# EV CHARGING SYSTEM

A Project Report

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Under the Guidance of

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## CERTIFICATE

This is to Certify that Project - 2 -Subject code 203105400 of $7^{th}$ Semester entitled "EV CHARGING SYSTEM" of Group No. PUCSE_182 has been successfully completed by

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# Abstract

EV Charging System" project presents an innovative solution designed to meet the constant growing demand of Electric Vehicle (EV) charging infrastructure in India. This mobile application utilizes the Google Maps API to provide users with a user-friendly way to find various charging options. What makes our app unique is its integration of three types of charging points: public, private, and semi-public.

The primary goal of our app is to reduce the time EV owners spend waiting to charge their vehicles and offer them more choices throughout India. Users can easily locate and use publicly accessible charging stations for their journeys. However, the key feature of our app lies in its ability to connect users with privately-owned chargers, including those at residences, and chargers located at places like shopping malls and universities. This feature empowers users to effectively plan their charging needs, even in areas where public charging infrastructure may be limited.

By bringing together public, private, and semi-public charging options, our app significantly enhances the convenience of owning an EV in India. It contributes to sustainable transportation by making charging more accessible and reliable. As India's transition to electric vehicles gains momentum, our project plays a crucial role in improving the user experience and advancing the country's efforts toward a cleaner and more sustainable future.

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# Chapter 1

# Introduction

## 1.1 Introduction

Electric Vehicles (EVs) are becoming popular day by day due to their low emissions, energy efficiency, and reduced our dependence on the fossil fuels. But, the lack of charging infrastructure remains a big challenge for easy EV adoption. In India, the number of EVs on the roads is increasing day by day, but the charging infrastructure is still not sufficient. Therefore, it is important to develop an efficient and user-friendly EV charging management system that can provide real-time information about all the available charging stations and help users book slots in advance. The EV Charging Management System is a project aimed at addressing the charging infrastructure challenges faced by EV users in India. This system lets users book a public charger, a semi-public charger, or a private charger. The app uses Google Maps API to show users all the available chargers in thier nearby radius. It also displays the current active hours for the charger and the speed of the charger. The system is designed to be user-friendly and easy to use and navigate through. The user can choose the type of charger they need and then see the available options. The app shows the active hours for the charger so that the user can plan their charging accordingly. The user will be able book a slot in advance to ensure that they have a charging spot reserved whenever they need it. The EV Charging Management System is important because the existing charging infrastructure in India is underwhelming, and this is a great problem for EV adoption.The lack of charging infrastructure leads to range anxiety and restricts the use of EVs.

## 1.2 Problem Statement

The ”EV Charging System” project addresses a big issue growing from the evolving adaptation of electric vehicle (EV) adoption in India. As EVs increase in popularity,need for accessible and useable charging infrastructure has become increasingly important. India’s charging infrastructure is

in a early stage of development, and there is a increasing need to provide users with more options to charge their EVs efficiently.The challenge lies in the fact that India's electricity generation heavily relies on fossil fuels and non green sources particularly coal. Knowing it is impractical for the government to solely rely on the construction of new charging imfrastructure to meet the growing demand. Building more charging stations without a sustainable energy source would undermine the ultimate goal of making the transportation sector greener. Hence, there are two problems: first, there's a lack of accessible and diverse charging points options for EV owners, and second, the charging infrastructure must align with environmental goals. Our project seeks to close this gap by providing a user-friendly platform that connects public, private, and semi-public charging points, thereby expanding charging options while taking into account the imperative to transition to cleaner energy sources for a greener planet.

## 1.3 Objectives

The objectives of the "EV Charging System" project focus on enhancing user options for chargers. To start with, the project aims to enhance charging availability for electric vehicle (EV) owners. This will be achieved by developing a user-friendly mobile application that enables easy access and location of various charger types, including public, private, and semi-public chargers. A key goal is to optimize the user experience through an intuitive interface providing real-time information on charger availability and payment options. The ultimate aim is to ensure a seamless and convenient EV charging experience.Furthermore, we are dedicated to promoting sustainability through the encouragement of electric vehicle (EV) adoption and sustainable transportation practices. Despite the ongoing development of charging infrastructure in our country, we strive to provide a solution that connects public and private charging stations, addressing any existing limitations. Additionally, our project aims to facilitate long-distance travel by assisting EV owners in locating and utilizing charging stations along their routes, ultimately reducing any concerns about range anxiety. By minimizing waiting times at charging points.

