PlugPoint - EV Charging Station Finder and Slot Booking System

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***Abstract* — Major changes are happening worldwide, from the conservation of energy resources vehicles to electric vehicles (EVs) with zero or very low tailpipe emissions. This paper examines the key elements involved in designing and deploying EV charging infrastructure. It focuses on encompassing information technology, decentralized energy production, and conducive government regulations. The study shows the current EV market, challenges in grid integration, and strategic placement of charging stations. It emphasizes the need to strategically situate fast charging stations while considering financial and grid repercussions into account, along with addressing adoption issues. Future developments including the combination of natural energy sources and vehicle-to-grid (V2G) technology are also examined in the study. Furthermore, it showcases an Android mobile application created using Java.**

Keywords* — *Ev's Charging Locations, Stations, Power Grid, Environmentally Friendly, Cost Efficient, Real-Time, Slot Booking, Payment Services

I. INTRODUCTION

The automotive sector worldwide is experiencing a revolutionary change as alternatively powered vehicles, especially electric vehicles (EVs), make progress. These eco-friendly alternatives offer notable benefits compared to conventional combustion engine cars, such as minimizing the dependency on non-renewable energy resources, decarbonization, and minimizing environmental impact. Fully electric vehicles, which operate solely on electricity, are at the forefront of this technological advancement. With more than 30 EV models currently being manufactured and substantial investments in their creation, marketing, and production, the EV market is experiencing rapid growth. In 2022, EV sales experienced a remarkable 141% increase, reaching an unprecedented 995,319 units, highlighting an increase in customer demand for green mobility options.

Till the year 2024, the growth of Electric Vehicles (EVs) has come to more than 5.6 million. The country satisfied an uncommon number of bargains for EVs, crossing the 2 million mark for the first time. In the year 2023, the total number of EV deals was 1.6 million roughly, 2024 brought a wave in the deals coming to over 2 million units, this illustrates a development rate of 24% and appears the increment in customer requests. This comes about in a noteworthy increment in the showcase share of EVs in India that went from 6.8% to around 8% in the final year.

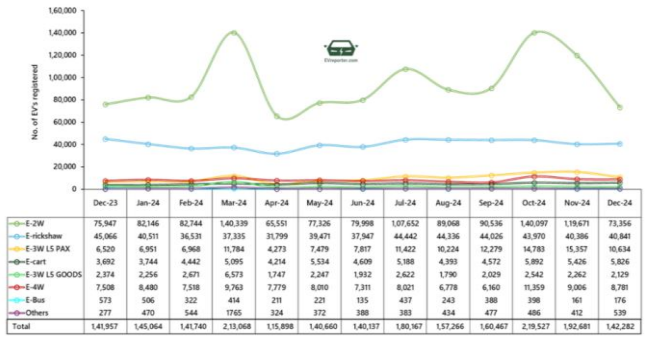
However, the extensive use of EVs depends on the presence of an active charging network. Since the public needs to charge points for EV consumers, their placement is done inconsistently, specifically in places such as India, Ceylon, and Bangladesh, where the charging points are present in limited numbers, which creates issues for EV users. The shortage of a hassle-free experience for charging their EVs due to the shortage of charging facilities and the difficulty of locating them results in problems and an unsatisfied user. In the context of resolving this issue, vast automation is being introduced, such as mobile applications for showing the location and details of the charging stations, also booking the slot for better management of time.

The increase in the use of EVs has also given many opportunities and challenges to power source and power grid integration. While there is increased utilization of EVs, the necessity for the power supply and consumption will rise, resulting in essential modification to the electrical distribution grid and a system that affiliates with renewable energy resources. The calculated and accurate arranging of the charging stations, considering financial aspects and productivity of the electricity network, are the most important factors for determining a robust EV charging station infrastructure. Therefore, advancements in technologies like battery technology, charging technologies, and vehicle-to-grid (V2G) systems are essential to increase the efficiency of EVs.

This research aims to determine the major factors affecting the strategies for implementing the EV charging infrastructure, technical development, problems during the integration of the power grid, and following regulations. Eventually, this indicates that transformations like mobile applications and priority-based slot-booking systems can take the user's experience to another level of satisfaction and also raise the level of efficiency of the infrastructure. Subsequently reviewing these problems and using today's emerging technologies, the worldwide rate of transformation for EVs can speed up, resulting in a clear and environmentally friendly future.

