www.ijarp.com ISSN 2456-9992 Page: 01-08

International Journal Advanced Research Publications

Review Article

Volume: 02
Issue: 05

SMART EV RESERVATION SYSTEM

***[1]S.Sudharshan, [2]S. Leena Sylviya, M.Sc., (Ph.D)**

[1]Department of Computer Technology, Dr. N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India.

[2]Assistant Professor, Department of Computer Technology, Dr. N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India.

Article Received: 21 March 2026, Article Revised: 11 April 2026, Published on: 01 May 2026

***Corresponding Author: S. Sudharshan**
Department of Computer Technology, Dr. N.G.P. Arts and Science College, Coimbatore, Tamil Nadu, India.
DOI: https://doi-doi.org/101555/ijarp.1823

ABSTRACT

The shift towards electromobility worldwide is the key approach to counter the 25% of Aglobal carbon dioxide emissions produced by the transportation sector. But the massive adoption of electric vehicles is obstructed by "range anxiety," long waiting times, and the absence of real-time infrastructure information. This paper describes a complete Internet of Things (IoT)-based framework for smart electric vehicle charging management, combining diverse sensing hardware with cloud-based reservation algorithms. We test the performance of the SCT013 current sensor and ZMPT101B voltage sensor, observing an average error of only 0.036A and 1.66V, respectively. Moreover, we examine AI-powered scheduling models, namely Long Short-Term Memory (LSTM) and Random Forest networks, which provide an accuracy of 87.4% in availability forecasting and minimize urban waiting times to an average of 7.8 minutes. The research also measures the sustainability value of solar-integrated stations, proving that a 10-panel solar photovoltaic system can completely compensate for the standard user's daily 37-mile commute, ensuring a 100% carbon-neutral footprint. The results prove that smart coordination can decrease the mean travel time per trip by 9.8% and minimize station peak loads by 25%.

KEYWORDS: Electric Vehicles (EV); Internet of Things (IoT); Smart Charging; LSTM; Load Balancing; Sustainable Smart Cities; Renewable Energy.

Significance Statement

The integration of IoT and Artificial Intelligence in EV charging infrastructure solves the crucial bottleneck of "range anxiety" that has been hindering the adoption of green transport by consumers. This research helps in the creation of intelligent nodes from passive charging points, thus offering a scalable solution for smart cities to deal with energy demand. The solution not only optimizes convenience for users by decreasing waiting times by more than 60% but also secures the national grid against any overload.

1. INTRODUCTION

The pressing need to lower the carbon footprint of urban transportation has expedited the global transition to electromobility. In modern smart cities, the integration of 5G networks and Battery Energy Storage Systems (BESSs) has enabled the development of a ecosystem where EVs and autonomous driving capabilities are gradually becoming the norm. Nevertheless, the deployment of large-scale EV networks creates substantial challenges to the existing power infrastructure, frequently resulting in localized overload conditions during peak hours.

In nations such as India, which aims to achieve 30% EV penetration by 2030, the lack of charging infrastructure and inefficient management of existing resources remains the foremost hindrance. Conventional charging stations function on a "First-Come, First-Served" (FCFS) system, resulting in uncertain queuing and passenger aggravation. The Internet of Things (IoT) brings about a revolutionary change by enabling the conversion of passive charging infrastructure into "Smart Connected Hubs" that can be autonomously controlled in real-time. This allows for the interconnection of physical devices via identification, sensing, and computation, thereby enabling a smooth integration of the power grid and the transportation sector.

2. Literature Review and Related Work

Current studies have progressed from mere connectivity to more intelligent orchestration and resource optimization.

2.1 Intelligent Scheduling Models

Bernal et al. designed an intelligent model for optimizing station management with advance reservations to address the uncertainty of connector availability. Likewise, Kumar et al. designed distributed systems for planning energy-efficient routes by integrating battery State of Charge (SoC) with real-time road conditions.

2.2 Edge vs. Cloud Architectures

Roadside Units (RSU) are used in current systems such as "Mobile Edge Computing" (MEC) to predict availability with low latency. Current systems lack the processing power of cloud infrastructure and are only capable of short-range connectivity, despite their lower latency. Better scalability for urban management is offered by cloud infrastructure that integrates Open Charge Point Protocol (OCPP) features, such as blockchain for safe payment processing and artificial intelligence (AI) for smart alerting.

2.3 Battery Health and Monitoring

Machine learning (ML) can help manufacturers develop longer-lasting batteries, help users plan their routes optimally, and predict the remaining useful life (RUL) of EV batteries. Compared to conventional physics-based models, machine learning models are able to predict outcomes 25 times more quickly.

