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Dynamic Wireless Recharging of an Electric Vehicle with the Incorporation of Various Energy Sources

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Abstract: *The combination of renewable energy sources like wind and solar with the grid for dynamic wireless charging of electric vehicles (EVs) presents a groundbreaking solution for eco-friendly transportation. This research introduces a framework that merges renewable energy with dynamic wireless charging systems, backed by a sophisticated battery management system (BMS). Utilizing solar and wind power to operate wireless charging networks guarantees a consistent supply of energy while diminishing dependence on fossil fuels. Dynamic wireless charging allows EVs to power up while in transit, alleviating range anxiety and minimizing the necessity for fixed charging stops. The integration of a BMS facilitates effective management of energy flow by optimizing the charging and discharging processes to prolong battery lifespan and sustain operational efficiency. This study presents a viable and eco-friendly approach to enhance the adoption of electric vehicles and the use of renewable energy, while also facilitating the growth of more sustainable transportation systems. Upcoming efforts will aim to enhance the scalability of the system and its integration with smart city projects to optimize its effectiveness.*

Keywords: Renewable energy, dynamic wireless charging, electric vehicles, battery management system, solar energy, wind energy, smart grid, sustainability

I. INTRODUCTION

The transportation industry is experiencing a groundbreaking shift, with electric vehicles (EVs) becoming a viable and eco-friendly alternative to conventional internal combustion engine (ICE) vehicles. Key factors driving this change are environmental issues, increasing fuel prices, government incentives, and advancements in battery technology. Nonetheless, a major obstacle preventing widespread EV adoption remains the insufficient development of a robust and efficient charging network. Traditional EV chargers are completely dependent on the electrical grid, leading to higher demand and potential instability in the grid during peak usage times. Therefore, innovative charging solutions are essential. Incorporating renewable energy sources (RES) such as solar and wind power into EV charging infrastructure can provide several benefits, such as eliminating reliance on electricity generated from fossil fuels.making transportation completely zero-emission. Overtime, renewable energy systems can significantly reduce operational costs, as solar and wind energy are freely available once infrastructure is set up.

The project will focus on a small-scale prototype to demonstrate the practical feasibility of integrating renewable energy with wireless EV charging. The key technical aspects include:

Power Sources & Energy Storage.

- Solar Panels (12V, 1A) and Wind Turbine (12V, 1A) for primary energy generation.
- AC Grid Input (230V, AC to DC Converter) as a backup.
- 12V Rechargeable Battery Pack (3 × 4V = 12V, 1.5Ah) for energy storage.

Wireless Power Transmission (WPT) System.

- Primary (transmitter) coil at charging station and secondary (receiver) coil in EV.
- Resonant inductive coupling for efficient energy transfer.

Battery Management System (BMS) & Safety Mechanisms

- Microcontroller-based BMS with voltage, temperature, and current monitoring.

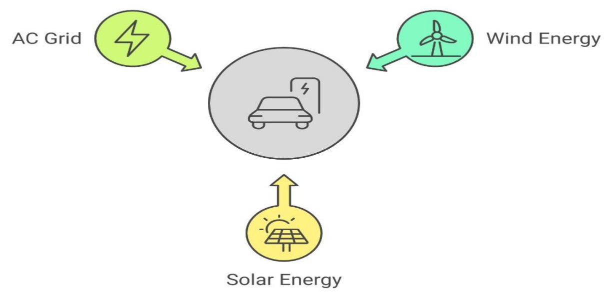

Fig 1 .Integration of Renewable Energy

The Grid-Integrated Solar and Wind Hybrid System represents an innovative energy solution that unites solar and wind technologies to deliver a dependable and environmentally friendly power source. Solar panels harness sunlight to create direct current electricity, while the wind turbine produces energy from wind. Through inverters, both energy sources are converted into alternating current electricity suitable for residential use and the power grid. Extra energy is stored in batteries for times when generation is low. The microgrid controller effectively regulates energy distribution, emphasizing renewable sources and optimizing storage. At the same time, the smart meter tracks energy consumption and the exchange of energy between the hybrid system and the grid. When renewable generation is insufficient, the grid supplements the demand. This dual-source generation strategy ensures consistency, as solar panels generate power during daylight while wind turbines operate as long as there is adequate wind, creating a steady energy output. The battery bank storing energy further minimizes reliance on the grid. Additionally, the system's capability to send surplus energy back to the grid boosts its efficiency.