## 1.4 Scope

The "EV Charging System" project focuses on creating and implementing a mobile application that will simplify the process of charging electric vehicles (EVs) in India. The goal is to integrate different types of charging points within this project scope. The project aims to provide users with a comprehensive charging network, including public, private, and semi-public chargers. To enhance accessibility, real-time location tracking and availability information will be integrated using the

Google Maps API. The project also involves user registration and authentication for EV owners and institutions to list their charging stations. However, it does not include the physical installation of charging infrastructure or address energy source management or environmental impact assessment. Initially, the project's geographical coverage is limited to specific regions but may expand in the future. It serves as a proof of concept with ongoing support and maintenance considerations.

# Chapter 2

# Literature Survey

## 2.1 Charging infrastructure planning for Electric Vehicle in India.

Authors: S. Sachan and P.P. Singh

Year: 2022

The shift towards electrifying the transportation sector has emerged as a viable solution to combat greenhouse gas emissions and mitigate global temperature increase. India, being a signatory to the Paris Agreement, is dedicated to reducing its emissions and limiting global temperature rise below 2 degrees Celsius. However, the widespread adoption of electric mobility in India encounters several obstacles. These include concerns about charging times and driving range anxiety, as well as disparities in the distribution of electric vehicles (EVs) and charging infrastructure. To address these challenges, the government has implemented various initiatives to promote the development of charging infrastructure, including subsidies, tax incentives, and public- private partnerships. Charging stations have been sanctioned in different states, and case studies of charging station placement in Bangalore and Delhi have been conducted using grid-based and traffic flow-based methodologies, respectively. However, the availability of suitable charging sites remains a major concern in urban areas, and a comprehensive methodology is proposed to address this issue. The importance of an integrated power and transportation network to support the dynamic location load of EVs and ensure effective communication between the vehicle network and the power grid is highlighted. Vehicle-to-grid technology is identified as a potential solution to balance the power grid and reduce the need for additional power generation capacity. However, vehicle-to- Lastly, there is a significant need for accessible and straightforward information regarding government programs and subsidies to benefit all stakeholders. Additionally, effective private-sector leadership plays a crucial role in promoting competition and innovation. Regulators should support the

development of such leadership through government programs. The literature indicates that the adoption of e-mobility in India presents several challenges. However, the government has implemented various initiatives to foster the development of charging infrastructure. One major concern in urban areas is the availability of suitable charging sites. Additionally, there is a need for an integrated power and transportation network to accommodate the dynamic location-based load of electric vehicles (EVs). Vehicle-to-grid technology shows promise as a solution to balance the power grid, although it is still at an early stage of development in India. It is crucial to provide clear and easily accessible information about government programs and subsidies to assist all stakeholders. Furthermore, effective leadership from private sector entities can drive competition and innovation within this domain.

**Conclusion:** In conclusion, the literature suggests that the adoption of electric mobility in India faces several challenges. These include concerns about charging times and driving range, as well as the uneven distribution of electric vehicles (EVs) and charging stations. However, the Indian government has implemented various initiatives to promote the development of charging infrastructure. Vehicle-to-grid technology is also considered a potential solution to balance the power grid.

To ensure success, clear and easily accessible information on government programs and subsidies is needed for all stakeholders involved. Additionally, effective private-sector leadership plays a crucial role in promoting competition and innovation.

Overall, electrifying the transport sector offers a viable solution to reduce greenhouse gas emissions and limit global temperature rise. The Indian government is committed to these goals by aiming to decrease greenhouse gas emissions and keep global temperature increase below 2 degrees Celsius.

