Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 3, No.2, March : 2025

ASSESSING CHALLENGES IN EV CHARGING INFRASTRUCTURE: ACCESSIBILITY, AND ECONOMIC VIABILITY FOR LONG-DISTANCE TRAVEL- A STUDY ON PALAKKAD DISTRICT, KERALA

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ABSTRACT
The project is targeted at understanding the issues that are typically encountered by the EV user in long travel and provides a detailed assessment of the contemporary Electric Vehicle (EV) charging infrastructure, which encompasses public and private stations. We assess the AC (slow), and DC (fast) chargers. Surveys from the Electric vehicle users are collected and analysed to obtain a detailed understanding about the issues encountered while they access these charging stations. We also look at distribution in terms of geography of Charging stations and pricing structures, because they give better insight into which users are paying for the station. Another challenge addressed is on user accessibility that is illiteracy and people's unfamiliarity with mobile application usage for facilitating charging stations utilization. Based on this, suggestions on implementable measures to spur the development of the EV charging ecosystem will aid large-scale deployment toward the objective of sustainable transport.
Keywords: EV Charging Infrastructure, Long-Distance Travel, Geographic Distribution

I. Introduction
Market for electric vehicles has been growing rapidly over the last few years due to a range of moves made globally to opt for sustainable transport. The potential has been fashioned, largely, because it is becoming viable to opt for a near replacement of the conventional Internal Combustion Engine (ICE) vehicles by the Electric Vehicles. Investment by governments and private sectors around the globe in the field of EV technology, charging infrastructure, and policy incentives has turned out to be a way of expediting adoption. Currently, 1,83,686 electric vehicles are registered in the state of Kerala with this year alone accounting for 54,703 new registrations, reflecting the states growing shift towards sustainable transport options.

II. Literature
This paper highlights the EV policy of Kerala and the multi-faceted approach in promoting e-mobility by building charging infrastructure, fiscal incentives, and converting public transport into electric [1]. The study identifies 11 significant challenges in the Indian development of EV charging infrastructure, including a lack of charging stations, the high cost of batteries, limited range, and many more. It reflects the need for a systemic approach to such challenges for the smooth adoption of EVs in India. Focus on the FAME scheme, and the NEMMP as well, aiming at the facilitation of electric vehicle adoption, building the needed infrastructure, etc [2].The study provides insights into the costs, benefits, and technological advancements required for the successful implementation of EVs, emphasizing the need for continuous research and development, uses the MCDM approach to rank the evaluation criteria for EV adoption based on expert opinion.[3]. Shows that dual-mode charging stations are beneficial in dropping service rates when compared to single-mode stations, and strategic pricing is the key to maximizing this charging infrastructure [4]. The paper provides an extensive overview of current EV charging technologies, international standards for interoperability and safety, and various architectures for EV charging stations. It deals with the current EV charging technologies, international standards, and different architectures of charging stations. The paper also focuses on the converter configurations used in charging systems, especially on isolated and non-

isolated DC-DC converters. Further, the paper reveals the integration of renewable sources of energy to make the EV charging infrastructures more effective and sustainable [5]. Highlights that smart tariffs, especially dynamic ones, can reduce grid carbon emissions but may still increase peak demand. The study emphasizes the need for capacity management to mitigate the risks of grid overload [6]. The paper gauges the impacts of different tariff policies on carbon reduction and stress at the grid. It presents that smart tariffs, especially the dynamic ones, would reduce grid carbon emissions, though peak demand could increase in such cases. This study concludes by underlining the importance of capacity management for overcoming the threat of grid overloading [7]. It evaluates the societal impacts and technical aspects of EV charging systems, focusing on vehicle-to-grid (V2G) technology. The study highlights the benefits and issues of different charging methods and their effects on the power grid and environment [8]. It examines the types and methodologies of EV charging stations, comparing Indian standards with global ones. It highlights the advantages of the combined charging system (CCS) and CHAdeMO, and addresses key challenges in standardization [9]. The government policies, standardization, and public-private partnerships have emphasized the main role in welcoming the access and deployment of EV charging infrastructure [10]. The paper also presents the innovative idea of Vehicle-to-Grid (V2G) technology, which enables the simultaneous provision of supply of power back to the grid from an EV, hence increasing the integration of renewable energy and offering a supplementary source of power. The study stresses the role of policies by the governments, technological advancements, and public awareness in overcoming all these barriers and promoting the adoption of EVs in India [11]. The paper emphasizes the need for a systematic methodology to ensure the profitability and effectiveness of EV charging infrastructure, with a focus on the city of Kolkata, India [12]. The study emphasizes the role of machine learning in understanding consumer behavior and aiding policymakers in designing effective strategies to boost EV adoption [11].

