carbon emissions but also ensures uninterrupted power supply in off-grid scenarios. This project explores the design, components, functionality, and benefits of wind and solar mobile charging stations, highlighting their potential to contribute to a greener and more energy-resilient future.

The Wind and Solar Mobile Charging Station project is an innovative solution designed to provide clean, renewable, and portable power for charging electronic devices in off-grid or emergency scenarios. This system integrates both solar panels and a compact wind turbine to harness energy from the sun and wind, ensuring continuous power generation regardless of weather or time of day. The energy collected is stored in a battery system and can be used to charge mobile phones, laptops, tablets, or even small appliances through USB ports or AC outlets. The station is built with mobility in mind—mounted on a lightweight frame with wheels or designed as a trailer unit, making it ideal for deployment in disaster-struck areas, outdoor events, rural locations, and during camping or military operations. The inclusion of a charge controller and inverter ensures efficient energy management and stable power output. By relying on renewable sources, this mobile charging station not only reduces dependence on fossil fuels but also promotes environmental sustainability and resilience in areas without reliable grid access. Overall, the project serves as a practical demonstration of how hybrid renewable energy systems can support modern power needs in a portable, eco-friendly, and user-friendly form.

Hybrid wind and solar-powered mobile charging stations offer a promising solution by integrating two renewable energy sources to provide reliable power. These systems capitalize on the complementary nature of wind and solar energy: solar panels generate electricity during sunny periods, while wind turbines can produce power during breezy conditions, even at night. By combining these sources, hybrid systems can ensure a more consistent and dependable energy supply.

The design of such charging stations typically includes photovoltaic panels, wind turbines, energy storage systems, and power conversion units. These components work synergistically to capture, store, and distribute energy efficiently. Additionally, integrating user-friendly interfaces and security features enhances the accessibility and safety of the stations.

The implementation of hybrid wind and solar-powered mobile charging stations not only addresses the growing need for charging infrastructure but also promotes the use of clean, renewable energy sources. These stations are particularly beneficial in urban areas with limited grid access, as well as in rural and remote regions, contributing to energy equity and environmental sustainability.

Fig .1 Solar And Wind Mobile Charging

II. LITERATURE SURVEY

1) Engelhardt et al. (2021) proposed an energy management strategy for a multi-battery system in renewable-based high-power EV charging stations. Their design, incorporating a busbar matrix without power converters, enabled efficient energy distribution among solar PV systems, EV fast chargers, and the grid. Simulations indicated that enhanced control strategies increased self- sufficiency and reduced grid exchange, although they also highlighted potential impacts on battery lifespan due to deeper cycling.

2) AbdElrazek et al. (2025) evaluated the techno-economic viability of a solar PV-wind turbine hybrid system with battery storage for an EVCS in Khobar, Saudi Arabia. Using the HOMER simulation model, they optimized system components to meet an AC base load of 2,424.25 kWh/day, achieving an optimal cost of energy and renewable energy penetration.

3) Bastida-Molina et al. (2021) developed a multicriteria design methodology for HRES in electric vehicle charging stations (EVCS), considering local renewable resources, electricity demand, and environmental, economic, and technical factors. Their study in Valencia, Spain, demonstrated that an off-grid system combining solar photovoltaic (PV), wind energy, and battery storage effectively met the energy requirements of the EVCS, reducing grid dependency and CO_2 emissions.

DOI: 10.48175/IJARSCT-27911

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, June 2025
Impact Factor: 7.67

III. METHODOLOGY

3.1 Block Diagram

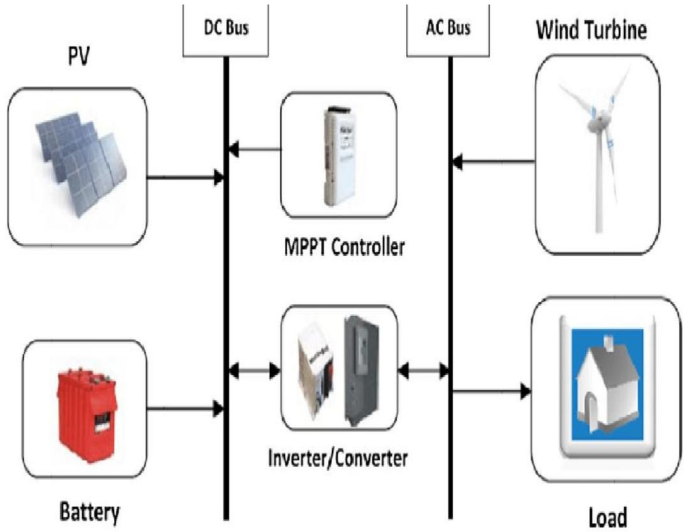

Fig.2 Block Diagram

Block Diagram Representation

A typical block diagram of a hybrid wind and solar-powered mobile charging station includes the following components:

a. Wind Turbine and PV Panels: These are the primary energy sources, converting wind and solar energy into electrical power.
b. Power Conversion Units: Inverters and DC-DC converters that manage the voltage levels and direct current (DC) to alternating current (AC) conversion as needed.
c. Energy Storage System: Batteries that store excess energy for use during periods of low generation or high demand.
d. Charging Ports: Interfaces where users can connect their mobile devices for charging.
e. Controller: A central unit that monitors and manages the operation of the system, ensuring efficient energy distribution and system protection.

System Design and Component Selection

The first step is to assess the local environmental conditions to determine the optimal combination of wind and solar energy sources. This includes analyzing average wind speeds and solar irradiance levels to size the wind turbines and photovoltaic (PV) panels appropriately. Energy storage solutions, typically batteries, are selected based on the expected load and desired autonomy. Power conversion units, such as inverters and DC-DC converters, are chosen to efficiently manage the energy from the hybrid sources and deliver it to the charging ports.

System Integration and Control

Once the components are selected, they are integrated into a cohesive system. This involves connecting the wind turbines and PV panels to a common DC bus, with appropriate power electronics to manage energy flow. A central controller is implemented to monitor and control the system's operation, optimizing energy production, storage, and distribution to meet the charging demands.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 6, June 2025 Impact Factor: 7.67

Installation and Testing

The system is then installed at the chosen site, ensuring that the wind turbines and PV panels are positioned to maximize energy capture. The installation process includes setting up the structural supports, electrical connections, and safety systems. After installation, comprehensive testing is conducted to verify the system's performance under various operating conditions, ensuring it meets the required standards and user expectations.

Monitoring and Maintenance

To ensure long-term reliability, the system is equipped with monitoring tools that provide real-time data on energy production, storage levels, and usage patterns. Regular maintenance schedules are established to inspect and service the components, addressing any issues promptly to minimize downtime and extend the system's lifespan.

3.2 Working Principle

The working principle of a hybrid wind and solar-powered mobile charging station integrates solar photovoltaic (PV) panels and wind turbines to generate electricity, which is then stored in batteries and used to charge mobile devices.

1) Solar Energy Conversion: Solar panels capture sunlight and convert it into direct current (DC) electricity. This DC output is often regulated using a Maximum Power Point Tracking (MPPT) controller to optimize energy capture. The regulated DC power is then stored in batteries for later use.
2) Wind Energy Conversion: Wind turbines harness kinetic energy from the wind and convert it into mechanical energy, which is then transformed into electrical energy using a generator. The output is typically alternating current (AC), which is rectified to DC using a rectifier to match the battery storage requirements.
3) Energy Storage: Both solar and wind-generated DC power is stored in batteries. This stored energy ensures a continuous power supply, even during periods when sunlight or wind is insufficient.
4) Power Conversion and Distribution: An inverter converts the stored DC electricity into AC, which is suitable for charging devices. The system includes charging ports, such as USB or AC outlets, allowing users to charge their mobile devices. A charge controller manages the power flow, ensuring efficient and safe charging.

IV. SYSTEM DESIGN

Energy Generation

• Solar Panels: Photovoltaic (PV) panels capture sunlight and convert it into direct current (DC) electricity. The output is regulated using a Maximum Power Point Tracking (MPPT) controller to optimize energy capture.

• Wind Turbine: A vertical-axis wind turbine harnesses wind energy, converting it into mechanical energy, which is then transformed into electrical energy using a generator. The output is typically alternating current (AC), which is rectified to DC using a rectifier to match the battery storage requirements.

Energy Storage

• Both solar and wind-generated DC power is stored in batteries. This stored energy ensures a continuous power supply, even during periods when sunlight or wind is insufficient.

Power Conversion and Distribution

• Inverter: An inverter converts the stored DC electricity into AC, which is suitable for charging devices.