3. Architectural Framework of IoT-Integrated Systems

A resilient IoT ecosystem for EV management is characterized by a multi-layered functional stack designed for high Quality of Service (QoS) and low-power operation.

Architectural Layer	Core Technical Components	Primary Functionality and Data Flow
Perception Layer	SCT013 current sensors, ZMPT101B voltage sensors, temperature probes, RFID readers, QR code scanners	Real-time acquisition of electrical and environmental parameters; user authentication and physical session initiation
Network Transport Layer	Wi-Fi (ESP32/ESP8266), 4G/5G cellular modules (LTE Cat 1/4), LoRaWAN, NB-IoT, Ethernet	Secure transmission of telemetry data to cloud-based servers; handling of bidirectional control signals
Application Layer	Google Firebase, ThingSpeak, Cloud Management Systems (CMS), Mobile Apps (Android/iOS)	Big data analytics, demand forecasting, automated billing, remote diagnostics, and user-centric scheduling

3.1 Communication Protocols

Interoperability is maintained through standardized protocols:

- **OCPP (Open Charge Point Protocol):** The industry standard for communication between a station and the cloud, critical for remote start/stop, billing, and diagnostics.
- **MQTT (Message Queuing Telemetry Transport):** A lightweight protocol favored for real-time monitoring because it requires minimal bandwidth and offers high reliability in

lossy networks.

- **OCPI (Open Charge Point Interface):** Facilitates "roaming," allowing users to use different charging networks with a single account by sharing station location and availability.

4. Hardware Integration and Circuit Design

The practical implementation relies on a synergy of robust microcontrollers and precise electrical sensors.

4.1 Microcontroller Unit (MCU) Selection

The ESP32 microcontroller is selected as the central processor due to its dual-mode Wi-Fi and Bluetooth capabilities, high-resolution ADC, and dual-core processor which allows for parallel processing of sensor polling and cloud communication. For smaller-scale data acquisition, the ESP8266 (NodeMCU) provides a cost-effective Lua-based firmware alternative.

4.2 Electrical Sensing Technologies

To ensure safe power delivery, the system incorporates non-invasive sensors:

- **SCT013 Current Transformer:** A split-core clamp sensor capable of measuring AC current up to 100A using magnetic induction.
- **ZMPT101B Voltage Sensor:** A micro voltage transformer module used for monitoring AC mains up to 250V with high precision and safe electrical isolation.

Table 1: Technical Performance Metrics of Sensing Hardware.

Sensor Model	Parameter	Rated Capacity	Observed Accuracy/Error
SCT013	AC Current	0-100 A	0.036 A Deviation
ZMPT101B	AC Voltage	0-250 V	1.66 V Deviation
DHT11	Temperature	0-50 °C	±2 °C Accuracy

4.3 Circuit Logic and Calibration

The SCT013 requires a burden resistor to convert the induced current signal into a voltage signal readable by the MCU's ADC. RMS voltage and current are calculated by sampling multiple cycles to account for AC fluctuations. Calibration is performed using the formula:

$$OutputVoltage = Sensitivity \times Current$$

Experimental results indicate that the ESP32 + ZMPT101B combination maintains consistent performance with error values spanning only 0.089V to 0.456V after initial setup.

5. Artificial Intelligence and Optimization Algorithms

The core value of smart charging lies in its ability to process vast data streams to optimize resource allocation.

5.1 Scheduling Algorithm Comparison

While FCFS is easy to implement, it leads to high wait times and poor resource utilization. Our system evaluates three advanced alternatives:

- **Round-Robin Scheduling:** Allocates charging slots based on predefined time intervals, ensuring fair access for multiple EVs plugged in simultaneously.
- **Greedy Algorithm:** Makes locally optimal decisions based on immediate criteria such as current battery levels and electricity prices.
- **AI (LSTM) Forecasting:** Utilizes Long Short-Term Memory (LSTM) networks to analyze historical transaction data and predict availability with 87.4% accuracy.

Table 2: Comparative Analysis of Scheduling Algorithms.