III. Methodology

The project focuses on examining the challenges that EV users face while driving for long distances and investigate the charging infrastructure's operational capabilities, this current research study uses a mixed-method research methodology. The data collection method consists of both quantitative and qualitative forms, such as user surveys, geospatial analysis, and secondary research. By undertaking an analysis of public and private charging points, AC (slow) and DC (fast) charging points, pricing models, and user access problems, the study seeks to give a general assessment of the current EV charging infrastructure today. The study also explores the influence that digital literacy will have on station usage, specifically the access problems for illiterate users of mobile apps.

3.1 Data Collection

Data collection is carried out in a mixed method design in an attempt to gather the required information for the study. The 30 EV users are interviewed and surveyed through structured interviews and surveys to gather firsthand data on issues encountered during driving long distances, such as charging point availability, waiting time, pricing plans, and user accessibility. The various charging data and energy consumption of various stations also have been obtained during the data collection process. Literature reviews, official reports, and industry journals are scrutinized for finding present-day EV infrastructure, charging efficacy, and world's best practices. Geospatial allocation of charging points is drawn from official databases, EV service providers, and geographic information system software for recognizing areas of station shortages. The study differentiates between public and private charging networks, assessing their accessibility, utilization, and pricing models.

3.2 Analysing the Charging infrastructure

The chargers commonly available in the locations can be categorized into AC and DC chargers. While the AC chargers even though they are available in the market typically since they are of slow charging they are not mostly preferred over the fast DC chargers. But some vehicles with low battery

capacities available in the market can be charged using these AC chargers. Since the AC chargers take relatively very high charging time compared to the DC chargers they are very less used among the long distance travellers or the people who have to charge their vehicles depending on the urgency of travel. While most of the EV users have an inbuilt AC charger or a wall mount charger at their residence so that they can charge their vehicles at the night time and use them or the day use. While some vehicles do require a slow charging after multiple times of fast charging the slow chargers are necessary at the residence. The DC fast chargers are the mostly preferred over the EV users since they offer faster charging to charge their own respective vehicles. The DC fast chargers can be offered at various rating such as commonly 60kw and 30 kw chargers. While most of the charging stations have a 60kw chargers available in the charging stations in Kerala . Most commonly in the charging stations the users can chargers mostly 2 vehicles at the same time, then each vehicle can have a consumption of 30kw each for a 60kw charger, charging depends on the ability of the EV to recieve the charge from the charger. The most commonly used charging connector type observed in the charging stations while conducting the study are Combined Charging System (CCS) type 2 Connectors with power outputs ranging from 50 - 350 kw. Also Some of the charging stations uses the Chademo and GBT connectors. The study have undergone detailed analysis of the charging stations and found out that there are a lack of charging stations for the smooth and efficient working of the EV users.