## 2.2 Evaluating the effects of a ban on internal combustion engine passenger cars in Sweden.

Authors: Johannes Morfeldt, Simon Davidsson Kurland, and Daniel J.A. Johansson.

Year: June 2021

In a recent study, Morfeldt et al. (2021) introduced an innovative method to assess the impact of banning internal combustion engine passenger cars in Sweden. Their approach combines a vehicle

turnover model and prospective lifecycle assessment to estimate the carbon footprint effects of this ban. They also highlight the significance of decarbonizing supply chains as a crucial aspect of transitioning away from internal combustion engines. This study builds upon previous research that has assessed the carbon footprint implications of shifting to electric vehicles. For instance, Sierzchula et al. (2014) conducted a study examining the environmental impacts of electric vehicles in comparison to internal combustion engine vehicles. The findings revealed that electric vehicles have lower greenhouse gas emissions and fewer other pollutants throughout their lifespan. A study conducted by Brand et al. in 2019 examined the potential advantages of Germany transitioning to electric vehicles. The findings of the study indicated that this transition would lead to notable reductions in greenhouse gas emissions and other harmful pollutants, along with positive effects on public health and the economy. Morfeldt et al. (2021) conducted a study that adds to previous research on the economic impacts of transitioning to electric vehicles. One example is a study by Bo¨ hringer et al. (2019) which evaluated the economic effects in Germany. The study found that transitioning to electric vehicles would bring about substantial economic benefits, including job creation and increased economic growth.

**Conclusion:** In conclusion, the research paper conducted by Morfeldt et al. (2021) offers a comprehensive analysis of the carbon footprint impacts associated with banning cars that rely on internal combustion engines in Sweden. The study incorporates a unique vehicle turnover model and prospective lifecycle assessment, providing insightful observations into the broader dynamics of shifting away from fossil fuels and traditional engines. The findings hold significant implications for climate change mitigation strategies concerning passenger vehicles, emphasizing the necessity for a multifaceted approach to facilitate this transition. Ultimately, this study represents a valuable contribution to existing literature on the adoption of electric vehicles and the decarbonization of transportation systems.

## 2.3 Poor Charging Infrastructure, high prices' — what's putting the brakes on India's 2030 EV target.

Author: Nikhil Rampal

Year: 2022

**Conclusion:** nbsp;Conclusion: Overall, India's plan to reach its target of 30 percent electric vehicle (EV) adoption by 2030 is facing significant obstacles. The lack of adequate charging infrastructure

and the high prices of EVs are major challenges. Currently, there are only around 2,000 public charging stations in the country, which falls far short of what is needed for widespread EV use. Additionally, the high cost of EVs remains a barrier for many potential buyers. These factors pose considerable hurdles to achieving India's ambitious EV goals. The challenges mentioned above have also discouraged many potential buyers from transitioning to electric vehicles. However, the Indian government is actively taking steps to tackle this issue. These include providing subsidies and incentives to individuals purchasing electric vehicles and increasing investments in charging infrastructure.

## 2.4 High costs, low use may derail development of EV charging infrastructure.

Authors: Shouvik Das , Avishek Banerjee

Year: 11 Jan 2022

India has set an ambitious goal of having 2 million electric vehicles (EVs) on the road by 2026. However, in order to support this target, the country would need a whopping 400,000 public charging stations. Unfortunately, as of December 16, 2021, India only has a mere 1,028 public EV charging stations available. This glaring disparity highlights the significant infrastructure challenge that lies ahead in achieving their electric vehicle ambitions. Industry experts are skeptical about the government's goal of establishing 40,000 public EV charging stations by the end of 2022. They argue that installing public chargers is costly and their usage remains low at present. Furthermore, India's lack of organized parking spaces poses challenges for setting up public chargers. According to experts, it is important for India to establish its own model for EV charging infrastructure instead of solely relying on international models. This is because the majority of passenger vehicles in India (approximately 94 percent) are charged at home, resulting in a lesser demand for public charging stations at this time. Therefore, the focus should be on developing faster charging stations and exploring strategies to make public charging economically viable. India faces several challenges in establishing a comprehensive public EV charging infrastructure. These challenges include the high cost of setting up charging stations, low utilization rates of existing chargers, a lack of organized parking spaces, and the need for faster charging options. Another hurdle lies in making public charging economically viable.