Category wise-Sales Trend from Dec 2023 to Dec 2024

19,48,957 EVs sold in last 12 months from Jan 2024 to Dec 2024



	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
E-2W	75,947	82,146	82,744	1,40,339	65,551	77,326	79,998	1,07,652	89,068	90,536	1,40,097	1,19,671	73,356
E-rickshaw	45,066	40,511	36,531	37,335	31,799	39,471	37,947	44,442	44,336	44,026	43,970	40,386	40,841
E-3W L5 PAX	6,520	6,951	6,968	11,784	4,273	7,479	7,817	11,422	10,224	12,279	14,783	15,357	10,634
E-cart	3,692	3,744	4,442	5,095	4,214	5,534	4,609	5,188	4,393	4,572	5,892	5,426	5,826
E-3W L5 GOODS	2,374	2,256	2,671	6,573	1,747	2,247	1,932	2,622	1,790	2,029	2,542	2,262	2,129
E-4W	7,508	8,480	7,518	9,763	7,779	8,010	7,311	8,021	6,778	6,160	11,359	9,006	8,781
E-Bus	573	506	322	414	211	221	135	437	243	388	398	161	176
Others	277	470	544	1765	324	372	388	383	434	477	486	412	539
Total	1,41,957	1,45,064	1,41,740	2,13,068	1,15,898	1,40,660	1,40,137	1,80,167	1,57,266	1,60,467	2,19,527	1,92,681	1,42,282

Source: Vahan dashboard data as of 2nd Jan 2025. Data as per 1373 out of 1434 RTOs across 35 out of 36 state/UTs.

II. LITERATURE REVIEW

A. Challenges in EV Adoption and Charging Infrastructure

The use case for electric vehicles (EVs) is generally considered a crucial step toward green mobility or transportation, solving problems like conservation of energy resources, scarcity, greenhouse gas emissions, and contamination of the environment. However, the adoption of EVs faces several challenges. The major concern is how EV charging results in the power grid. In today's changing world, the number of EV users has increased; ultimately, EV demand increases, and it affects power grid dependency, resulting in transformer overloading and loss of energy. These problems or issues increase as the power usage of EVs increases, which results in making essential modifications or updates to the power grid infrastructure to manage energy systems efficiently and effectively. The following are the notable challenges that can affect the adoption of EVs:

- **High cost of EV components:** EVs' costliest component is the battery, such as Lithium batteries or cells, which are most commonly used and adopted at this point. Manufacturing Lithium batteries is currently expensive, and making EVs usually more expensive, hampering the adoption of EVs.
- **High demand on the electricity grid:** If the electricity is created from normal energy sources such as thermal/ hydro power plants, the overall reduction in emissions may be hampered, impacting the ecological advantages of EVs. To solve this problem, it is necessary to blend renewable energy sources such as stellar or solar and wind with the load infrastructures.
- **Lack of charging infrastructure:** The lack of rapid charging stations (RCS) further complicates EV adoption. Range anxiety— When we don't have enough battery power left before reaching a charging station, there are important barriers for EV users that are potential. RCS solves this issue by reducing charging times, their availability is limited, and high installation costs hamper their widespread deployment.
- **High cost of implementation:** In the beginning, the implementation of vehicle-to-grid (V2G) technology allows EVs to feed energy back into the grid. V2G stabilizes the grid and provides some additional income for EV owners.

B. What is an EV Charging Application & Why is it essential?

An EV charging application is a platform-based service offering real-time information on the available chargers in the user's area/ route. These apps make identifying locations and information about available chargers, pricing, connectors, etc. extremely convenient for EV users. EV charging app providers can integrate booking slots for charging and also in-app payment services and subscription-based models.
Advanced features can include information on car usage and suggest products based on the usage pattern, making predictive maintenance to change/ replace critical parts such as brake pads, battery health, etc. It can also provide information on the availability of charging stations along with locality information like food courts, restrooms, etc. The app can provide a platform for EV users to form a community sharing experiences and can help in the further adoption of EVs.

C. Types of EV Charging Stations

Basically, there are three main classifications or categories based on their power source and charging requirements:

- **Hybrid Electric Vehicles (HEVs):** A hybrid electric vehicle (HEV) is a type of hybrid vehicle that couples a conventional internal combustion engine (ICE) with one or more electric machines into a combined propulsion system. The presence of the EV drivetrain, which has fundamentally better energy conversion effectiveness, is considered to achieve either better energy frugality or better acceleration performance than a conventional vehicle. There are various types of HEV and the degree to which each functions as an electric automobile also varies. The most frequent form of HEV is hybrid electric passenger buses, although hybrid electric exchanges (pickups, hitch exchanges, and tractors), motorcars, motorboats, and aircraft also exist.
- **Plug-in Electric Vehicles (PEVs):** Plug-in EVs are categorized into Battery EVs (BEV) and Plug-in hybrid EVs (PHEV). Battery EVs are totally electric motors that operate on a battery and motor solely. PHEVs are hybrid vehicles that run on a fusion of electric motors and are mated to a gasoline engine, increasing the vehicle span and making the vehicle partly a green vehicle to an extent.

