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Wireless Electric Vehicle Charging with Vertical Axis Wind Turbines

Sitaram Solanke[1], Satwik Shinde[2], Pratik Shewale[3], Dr. Arati J. Vyavahare[4]
Dept. of Electronics and Telecommunication, Progressive Education Society's Modern college of Engineering, Pune, India

Abstract: Electric Vehicles (EVs) are emerging as a critical component in the global transition toward sustainable and low-carbon transportation systems. However, the effectiveness and adoption rate of EVs are directly influenced by the availability and reliability of their charging infrastructure. Conventional plug-in charging methods are often limited by dependency on fossil-fuel-powered electricity grids, physical connector degradation, and user inconvenience. To address these challenges, this paper presents a novel, sustainable, and autonomous Wireless EV Charging System powered by a Vertical Axis Wind Turbine (VAWT).

The system utilizes wind energy generated by vehicular motion along highways and urban roadways, captured using a custom-designed VAWT. The mechanical energy is converted into electrical energy via a DC generator and stored in a lithium-ion battery. This stored energy is then transmitted wirelessly to an EV's onboard battery using Resonant Inductive Power Transfer (RIPT). A microcontroller-based monitoring system (ESP32) captures real-time voltage and current values and Display on station and Vehicle screen .The proposed solution is modular, scalable, and well-suited for integration into smart city and highway infrastructures, offering a promising step toward clean, plug-free mobility.

Keywords: Wireless Power Transfer (WPT), Resonant Inductive Coupling, Vertical Axis Wind Turbine (VAWT), Electric Vehicle (EV) Charging, Smart Transportation Systems, Highway Energy Harvesting, IoT-Based Monitoring, ESP32 Microcontroller, Renewable Energy Integration, Contactless Charging Infrastructure.

I. INTRODUCTION

The transportation sector is undergoing a transformative shift with the widespread adoption of electric vehicles (EVs). As governments worldwide push for decarbonization, the EV market is growing rapidly. However, the supporting infrastructure for EVs—particularly charging facilities—faces significant limitations. Conventional plug-in charging stations are often expensive to deploy, require regular maintenance, and rely on the electricity grid, which is frequently powered by non-renewable energy sources. Additionally, the physical connection of plug-in systems presents wear-and-tear issues, hygiene concerns, and user inconvenience. Wireless Electric Vehicle Charging (WEVC) presents an innovative solution to many of these challenges. By using resonant inductive power transfer (RIPT), electricity can be transmitted through an air gap without physical connectors, allowing for convenient and automated charging. However, the success of WEVC depends heavily on the availability of sustainable power sources. Solar-based systems have already been explored extensively, but they are limited by environmental conditions such as cloud cover and nighttime operation. In contrast, wind energy, particularly that harvested from roadside turbulence caused by moving traffic, offers a highly underutilized yet promising opportunity. This paper introduces a novel system that combines a Vertical Axis Wind Turbine (VAWT) with a wireless power transfer (WPT) system to charge EVs in a contactless, grid-independent, and eco-friendly manner. The system uses a custom-designed VAWT to convert wind energy into electricity via a DC generator. The energy is stored in a battery, which then powers a transmitter coil to wirelessly charge EVs. A microcontroller (ESP32) and IoT platform (Telegram) are used for real-time monitoring and control, enhancing the usability and scalability of the solution.

II. RELATED WORK

The development of sustainable charging systems for electric vehicles (EVs) has attracted considerable interest in recent years. Multiple research efforts have explored the integration of renewable energy sources, such as solar and wind, with wireless charging technologies to improve efficiency, accessibility, and environmental impact.

In their work, Ritika Madkar et al. [1] proposed a solar-powered dynamic wireless EV charging system that utilizes Resonant Inductive Power Transfer (RIPT) combined with ESP32 microcontrollers for real-time monitoring. Their system successfully demonstrated plug-free charging using a monocrystalline solar panel and IoT-based data logging via the Blynk platform. While effective under direct sunlight, their model faces performance limitations in cloudy or low-light conditions.

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Muganur et al. [2] and Chobe et al. [3] presented ESP32-based solar charging stations, emphasizing static wireless transmission. Their work also explored predictive maintenance and energy storage, but they did not implement the system in mobile or dynamic environments, nor did they consider alternative renewable sources such as wind.