Despite these obstacles, industry experts believe that India's EV charging infrastructure is still in its infancy and holds immense potential for future growth. To harness this potential, collaboration

between the government and private companies is crucial. They must work together to develop a sustainable model for public charging by offering subsidies, tax incentives, and other supporting measures.

Additionally, educating the public about the benefits of electric vehicles and creating awareness about EV charging infrastructure is equally important to encourage adoption and usage. By addressing these challenges collectively, India can pave the way for significant advancements in its EV charging network in the coming years. To alleviate any concerns or doubts about the range of electric vehicles (EVs), it is essential to educate and inform the public about their numerous benefits.

**Conclusion:** In conclusion, the EV charging infrastructure in India may not meet its 2022 targets. This poses a significant challenge for the widespread adoption of electric vehicles in the country. India's electric vehicle (EV) charging infrastructure is encountering significant hurdles, such as high costs and limited accessibility. India may struggle to meet its goal of establishing 40,000 public EV charging stations by the end of 2022 due to infrastructure challenges such as limited availability and disorganized parking spaces. To address these challenges, India should focus on establishing a sustainable model for public charging infrastructure. This could entail implementing subsidies, tax incentives, or other forms of support. Additionally, educating the public about the advantages of electric vehicles and addressing concerns like range anxiety is crucial. Despite the challenges, India's EV charging infrastructure is still in its early stages of development and has the potential to grow rapidly in the coming years.

## 2.5 Challenges and Prospects of Electric Vehicle in India.

Author: AP Agency

Year: 2023

This article examines the challenges and potential of electric vehicles (EVs) in India, as the country aims for a significant increase in EV sales by 2030. The Indian Venture and Alternate Capital Association (IVCA) report highlights that achieving this target is ambitious and reliant on various factors. These factors include the accessibility and affordability of charging infrastructure, battery costs, performance improvements, and investments in research and development. Furthermore, the article presents data and examples to illustrate the current state and future prospects of EVs in India, with a particular focus on the two-wheeler segment. The article begins by introducing the case of Pravinbhai Parmar, a farmer in Gujarat state who has been using solar power for irrigation and

selling the excess electricity to the state's grid1. He is one of the thousands of farmers who have been encouraged to take up solar power in the state, which has reduced its coal share from 85 percent to 56 percenr in the last six years. However, Gujarat is an exception among Indian states, most of which have installed less than 50 percent of their renewable energy targets for 20222. The article highlights a contrast between India's goal of achieving net zero emissions by 2070 and its ongoing dependence on coal for electricity generation. It emphasizes that India has installed 168 gigawatts of coal-fired generation between 2001 and 2021, which is almost double the capacity added in solar and wind power combined. The article also mentions that India's electricity demand is projected to increase by up to 6 percent annually over the next decade, making it challenging to decrease the reliance on coal. The article emphasizes the potential advantages of renewable energy for India's economy, environment, and energy security. It references a report from the Global Energy Monitor that positions India among the top seven countries worldwide in terms of prospective renewable power. The report states that by 2025, the planned expansion of solar and wind power to reach 76 gigawatts will prevent nearly 78 million tonnes of carbon dioxide emissions. The coal industry could save up to 1.6 trillion rupees (approximately 19.5 billion dollars) annually by producing and utilizing tons of coal. This article explores the challenges that hinder the widespread adoption of renewable energy and electric vehicles (EVs) in India. These obstacles include difficulties with land acquisition, necessary policy reforms, energy storage options, and the financial stability of electricity distribution companies. However, there are also progressive policies in place to support clean energy development, such as a government scheme worth 2.6 billion dollars that incentivizes the production of solar energy components. The article primarily discusses the growing popularity of electric vehicles (EVs) in India's two-wheeler segment, which represents over 80 percent of the country's vehicle sales. It highlights how EVs are increasingly favored by urban commuters who aim to reduce expenses associated with fuel and maintenance. Additionally, it mentions successful EV startups like Ola Electric, which intends to release its electric scooter in the near future. In conclusion, the article offers several suggestions for expediting the shift towards clean energy. These include increased investment in battery storage, green hydrogen technologies, and policy reforms. The article also expresses optimism about India's clean energy future, predicting a significant surge in renewables and the affordability of storage technology and green hydrogen in the near future.