Algorithm	Logic	Wait Time Reduction	Strategy
FCFS	First-Come First-Served	0% (Baseline)	Static Queue
Round-Robin	Predefined intervals	35-45%	Time-Sharing
Greedy	Locally optimal decisions	60-70%	Priority-Based
AI (LSTM)	Predictive forecasting	83.25%	Dynamic Optimization

5.2 Nearest Station Selection (KNN)

The K-Nearest Neighbor (KNN) algorithm is employed for trip planning, identifying the nearest station based on Euclidean distance:

$$d(p,q) = \sqrt{\sum_{i=1}^{n}(q_i - p_i)^2}$$

where p and q represent the geographical coordinates of the vehicle and the station. The system typically uses $K = 5$ to ensure a balance between speed and reliability.

6. Sustainability Through Solar and Renewable Integration

A significant limitation of current EVs is their reliance on a power grid that may still be 40-60% fossil-fuel dependent.

6.1 Synergy Between PV and EV Infrastructure

Integrating solar Photovoltaic (PV) arrays with IoT-enabled stations provides a solution for achieving a 100% carbon-neutral footprint. Excess solar energy generated during the day can be stored in "second-life" batteries—retired EV batteries that retain 70-80% capacity—for use during peak night hours.

6.2 Net Metering Calculations

Net metering allows users to pump excess energy into the grid for credits. **Mathematical Model for Capacity:**

- Average daily commute: 37 miles.
- Energy requirement: ~10 kWh/day.
- Solar Panel output: A 250-watt panel produces ~30 kWh/month.
- **Result:** A 10-panel array is sufficient to power a standard daily EV commute.

7. Performance Analysis and Results

Quantitative analysis reveals profound improvements in infrastructure efficiency:

- **Wait Time Reduction:** In crowded urban centers, average wait times were reduced from over 20 minutes to 7.8 minutes.
- **Infrastructure Utilization:** A moderate density of smart-connected stations combined with effective scheduling can eliminate wait times for 94% of users.
- **Grid Stability:** AI-managed charging reduced peak grid loads by approximately 25% and CO$_2$ intensity by 8%.

8. Strategic Challenges and Future Perspectives

Even with technological advancements, there are still a number of obstacles to widespread adoption.

8.1 Data privacy and cybersecurity

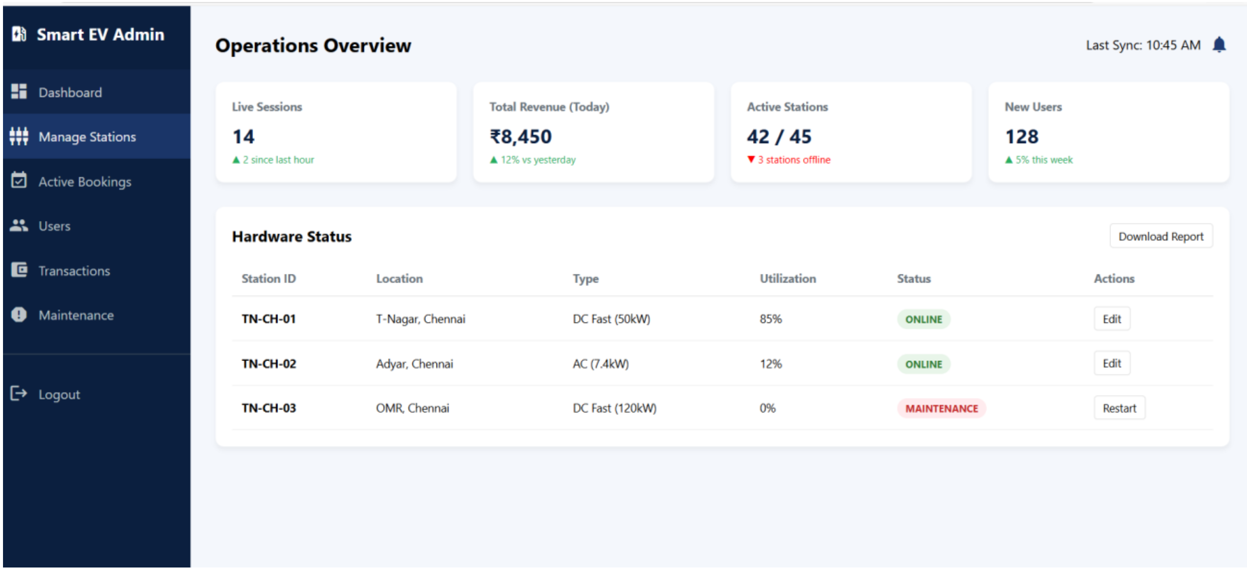
Unauthorised access and grid manipulation are risks associated with increased connectivity.