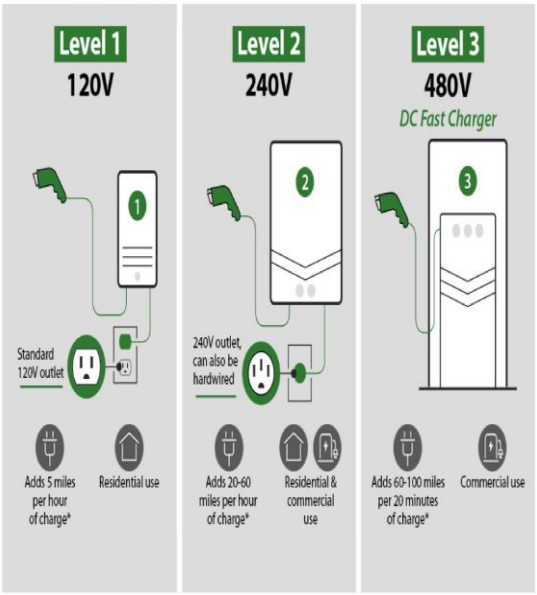
- **Fuel Cell Electric Vehicles (FCEVs):** FCEVs are based on the energy that is generated from hydrogen Fuel Cells and the by-product is H2O (water). The Fuel Cell is currently a very niche technology as storing and conversion of hydrogen requires special material cylinders, making the technology expensive at this point.

D. Technological Developments in the field of infrastructure load

The development of EV charging infrastructure has been significant in the last few years, driven by the necessity to support the increase in the number of EVs on the road. Key technological developments include:

Charging Levels and Modes: There are three levels of EV charging based on the power output and charging speed:

- **Level 1 (L1):** L1 charging is the slowest charging, usually taking more than 8 hours. L1 charging is known as overnight charging as the power output ranges from 1 to 7.2kW. These chargers work on 120V connections found in homes. These could be wall-mounted or portable.
- **Level 2 (L2):** L2 charging is slightly faster than L1 as the power output ranges from 7.2kW up to 22kW. These chargers usually take 5 to 6 hours for an electric vehicle to charge fully. These are usually wall mounts and require a 3-phase connection.
- **Level 3 (L3):** L3 charging or load is additionally called DC fast charging. These are usually up to 50kW to 100kW. Mostly they are located as public chargers and can charge the vehicle up to 80% within 15-20 minutes. Currently, in India, public chargers are set up by companies like Tata Power, Jio, etc. The common charging base or infrastructure is set to improve and increase because of the high rise of EVs in India. DC fast load is a paid service done on a pay-as-you-use basis.



III. PROPOSED SYSTEM

Electric vehicle (EV) charging stations can be easily detected, located, and used. The proposed system provides an extensive and well-designed infrastructure. Figure 5.1 is an architecture of the EV charging station system which demonstrates the combinations of various key components to ensure a user-friendly experience for EV users. The EV Charging Station Finder is the main component that uses Map Integration Service or Google Maps API to give real-time information about the nearest or closest charging stations that are on the way. It makes it efficient for users to view detailed data, and search for stations on the application, such as availability of stations, pricing range, and charger type. Also, the user can use the provided filters to get the most suitable and relevant option. Even if the user resides in rural or urban areas, these features help users to find the charging station nearest to them and satisfy the needs of the user.

There are numerous steps to ensure a secure avenue to the system for the user, which has to complete the registration and login process. This process includes the creation or making of a unique or special profile using the username and password of the user. The user of the application can modify, change the options for the filter, control their profile, and look for booking history after logging in. This fulfills the user's needs, which makes the user experience more efficient and makes the application more user-friendly.

The user can make use of charging stations efficiently as the Manage Charging Slots key components grant users to book and manage them. The users or end users can book the slot as per their schedule, as they can verify and confirm the attainability of charging slots in real time. On the basis of urgency and priority, the regular users get the delegated slots on a first-come, first-served basis to book their charging slot on a station. These functions and

features reduce the waiting time, ensuring efficient and effective usage of electric charging station infrastructure.

If the booking is successful, users get the booking confirmation via the application. The details consist of EV charging station location, slot timings, one-time password (OTP) for user authentication, pricing, and offers. To certify only legitimate end users are using or accessing the application, OTP is used to enhance the security and privacy of users, avoiding misuse of information and leakage of the user's data. By this process, the user gets peace of mind and an assurance that the slots are booked securely, and the slot is confirmed.

As the user profile is created, below the profile, the Manage EV Listings feature is present where users can add as well as manage multiple electric vehicles. Even if the user wants to book the slots for multiple vehicles, there's no need for separate accounts, which is more convenient and useful to users who possess more than one vehicle. Rather than having many accounts on different platforms, users can command all their EVs from one platform, due to this, the user gets a simplified feature for booking slots.