By merging solar and wind power with advanced energy storage and smart metering, this hybrid system presents a sustainable and cost-effective energy solution. It not only contributes to lower greenhouse gas emissions but also offers a dependable power source for residential, commercial, and isolated applications. The hybrid system takes advantage of the complementary nature of solar and wind energy to guarantee a continuous power supply. Solar energy peaks in the daytime, whereas wind energy can provide additional power throughout nighttime or during low sunlight times. This collaboration diminishes unpredictability and improves grid stability, rendering the hybrid system more dependable and effective.

Hybrid Solar-Wind System with Battery Storage in Grid-Connected and Standalone Modes

Hybrid energy systems that combine solar and wind sources tackle the intermittent nature inherent in renewable energies. During the day, solar photovoltaic cells produce energy that can either be consumed directly or stored. At the same time, wind turbines function independently of time and offer supplementary energy. This arrangement is beneficial in grid-connected settings, where surplus energy can be sent to the utility grid and deficit energy can be drawn from it. In standalone mode, solar energy systems utilize maximum power point tracking (MPPT) algorithms to extract the best possible energy under varying irradiance conditions. Wind energy systems employ DC/DC converters to stabilize their output. Merging these technologies improves the resilience and reliability of the power supply in both rural and urban environments. In conclusion, the integration of solar and wind energy with wireless charging technology presents a powerful, sustainable, and adaptable solution for modern energy needs, especially in applications involving electric vehicles and off-grid situations.

The operational principle of hybrid systems revolves around how solar panels gather sunlight through photovoltaic cells, transforming it into electricity, while wind turbines capture kinetic energy to produce electrical energy via coil-based generators. These systems collaborate to ensure a reliable energy supply by offsetting the intermittency of each respective source. The incorporation of energy storage solutions such as batteries or flywheels is crucial to retain excess energy produced during peak times for later use. Various coil designs are commonly employed in electromagnetic systems including inductors, transformers, antennas, and wireless power transfer configurations. Each coil type serves specific purposes and possesses unique advantages tailored to its application.

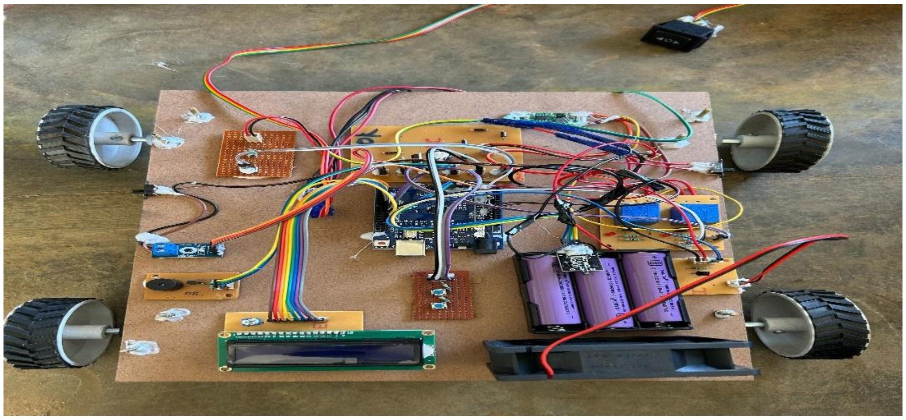

Figure 2: prototype of 12v DWPT

Dynamic wireless charging for electric vehicles (EVs) marks a significant advancement in environmentally friendly transport, facilitating the recharging of EVs while they are in motion. This approach reduces the reliance on fixed charging stations and helps mitigate range anxiety for drivers. A critical aspect of these systems is the precise alignment of coils—specifically, the transmitter coil set into the roadway and the receiver coil located within the vehicle.