3.3 Geographic Mapping and pricing structures

Geographic location of charging stations is critical in the take-up of electric vehicles (EVs). Unlike traditional fuel vehicles, EVs rely on the battery capacity to cover different distances, and therefore the availability of charging stations becomes a key concern for consumers. To ensure a comfortable riding experience, EV consumers require charging stations to be conveniently located in their vicinity. A questionnaire among various consumers of EV introduced the inconvenience they face with the fewer charging points in certain areas. Approximately 95% of the respondents indicated the need for more charging points to enable the utilization of EV in the market. The few charging points have hindered their ability to move their vehicles, resulting in range anxiety and inconvenience for EV consumers. Besides, 70% of the surveyed users indicated that they would like fast chargers more than the previous slow AC chargers. Fast chargers significantly reduce charging time, which provides greater convenience to users requiring rapid charging solutions. The demand for fast chargers indicates the trend towards infrastructure with high-efficiency energy resupply support, hence improving the general feasibility of EV ownership. Aside from the presence of chargers, users also underscored the charger uptime. Charging stations that operate around the clock are preferred by EV owners instead of those being regularly maintained and subjected to downtimes. Credible charging facilities are important to instill confidence among users and persuade additional users to adopt EVs. Another key element determining the preference of charging stations is location.

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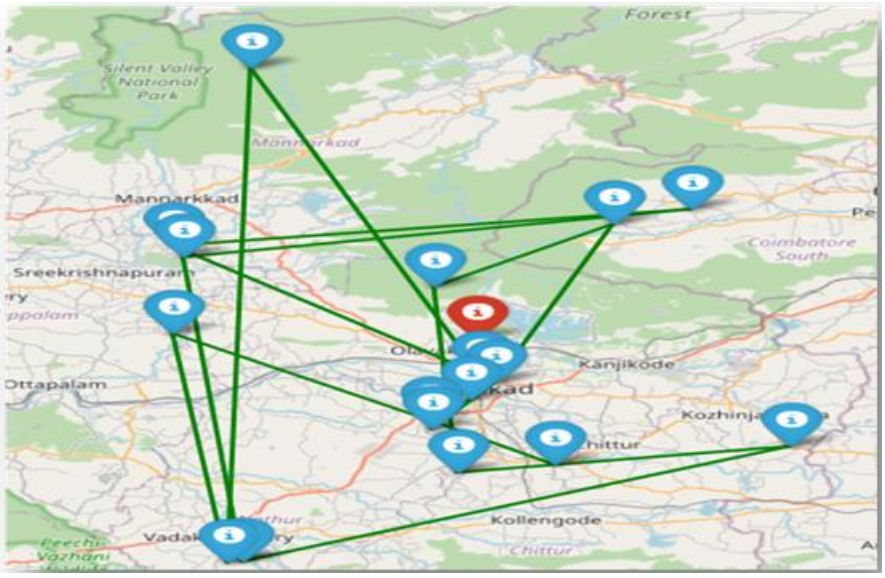

Figure 1. Geographic distribution of DC fast chargers across Palakkad district

The coverage of EV charging points in Palakkad is of high density along the Palakkad-Coimbatore stretch, making frequent users accessible. Yet, some areas, especially to the west and south of the city, have stations that are far apart, creating range anxiety among EV users. The largest distance between two successive chargers is 70 km, and the shortest distance is 18 km, reflecting the need for an even spread of charging points. According to the central government policies in India by the year 2030 the charging stations should be at a distance of 1km in urban areas and 20km in highways, this shows the need for significant infrastructure in the Palakkad district. Almost 62% of the participants declared that they would opt for a charging station because of its geographic position. The outcome signifies that there should be strategic placing of charging stations for better convenience and ease. Furthermore, 85% of consumers wished charging stations could be available at easy-access points such as shopping centers, workplaces, and highways. They not only offer handy access but also the option of users to integrate charging into daily life without being interrupted. From the geographic mapping study conducted using various applications like the Plugshare, kE-mapp, Google maps and Charge mod the total number of fast chargers available in the market is found to be 17 DC charging stations which is comparatively very low compared to the number of Electric vehicles that are registered in the market. The study also found that the charging stations can be even more installed in the malls as well as the petroleum pumps, highways, and rural areas to facilitate the smoother operation of these Electric vehicles in long distance travelling across the district. And almost 30 minutes to 1 hour is the time that the EV users to have to wait in order to charge the vehicles, this in turn emphasizes the need for a charger that can efficiently and smoothly charge these EVs with amore less waiting time for the users. The second key driver for EV adoption is the charging station price model. Domestic charging points are far more expensive at ₹18 to ₹21 per kWh compared to publicly owned charging stations at ₹13 per kWh. This price difference affects the consumer's choice and directs towards level playing field-based pricing to induce EV usage. The higher rates of charging at private stations have several reasons behind them. Firstly, private operators bear all the costs of developing infrastructure, such as the cost of land acquisition, equipment purchase, installation, and maintenance; as compared to public stations, which have government subsidies that ease their financial burden. Secondly, private stations prefer to place themselves in high-end locations, such as commercial locations, shopping complexes, and highways, which have high operating costs that ultimately get transferred to consumers. Electricity tariffs are a major driving force behind the differences in pricing models. Private operators buy electricity at industrial or commercial tariff levels, which are above the subsidized tariff of public operators. Private charging stations also have the ability to react to demand charges, which occur when there is heavy power