**Conclusion:** This article examines the contrasting goals of India's ambitious net-zero target

by 2070 and its ongoing dependence on coal for electricity generation. It explores the challenges and potential for expanding renewable energy, particularly solar power, in the country. The article suggests that India must overcome obstacles like land acquisition, policy reforms, and energy storage to achieve a swift and cost-effective transition to clean energy. Furthermore, it highlights the potential benefits of renewable energy for India's economy, environment, and energy security.

## 2.6 Clean energy gains a foothold in India, but coal still rules.European Plan To Ban New ICE Cars By 2035 Irks Manufacturers, Inspires Environmentalists.

Author: Neil Winton

Year: 2022

The article examines the European proposal to prohibit the production of new internal combustion engine (ICE) cars by 2035. It explores the reactions of car manufacturers, environmentalists, and experts to this plan. The European Automobile Manufacturers' Association (ACEA) opposes the proposal, expressing concerns and objections. Implementing widespread adoption of electric vehicles is often seen as premature and impractical without significant investment in the charging infrastructure[3][3]. However, there are proponents of this proposal, such as Transport Environment (TE), a green advocacy group based in Brussels. They argue that it is crucial for climate action, improving air quality, and making electric vehicles more affordable[4]. In addition, the article discusses India's aim to achieve net-zero emissions by 2070 and its ongoing dependence on coal for electricity production. It highlights that between 2001 and 2021, India installed 168 gigawatts of coal-fired generation, which is almost twice the capacity added in solar and wind power combined. The article also mentions that India's electricity demand is projected to increase by up to 6 percent annually over the next decade, posing challenges in reducing the reliance on coal. The article delves into the factors that influence the adoption of renewable energy and electric vehicles (EVs) in India. These factors include land acquisition, policy reforms, energy storage, and the financial stability of electricity distribution companies. According to a report by the Global Energy Monitor, India is considered one of the top seven countries globally with promising potential for renewable power. The report highlights that their plan to establish 76 gigawatts of solar and wind power by 2025 will result in avoiding nearly 78 million tons of coal usage annually. Additionally, this initiative could lead to savings amounting up to 1.6 trillion rupees (19.5 billion dollar) per year. The article presents data on the current status and future prospects of electric vehicles (EVs) in India,

particularly focusing on the two-wheeler market. It highlights the increasing popularity of EVs among urban commuters who seek to save money on fuel and maintenance expenses. The article also cites successful EV startups like Ola Electric, which intends to release its electric scooter within this year. The article concludes by offering suggestions to speed up the shift towards clean energy. It recommends investing in battery storage, green hydrogen, and implementing policy reforms. The article expresses optimism about India's clean energy future, stating that renewables are on the verge of significant growth. It also anticipates that storage technology and green hydrogen will become more affordable in the near future.

**Conclusion:** The European Union's plan to phase out new internal combustion engine (ICE) cars by 2035 and India's goal of achieving net-zero emissions by 2070 present both challenges and opportunities in the transition to clean energy. This article explores these aspects and offers suggestions for accelerating the shift, including investments in battery storage, green hydrogen technology, and policy reforms.

## 2.7 Landscape of EV charging system.

Auhor: Griden Power

Year: 2019

Each with their own unique characteristics and benefits.

**Private Charging Stations:** These chargers are specifically designed for individual use and are commonly installed in homes or offices. Owners have full control over the type of charger they choose and can easily monitor their EV's power consumption and performance. This personalized approach to EV charging provides convenience and autonomy, making it a highly appealing option for individual EV owners.