For efficient and effective electric vehicle charging services, the payment management component or payment gateway expedites the transaction at the final stage. Just like other payment gateways, users can check the traffic rates, make payments, access the receipt of their transaction, and get the confirmation of the slot booked. The user experience is satisfactory as the feature in the application of the electric vehicle charge station locator allows seamless and effortless payment transactions, emphasizing user ease. The main motto of this proposed system is to make or create a powerful platform for presiding over electric vehicle charging issues by combining the several components. The system is more sustainable, supports the growing adoption of EVs or electric automobiles, and creates a major impact in the ecosystem of transportation.

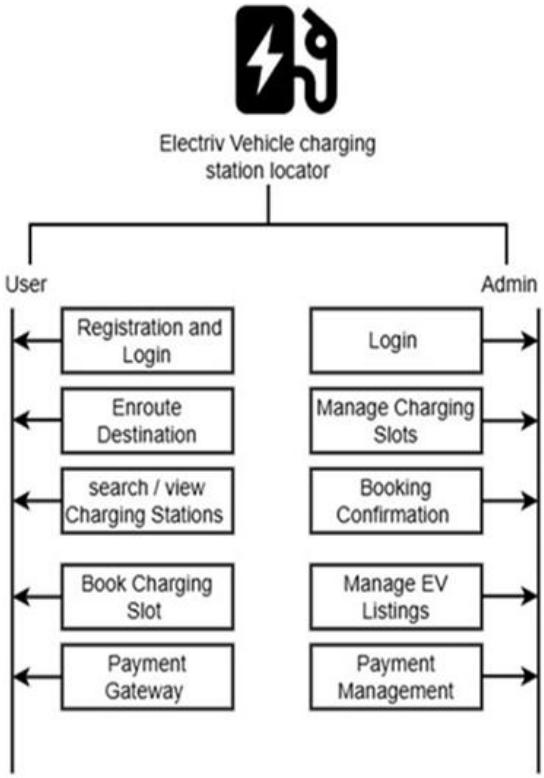


Fig – 5.1: System Architecture

IV. FUTURE TRENDS

The electric vehicle (EV) charging architecture will involve improvements in the future due to high-tech innovations and the worldwide change toward sustainable transportation and greener evolutions to make a significant impact. Advanced data storage with authentication will support the efficiency and reliability of the system, which is a key trend in the revolution of conventional power grids into smart electricity grids. The essential aspect of this evolution is the combination of vehicle-to-grid (V2G) technology, which enables bilateral power transmission between the grid and EVs. The grid stability is enhanced after decreasing blackouts, assisting system failures, losses, and overloads, allowing EV users to sell back extra energy to the power network with lower capital costs. The significant barriers to adapting and increasing the usage of EVs are overwhelming, as range apprehension is crucial to overcome. As conventional lithium-ion batteries have huge capacity, innovations like lithium-sulfur batteries will notably impact the development and expansion of rapid charging stations (RCS). If paired with smart grid integration and placement tactics, these developments can offer accessible charging alternatives, reducing wait times, travel lengths, and multiple options to EV consumers.

The user convenience, experience, and service provider cost can be reduced to support growing numbers of EVs after focusing on future trends. To handle the extra load, the

existing grid will require upgrades and stabilization as EV adoption increases. Sustainable energy supply is important and mandatory in lowering the environmental impact of authentic natural sources such as solar, wind, geothermal, and hydropower on distributed generation (DG) systems. AI-driven applications are developed for locating and managing EV charging stations which improves user and customer experience by assuming usage patterns, promoting station placement, and producing real-time data based on availability and demand. Payment gateway systems can be included in these applications to enhance the charging process to make it more efficient, effective, and user-friendly. The global transition to electric mobility will be accelerated if these trends come together to create a sustainable, convenient EV charging ecosystem.

V. CONCLUSION

The developments in grid integration, charging base or infrastructure, and technology are a boon and promising future opportunities for electric automobiles. A slight shift to an energy Internet-based grid, while smart charging systems, dependable communication networks, and coordinated charging with dispersed energy will be beneficial to electric vehicles due to possible and efficient automated energy management. To make the global use of electric vehicles standard, standardization of global charging stations is mandatory. The energy landscape can entirely change EV charging with scheduling, slot booking, and cost-efficient factors. As the EVs are user-friendly and provide effective features like charging station location apps along with comprehensive information and real-time updates, there is a high probability of using them. Further studies should emphasize factors like vehicle-to-grid (V2G) technologies, cost-effectiveness, and reducing charging estimated time to refine the upcoming future of electric vehicles and make them affordable. The EV ecosystem can achieve sustainable growth, minimize carbon emissions, and create a greener, cleaner future. This will be possible only after considering the current difficulties and innovations, leading to more efficient transportation.

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