Research by Niranjana S. J. [4] and Altab Hossain [5] highlighted the potential of Vertical Axis Wind Turbines (VAWTs) for roadside energy harvesting. They demonstrated that wind generated by high-speed traffic on highways could be effectively converted into usable electrical energy. These studies revealed that VAWTs are more suitable for urban deployment due to their compact size, low start-up speed, and omnidirectional operation. However, their work did not explore the wireless transmission of the harvested energy.

Additionally, Ali et al. [6] investigated high-frequency wireless charging circuits that improve power transfer efficiency but increase system complexity and cost. While efficient, these solutions require precise tuning and are sensitive to misalignment, making them less ideal for large-scale roadside deployments.

III. SYSTEM ARCHITECTURE

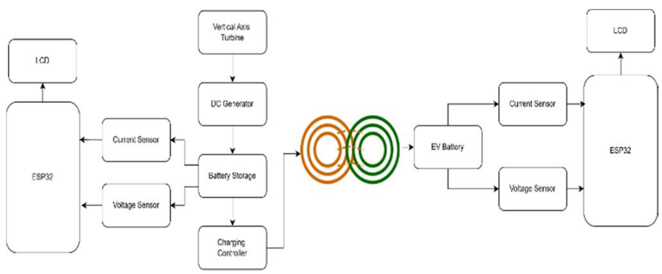

Fig.1 Block Diagram

The proposed system consists of two major components: the Transmitter Unit (installed roadside) and the Receiver Unit (mounted on the electric vehicle).

A. *Transmitter Unit (Roadside Setup)*

- Vertical Axis Wind Turbine (VAWT): Captures wind energy generated by moving vehicles.
- DC Generator: Converts mechanical energy into 12V electrical power.
- Battery Storage: Stores the generated energy for continuous operation.
- Inverter Circuit: Converts DC to AC for inductive transmission.
- Transmitter Coil: Generates a magnetic field for wireless power transfer.
- ESP32 Microcontroller: Controls system operations and collects data from sensors.[2]
- LCD Display: Shows real-time system data such as voltage, current, and battery level.

B. *Receiver Unit (Onboard EV)*

- Receiver Coil: Positioned to align with the transmitter, captures the magnetic field.
- Rectifier: Converts AC to DC for EV battery charging.
- Battery and Management Circuit: Stores and regulates power.
- ESP32 & Sensors: Monitor voltage/current and send data to a 20x4 LCD and IoT platform.

This architecture ensures efficient energy capture, storage, and wireless delivery using compact and cost-effective components, making it scalable for highway and smart city use.

The system illustrates the overall working of the proposed Wireless Electric Vehicle Charging System using Vertical Axis Wind Turbine (VAWT). The system is divided into two segments: Transmitter Side (roadside setup) and Receiver Side (onboard vehicle unit). Transmitter Side: The transmitter side consists of a Vertical Axis Wind Turbine (VAWT) connected to a DC generator. The turbine captures wind energy generated by passing vehicles and converts it into mechanical energy, which is further converted to electrical energy by the generator. This energy is then stored in a rechargeable battery pack. The receiver side is mounted on the electric vehicle and includes an inductive coil, rectifier, EV battery, voltage and current sensors, an ESP32 microcontroller, and an

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LCD display. It captures the magnetic field generated by the transmitter coil via inductive coupling and converts it into DC power to charge the battery. The ESP32 processes real-time sensor data and displays charging parameters, ensuring efficient and contactless energy transfer.

IV. FLOWCHART OF THE SYSTEM

The flowchart represents the software flow of the ESP32 microcontroller system on both transmitter and receiver sides. It outlines the stages of data initialization, monitoring, energy transmission, and display operation.

A. *Working of the System*

When the system is powered on, the ESP32 microcontroller initializes all required modules and communication channels.

