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Solar-Powered Dynamic EV Charging Road Infrastructure

PROF. PREETI S. PARIHAR[1], PREM D. INGLE[2], VIJAY D. KAMBLE[3], JYOTI V. PUNDE[4], OMKAR M. DUBALE[5]

[1, 2, 3, 4, 5]Department of Civil Engineering, Maharashtra, India JSPM'S RSCOE Polytechnic, Tathawade, Pune

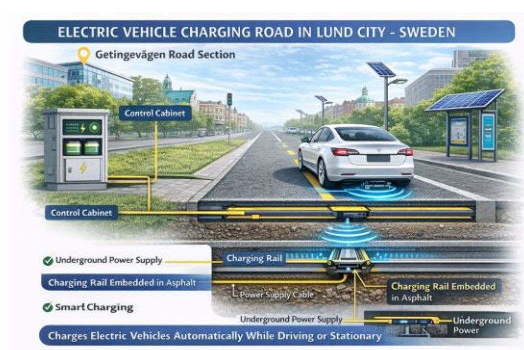
Abstract- The surging requirement for electric vehicles (EVs) is a direct response to the global objective of curbing carbon emissions and decreasing the usage of petroleum-based fuels. Nevertheless, the expansion of the EV market is hampered by a lack of charging points and "range anxiety" among drivers. This research explores the development and performance of a Solar-Powered EV Charging Road System, which facilitates the wireless replenishment of vehicle batteries during transit. The architecture utilizes photovoltaic arrays to capture solar energy, which is subsequently stored in high-capacity battery units. This power is then channeled to induction coils submerged beneath the pavement. Through the mechanism of electromagnetic induction, energy is wirelessly transmitted to a receiver unit attached to the vehicle's chassis. This mobile charging framework minimizes the necessity for stationary plug-in stations and effectively broadens the driving range. The proposed design features integrated power electronics, automated voltage regulation, and robust safety protocols. This study details the operational methodology, the physical construction phases, and fundamental power metrics, contributing to the advancement of smart city infrastructure and eco-friendly mobility.

Keywords: Electric Mobility, Inductive Power Transfer, Renewable Solar Energy, Wireless Charging, Intelligent Roadways.

I. INTRODUCTION

While transportation is a cornerstone of global economic health, traditional internal combustion engines fueled by gasoline and diesel are primary contributors to atmospheric pollution and climate crises. Electric vehicles offer a viable path toward sustainability by eliminating tailpipe emissions. However, the transition to EVs is slowed by two primary hurdles: the long duration required for a full charge and the scarcity of available charging locations. Range anxiety—the persistent worry that a vehicle will lose power before reaching a destination—remains a major psychological barrier for consumers.

To circumvent these challenges, dynamic wireless charging can be integrated into highway infrastructure. This technology enables vehicles to draw power continuously as they travel over specialized road segments. By combining solar energy harvesting with wireless induction, an autonomous and renewable energy loop is created. Solar panels situated along the roadway transform sunlight into electrical current, which is then stored and distributed to underground transmitter coils. A vehicle-side receiver captures the resulting magnetic field, converting it back into the electrical energy required to sustain the battery during the journey.



OBJECTIVES

1) To design and develop a working model of a solar-powered dynamic EV charging road system.
2) To study and implement wireless power transfer using inductive charging technology.
3) To utilize renewable solar energy for sustainable EV charging infrastructure.

OPERATIONAL MECHANISM

The system functions through a synergy of renewable energy management and inductive coupling:

1. Solar Conversion: Photovoltaic modules transform light into DC power.
2. Regulation: A charge controller stabilizes the voltage to protect the storage system.
3. Storage: Electricity is held in a 12V rechargeable battery buffer.
4. Inversion: A driver circuit (utilizing an inverter or 555 timer) switches DC to high-frequency AC.
5. Magnetic Generation: The buried road coils create a fluctuating magnetic field.
6. Flux Capture: As a vehicle passes, the onboard receiver coil intercepts this magnetic flux.
7. Rectification: The captured AC is converted back into DC via a bridge rectifier.
8. Charging: The final DC output feeds directly into the vehicle's battery.

II. METHODOLOGY

1. Literature survey and concept finalization.
2. Design of system block diagram.
3. Selection of components.
4. Fabrication of road model with embedded coil.
5. Installation of solar panel and battery storage.
6. Connection of wireless charging circuit.
7. Testing and performance analysis.
8. Result evaluation and documentation.

III. PHYSICAL INSTALLATION PHASES

Implementing the charging roadway involves the following engineering steps:

1. Geological Assessment: Analyzing the site and soil to ensure structural integrity.
2. Pavement Excavation: Removing the top layers of the road to accommodate the hardware.
3. Conduit Integration: Placing protective housing for the electrical wiring and sensors.
4. Coil Deployment: Setting the induction transmitters at precise intervals beneath the surface.
5. Electrical Networking: Routing power cables from the solar storage units to the road coils.
6. Concrete Encapsulation: Pouring high-strength (M30–M40 grade) concrete to secure the components.
7. Surface Treatment: Final curing and mechanical compaction to meet highway safety standards.
8. System Activation: Final commissioning and safety testing of the electrical field.

IV. FUTURE ENHANCEMENTS

The next generation of this technology will focus on:

- Resonant Optimization: Implementing high-efficiency coils to reduce energy dissipation.
- Grid Synergy: Integrating the system with smart grids for bidirectional energy flow.
- Automated Oversight: Utilizing AI for real-time monitoring and charging optimization.
- Vehicle Recognition: Sensors for the automatic detection and billing of EVs.
- Rapid Charging: Upgrading power electronics to support high-speed energy transfer.
- Heat Regulation: Developing advanced thermal management systems for heavy-use highways.

V. ACTUAL CONSTRUCTION PROCESS OF EV ROAD

1. Site survey and soil testing
2. Excavation of the road surface
3. Installation of protective conduits
4. Placement of transmitter coils
5. Power cable routing
6. Concrete pouring (M30–M40 grade)
7. Curing and compaction
8. Electrical testing and commissioning

VI. FUTURE SCOPE

1. High efficiency resonant coils
2. Smart grid integration
3. AI-based charging control
4. Automatic vehicle detection
5. Fast charging capability
6. Commercial highway deployment
7. Improved thermal management
8. IoT monitoring system

VI. CONCLUSION

The Solar-Powered EV Charging Road System represents a transformative solution to the logistical hurdles of electric mobility. By merging renewable energy generation with wireless induction, it allows for continuous driving without the downtime traditionally required for charging. While the initial investment for such specialized infrastructure is significant, the long-term ecological benefits and the reduction in fossil fuel dependency provide a strong case for its implementation. This research confirms that on-road charging is a key pillar for the future of sustainable transportation and intelligent urban development.

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