• Charging Ports: Interfaces such as USB and AC outlets allow users to connect their mobile devices for charging.

• Charge Controller: Manages the power flow, ensuring efficient and safe charging of devices.

User Interface and Monitoring

• Control Panel: Allows users to select the type of device and charging duration, activating the appropriate charging port.

• Monitoring System: Displays real-time data on energy production, storage levels, and usage statistics.

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 5, Issue 6, June 2025 Impact Factor: 7.67

Portability and Deployment

• Mobile Design: Equip the station with wheels or a modular structure for easy relocation to high- footfall areas.

• Deployment Strategy: Identify strategic locations such as bus stops, parks, and tourist spots to maximize user access.

V. CONCLUSION

Hybrid wind and solar-powered mobile charging stations represent a significant advancement in sustainable energy solutions, particularly in the context of electric vehicle (EV) charging infrastructure. By integrating renewable energy sources, these stations not only provide reliable power but also contribute to reducing the carbon footprint associated with traditional grid electricity. The adoption of such hybrid systems offers numerous benefits, including cost reduction, environmental impact mitigation, enhanced energy independence, and increased convenience for EV users. Moreover, they align with global sustainability goals by promoting the use of clean energy and supporting the transition towards greener mobility options. While challenges such as high initial investment costs, intermittent energy production, and space constraints exist, ongoing technological advancements and supportive policies are paving the way for the widespread implementation of renewable energy-powered charging stations The design and implementation of such systems require careful consideration of various components, including photovoltaic panels, wind turbines, battery storage, charge controllers, and inverters. Advanced technologies such as Maximum Power Point Tracking (MPPT) controllers and hybrid controllers play a crucial role in optimizing energy capture and ensuring efficient operation. Case studies, such as the mobile base station in Ethiopia and the electric vehicle charging station in Kermanshah, demonstrate the feasibility and effectiveness of hybrid systems in providing reliable power in off-grid locations . These examples highlight the potential for hybrid charging stations to enhance energy access, reduce carbon emissions, and support the adoption of electric vehicles.

REFERENCES

[1]. Shreya R. Bhalerao, Prachi R. Kotkar, Rasika R. Nagare, Zeba S. Shaikh. Design of Wind & Solar Laptop Mobile Charging Station for Rural Areas. International Journal of Science and Engineering Management (ISJEM), March 2025.

[2]. 2) Ahmed S. AbdElrazek, Mohamed Soliman, Muhammad Khalid. Evaluating the Techno-Economic Viability of a Solar PV-Wind Turbine Hybrid System with Battery Storage for an Electric Vehicle Charging Station in Khobar, Saudi Arabia. arXiv, February 2025.

[3]. Ashraf Mohamed Hemeida, Mohamed El-Ahmar, Abou-Hashema Ahmed, Tomonobu Senjyu. Optimum Design of Hybrid Wind/PV Energy System for Remote Area. Energy Reports, August 2019.

[4]. Subodh Paudel, Jagan Nath Shrestha, Fernando J Neto, Jorge AF Ferreira, Muna Adhikari. Optimization of Hybrid PV/Wind Power System for Remote Telecom Station. arXiv, November 2014.

[5]. Subodh Paudel, Jagan Nath Shrestha, Fernando J Neto, Jorge AF Ferreira, Muna Adhikari. Optimization of Hybrid PV/Wind Power System for Remote Telecom Station. arXiv, November 2014.

[6]. Singh, S. P., Tiwari, P., Singh, S. N., & Singh, P. P. (2024). Estimation of hybrid energy generation of solar-wind tower for electric vehicle charging: A case study of Indian highway. Energy Storage, 6(5), e70004.

[7]. 7) Li, H., Liu, H., Ji, A., Liu, F., & Jia, Y. (2013). Design of a hybrid solar-wind powered charging station for electric vehicles. Proceedings of the 2013 International Conference on Mechanical, Robotics and Electronics Engineering (ICMREE), 6893835.

[8]. 8) Paudel, S., Shrestha, J. N., Neto, F. J., Ferreira, J. A. F., & Adhikari, M. (2014). Optimization of hybrid PV/wind power system for remote telecom station. arXiv:1411.5343.

[9]. 9) eshalem, M. T., & Khan, B. (2017). Design of an off-grid hybrid PV/wind power system for remote mobile base station: A case study. AIMS Energy, 5(1), 96-112