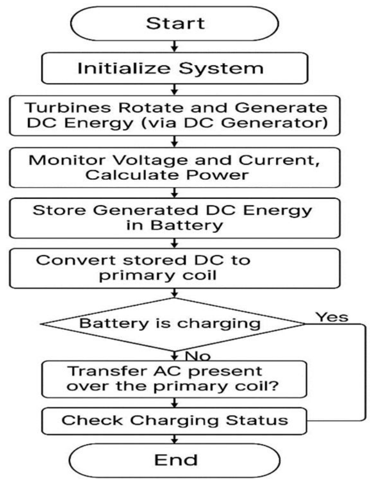
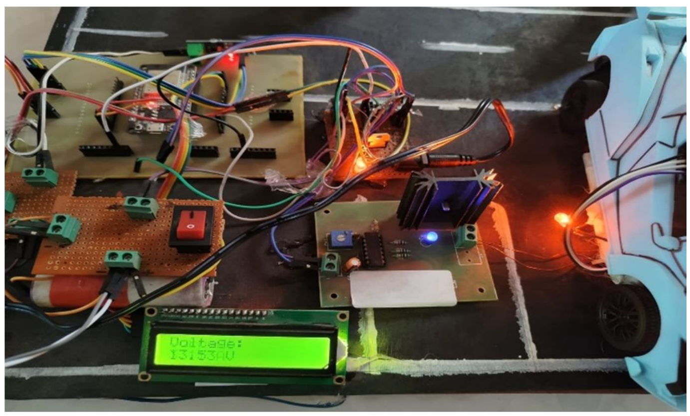


Fig.2 Flowchart

1. Wind Energy Conversion
   - The Vertical Axis Wind Turbine (VAWT) begins to rotate as vehicles pass by the road, generating wind turbulence.
   - The DC Generator connected to the turbine converts this mechanical motion into electrical energy (12V DC output).
2. Battery Charging and Storage
   - The generated DC power is passed through a charging controller that regulates the current and voltage before feeding it into a 12V lithium-ion battery.
   - The controller ensures safe charging, preventing overcharge and providing consistent power output.
3. Wireless Transmission Activation
   - Once sufficient voltage is available in the battery, the transmitter coil is energized.
   - It creates a magnetic field through Resonant Inductive Power Transfer (RIPT) when an EV with a receiver coil is aligned above it.
4. Energy Reception and Rectification
   - The receiver coil on the EV captures the magnetic field and induces alternating current (AC).
   - This AC is fed into a full-bridge rectifier, converting it into direct current (DC), which is then used to charge the onboard EV battery.
5. Sensor Data Acquisition and Monitoring
   - Voltage and current sensors connected to the ESP32 monitor the system performance (both on the transmitter and receiver side).
   - The ESP32 sends data to a 20x4 LCD display for local monitoring.
   - Simultaneously, the same data is uploaded to the Telegram IoT platform or similar cloud-based service for remote monitoring and control.
6. Continuous Operation
   - A short delay (usually 1 second) is implemented in each loop to allow proper sensor reading and data stability.
   - This loop continues indefinitely, allowing continuous system monitoring, energy transmission, and real-time updates.

V. RESULTS



The proposed system was tested using a scaled-down prototype in both static and controlled dynamic wind conditions, using industrial-grade fans to simulate the wind generated by highway traffic.

Wireless energy transfer was observed to be most efficient when the air gap between transmitter and receiver coils was between 1 cm to 2 cm. Beyond this distance, the induced voltage and current decreased significantly due to magnetic field dissipation.

A. Calculations

1. Swept Area of VAWT(A)
   $A=H*D$ … (1)
   Where:
   A = Swept area in square meters (m^2)
   H = Height of the turbine (m)
   D = Diameter of the turbine (m)

2. Power Available in the Wind
   $P_{wind}=1/2\cdot\rho\cdot A\cdot v3$ … (2)
   Where:
   P wind = Power in wind (Watts)
   ρ = Air density (typically 1.225 kg/m^3 at sea level)
   A = Swept area (m^2)
   v = Wind speed (m/s)

3. Betz Limit (Maximum Possible Efficiency)
   $P_{max}=0.593\cdot P_{wind}$… (3)

4. Actual Mechanical Power Output

P mechanical=Cp·P wind… (4)

Where:

Cp = Power coefficient (efficiency of turbine, usually 0.2–0.4 for small VAWTs)
P mechanical = Mechanical power output (Watts)

5. Electrical Power Output from Generator

P electrical=η g·P mechanical… (5)

Where:

η g = Efficiency of the generator (e.g., 0.7 to 0.9)
P electrical = Actual electrical power output (Watts)

6. Torque Generated by the Turbine

T= P mechanical/ω… (7)

Where:

T = Torque (Nm)
ω = Angular speed in radians/sec

ω=2π·RPM60\omega

7. Wireless Power Transfer Coil Design

Vp/Vs=NpNs…(8)

8. Battery Energy

Eb=Vb·Cb … (9)

9. Charging Time Estimation

t= Eb/ P received … (10)

B. Performance Observations

- Under optimal alignment and a simulated wind speed of approximately 5 m/s, the receiver coil captured up to 5–6V AC, which was successfully rectified and used to charge a 12V EV battery.
- Charging efficiency was found to range between 80–85% in favourable conditions.[6]
- ESP32 microcontrollers successfully recorded and displayed voltage and current values on the LCD module.
- Data was also transmitted in real-time to the Telegram IoT platform for remote monitoring, with a refresh rate of approximately 1 second.
- Coil misalignment and increased air gap caused an efficiency drop of up to 20%, highlighting the importance of precise coil placement.
- The prototype charged a 2200mAh Li-ion battery in approximately 2–2.5 hours under consistent airflow.

C. Practical vs Theoretical Readings

Relative distance between Transmitter and Receiver	Parameter	Theoretical Reading	Practical Reading
Distance < 1 cm	Voltage	6 V	5.2–5.5 V
	Current	2A	1.5–1.8 A
	Power	12W	7.5–9.9 W
Distance = 2 cm	Voltage	6V	5.0–5.2 V
	Current	2A	1.2–1.5 A
	Power	12W	6.0–7.5 W
Distance > 3 cm (12 cm)	Voltage	5V	3.5–4.0 V
	Current	1.5A	0.8–1.2 A
	Power	7.5W	3.2–4.8 W

VI. CONCLUSION AND FUTURE SCOPE

This research presents a novel approach to EV charging by integrating a Vertical Axis Wind Turbine (VAWT) with wireless power transfer technology. The system harnesses wind energy from passing vehicles, converts it into electrical energy using a DC generator, stores it in a lithium-ion battery, and transfers it wirelessly to electric vehicles through Resonant Inductive Power Transfer (RIPT).

The prototype achieved a power transfer efficiency of 80–85% with an optimal air gap of 10–15 cm. Real-time monitoring using ESP32 and IoT integration ensures accurate performance tracking. The system offers a plug-free, grid-independent, and renewable EV charging solution, ideal for highways and urban infrastructure.

The current prototype sets the groundwork for further development and real-world deployment. Future iterations and research directions include:

- Smart Road Integration: Install transmitter coils in road surfaces for on-the-go EV charging.
- Hybrid Renewable Sources: Combine wind with solar to ensure consistent power supply.
- AI-Based Optimization: Use machine learning for predictive coil activation and power demand estimation.
- Secure Payment Systems: Incorporate UPI, RFID, or biometric systems for automated billing and authentication.
- Safety Enhancements: Include shielding, temperature monitoring, and emergency shutdown features.
- IoT and Cloud Analytics: Deploy cloud dashboards for real-time data logging and usage trends.
- Supercapacitor Use: Introduce supercapacitors for rapid energy storage and discharge during peak load times.

REFERENCES

[1] R. Madkar, S. Mohite, V. Omble, "Dynamic Wireless Charging for Electric Vehicle using Solar Energy," IEEE International Conference on Smart Energy Systems, vol. 11, no. 5, pp. 891–892, 2023.

[2] N. Muganur, A. Joshi, M. Shinde, "ESP32-Based Wireless EV Charging with IoT Monitoring," International Journal of Research Publication and Reviews (IJRPR), vol. 4, no. 5, pp. 123–127, 2023.

[3] P. Chobe, A. Gaikwad, R. Patil, "Solar-Based Wireless Charging Station for Electric Vehicles," Journal of Electrical Systems, vol. 20, no. 9, pp. 45–52, 2024.

[4] Z. Ali, M. Hasan, S. Iqbal, "High-Frequency Wireless EV Charging Setup," Renewable Energy and Environmental Sustainability (REES), vol. 35, pp. 291–297, 2023.

[5] Niranjana S. J., "Harnessing Highway Wind via Vertical Axis Wind Turbines (VAWT)," International Journal of Engineering Research and Technology (IJERT), vol. 12, no. 3, pp. 124–128, 2023.

[6] A. Hossain, M. Rahman, "Design and Implementation of VAWT for Urban Wind Harvesting,