usage during peak hours. All these contribute to the generally high pricing models of private charging stations. Moreover, private operators aim to maximize profits, as contrasted to public stations whose primary interest is promoting EV adoption. Private stations will therefore implement pricing policies like membership plans, premium charging, and intelligent network management, further influencing pricing. While these ancillary services are more convenient to users, they also incur costs. The second important factor is the low usage rate of private charging points. Public charging points have improved usage rates in contrast, and therefore, it is feasible for the cost to be spread over a greater number of users. Alternatively, private stations, especially those in low-density areas, break-even points through a smaller number of consumers, leading to higher session charges per user. Reliability of service and length of uptime are also important considerations. Private charging points invest in better infrastructure, high-end charging hardware, and real-time monitoring software, all of which help create a better user experience. However, all these add-ons come at a heavy cost, and that reflects in higher charging prices. To fill the price gap, some of the solutions could be government incentives to private charging operators, use of regulated standard tariffs, and dynamic demand and price-based pricing mechanisms. Another solution could be increased competition in the private charging market that can lower cost without lowering quality of services.

3.4 User Accessibility challenges

The Ev users have a necessity of using the mobile applications in order to find the respective positions of the charging stations in the diverse areas. Even though some users use the Ev's still they are not that technically literate in order to carry out the transactions efficiently. One of the challenges the Ev users encounter is the payment system of the Ev's, different charging station providers have different types of charging wallets that are carried out in different mobile applications so that the users found it so difficult to use all these apps in one go as well as adding the money to the multiple wallets and which is not that economically convenient for the user. Another issue that the EV users face is the mapping of these stations, even for these cases the users need to have access to different platforms in order to carry out and find a perfect charging station to charge their vehicle.

IV. Conclusion

The study offers a critical analysis of long-distance travel challenges of EV users, such as accessibility, affordability, and geographical spread of charging stations. The conclusion is the lack of charging stations, long queues, and high fees in private stations, which act as impediments to simple EV uptake. Preferred use of DC fast chargers instead of AC chargers indicates the necessity for high-power highway chargers, mall place chargers, and rural area chargers. Convenience issues of customers regarding problems of digital illiteracy and inconvenience of using several charging apps and payment websites are also addressed in the research. While EV adoption gained momentum rapidly, charging infrastructure within the state of Kerala remains lacking. Although government policies and incentives promoted public charging station installations, price discrimination between private and public charging stations creates an imbalanced user experience. The study also concludes that adding smart tariffs and dynamic pricing can maximize charging cost and prevent grid overload. For these issues to be addressed, collaborative and integrated action through policy intervention at a level, greater investment in charging stations, and improved user-friendly digital platforms are necessary. Mobile apps and shared payment platforms can facilitate ease of access, while government regulation and subsidy can facilitate common pricing. Additional research will need to consider the introduction of new technology such as Vehicle-to-Grid (V2G) and renewal integration in attempting to maximize efficiency and greenness of EV charging networks. With such policies, mass-level adoption of EV as well as green transport aspirations can be realized in a fitting manner.

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