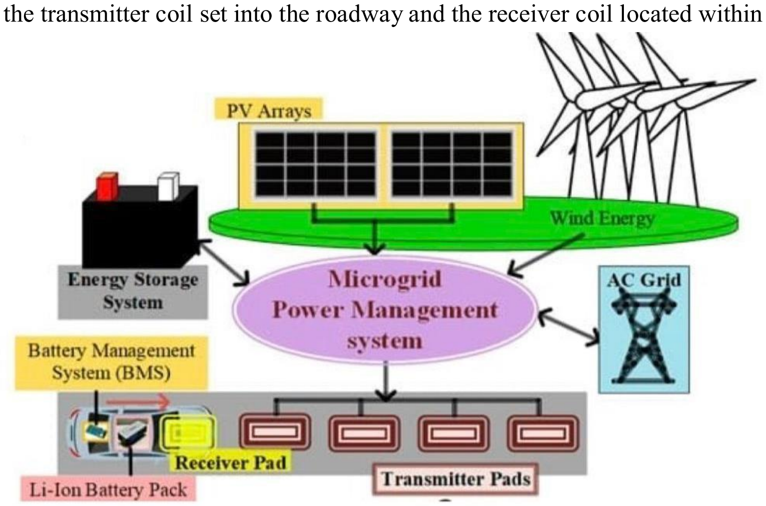

Fig 3 :Energy Storage System

Achieving and sustaining precise coil alignment is a challenging engineering endeavour affected by various dynamic factors such as vehicle speed, lateral movements, road surface conditions, and external environmental influences. These elements can greatly impact the efficiency and reliability of power transmission. To tackle these challenges, engineers are developing robust systems capable of maintaining suitable alignment across different conditions. These solutions frequently incorporate innovative materials, advanced coil designs, and real-time monitoring technologies to improve reliability and performance.

Transmitter and receiver coils are crucial in ensuring proper alignment for effective power transfer. Utilizing coils with larger surface areas can enhance tolerance to misalignment, providing increased flexibility in coil placement. Furthermore, multi-coil arrays—where multiple transmitter coils overlap—facilitate consistent power delivery, even when the receiver coil is not ideally aligned with a single transmitter coil. The inclusion of ferrite materials in coil design bolsters magnetic coupling and reduces energy losses. These components are vital for optimizing the efficiency of dynamic wireless charging systems in practical scenarios. To enhance alignment accuracy, dynamic wireless charging systems typically incorporate advanced sensing and control technologies. Real-time feedback systems can identify the relative positions of the coils and adjust power transfer settings accordingly.

II. CONCLUSION

The initiative named Dynamic Wireless Charging of an Electric Vehicle with Multiple Energy Sources successfully crafted an environmentally friendly and effective EV charging system by integrating solar and wind energy with traditional grid power, utilizing wireless power transfer technology. By employing resonant inductive coupling between transmitter coils embedded in the roadway and receiver coils placed on the vehicle, the system facilitated contactless charging. Issues related to coil alignment were tackled through optimized coil configurations and innovative compensation methods. A dependable Battery Management System (BMS) was integrated to consistently monitor essential parameters such as voltage, current, temperature, and state of charge. This system ensured safety by incorporating features like active cell balancing, automatic cooling, and real-time fault detection. The hybrid energy approach enabled smooth transitions between renewable sources and grid supply, effectively minimizing dependence on fossil fuels. Testing with a 12V prototype confirmed the technical feasibility of the system, while theoretical analyses underscored its potential scalability for higher-power applications. Key advancements included intelligent energy management algorithms, resilient wireless power transfer to misalignment, and thorough battery safety mechanisms. The effective combination of renewable energy sources with dynamic wireless charging presents a promising answer for sustainable transportation, addressing concerns related to range anxiety, convenience, and environmental impact.Looking ahead, enhancements could be aimed at improving power transfer efficiency, implementing AI-driven predictive energy management, and developing standardized systems to facilitate wider adoption. This project establishes both a practical and theoretical basis for the future EV charging infrastructure that merges advanced technology with ecological responsibility.

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