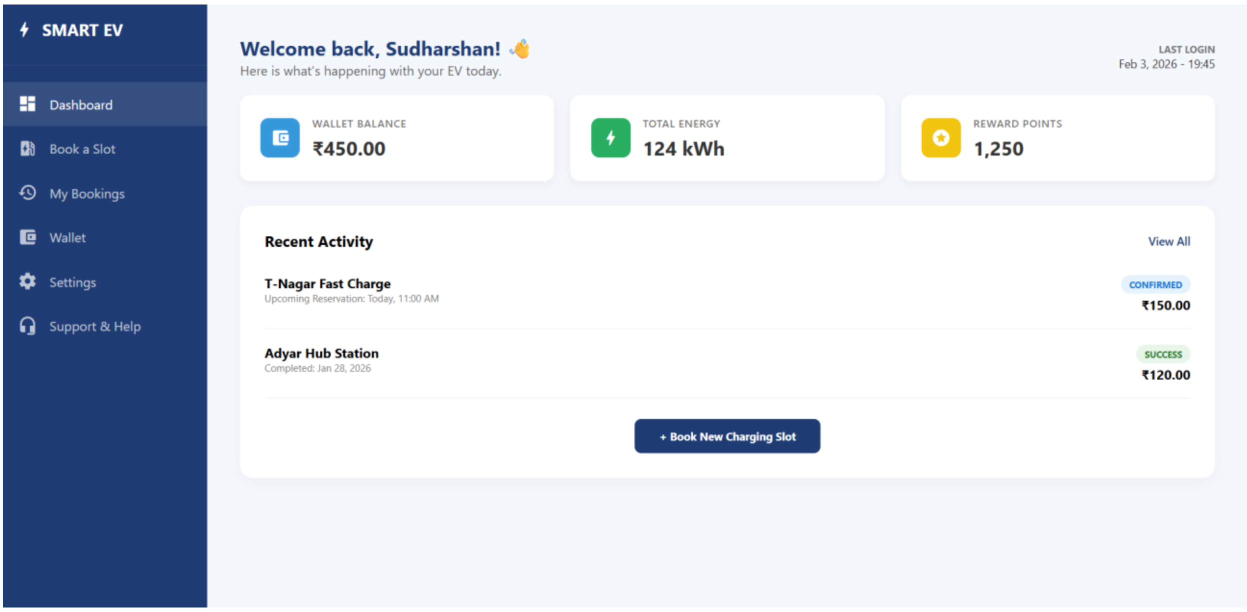
The power grid might become unstable in the event of a coordinated attack on smart chargers. Future security depends on the use of blockchain technology and WPA3 encryption in auditable payment systems.

8.2 Vehicle-to-Everything (V2X)

Systems of the future will switch to a bi-directional energy ecosystem. Parked EVs can act as distributed energy storage thanks to V2G (Vehicle-to-Grid) technology, which smoothes the "duck curve" of energy demand by discharging power during peak hours.

Output





9. CONCLUSION

An important paradigm shift for resilient urban mobility is the incorporation of IoT and AI into EV charging management. We greatly improve grid reliability and user satisfaction by substituting dynamic, predictive reservation systems for static FCFS queues. Our study demonstrates that wait times can be cut by more than 60% while maintaining grid stability when LSTM forecasting models are used in conjunction with high-fidelity sensing hardware. Decoupling EV transportation from fossil fuels and accomplishing a truly sustainable green mobility revolution require a shift to solar-coupled infrastructure.

REFERENCES

1. Advancements in AI-Powered Electric Vehicle Routing: Multi-Constraint Optimization and Infrastructure Integration Approaches for - IEEE Xplore, accessed on February 14, 2026, https://ieeexplore.ieee.org/iel8/6287639/10820123/11080438.pdf
2. Electric Vehicle Smart Charging Reservation Algorithm - PMC, accessed on February 14, 2026, https://pmc.ncbi.nlm.nih.gov/articles/PMC9028875/
3. Machine Learning-Based Prediction for EV Charging Station Avail-ability and Wait-Time Estimation - Prime Open Access, accessed on February 14, 2026. https://www.primeopenaccess.com/scholarly-articles/machine-learningbased-prediction-for-ev-charging-station-availability-and-waittime-estimation.pdf
4. Benefits of a Solar Powered EV Charging Station, accessed on February 14, 2026. https://www.solarbycir.com/ev-chargers/ev-charging-station-benefits/
5. Public EV Charging Queue and Reservation Hardware Market | Global Market Analysis Report-2036, accessed on February 14, 2026. https://www.futuremarketinsights.com/reports/public-ev-charging-queue-and-reservation-hardware-market