**Semi-Public Charging Stations:** These charging stations are specifically designed for customers or visitors of establishments like restaurants, malls, or hotels[1][1]. They serve a dual purpose - increasing foot traffic and revenue for the property owner while also providing a valuable service to electric vehicle (EV) drivers. Moreover, they can generate additional income by charging a fee for the service.

**Public Charging Stations:** These charging stations are available for all electric vehicle drivers. They typically have multiple charging points and provide fast charging capabilities.

**Conclusion:** In conclusion, the variety of EV charging stations available today cater to different needs and contexts, from private use to public services.

## 2.8 Comprehensive Review on Developments in Electric Vehicle Charging Station Infrastructure and Present Scenario of India.

Author(s): Mishra, S. H., Verma, S. H., Chowdhury, S. U.

Year: 2021

The rising popularity of electric vehicles (EVs) stems from their ability to curb greenhouse gas emissions and lessen reliance on fossil fuels. Nevertheless, the limited availability of charging stations poses a significant hurdle to widespread EV adoption. This extensive review delves into the various advancements and obstacles within the realm of EVs and their charging infrastructure, specifically examining the current situation in India. India's current policy framework for electric vehicles (EVs) is designed to promote their adoption through a partnership between the public and private sectors. The government has implemented various policies to incentivize EV ownership, including regulatory reforms and support for domestic production of EVs and battery manufacturing. Additionally, state governments are offering subsidies and implementing policies to facilitate the easy adoption of EVs. Despite these efforts, the lack of sufficient charging infrastructure remains a significant challenge in India. Renewable energy systems and electric vehicles (EVs) have the potential to bring flexibility to the power grid. To effectively leverage these resources, metaheuristic techniques are important tools along with optimization software. They can assist in various tasks such as identifying optimal charging station locations, managing and planning EV charging infrastructure, and overall operation management. To make EV charging stations more accessible and affordable in India, several solutions have been proposed. These include utilizing renewable energy sources for charging, establishing a network of stations along highways and major roads, integrating charging stations with existing infrastructure like parking lots and shopping centers, and implementing mobile charging options.

**Conclusion:** In conclusion, the widespread adoption of electric vehicles relies heavily on the development of sufficient charging infrastructure. While India has made notable strides in this aspect, there is still a considerable journey ahead. Employing efficient charging scheduling techniques and metaheuristic approaches can enhance the utilization of existing resources. Several

solutions have been put forth to improve the accessibility and affordability of EV charging stations in India, emphasizing the need to further explore and implement these ideas to expedite EV adoption.

## 2.9 India Energy Outlook 2021

Author(s): IEA

Year: 2021

The International Energy Agency (IEA) has released a report that analyzes the future of India's energy sector. The report explores different scenarios for energy demand, supply, emissions, and security in India based on various assumptions and policy goals. It also highlights India's potential to lead the way in global energy transition and achieve low-carbon, inclusive growth[1].*Hereisadetailedsummaryofthemainpointsofthereport* : *India*,*theworld*′*sthird* − *largestenergyconsumer*,*hasexperiencedsignificantgrowthinpopulation*,*urbanization*,*andindustrialization*.*A* 50*andenhancingoverallenergyefficiency*.*TheNationalInstitutesofHealthwarnsthattheCOVID* − 19*pandemic*,*beingatraumaticexperience*,*canleadtoarangeofmentalhealthproblems*.*Manyindividualsreport traumaticstressdisorderPTSDormajordepressivedisorder*.

Regarding India's energy future, the report presents four scenarios: the Stated Policies Scenario (STEPS), based on current policy settings; the India Vision Case, reflecting a more complete achievement of India's policy goals and faster economic growth; the Delayed Recovery Scenario, considering prolonged impact from COVID-19; and the Sustainable Development Scenario, based on increased clean energy investment and achieving net-zero emissions. Regardless of the scenario, solar power is expected to drive India's transformation in the power sector by 2040. India is also projected to become a global leader in battery storage with 140 to 200 GW capacity by 2040. However, coal will still play a significant role in industry and transportation while remaining a major emitter of CO2 and air pollutants.

India's oil demand is anticipated to increase by 1 to 4 million barrels per day (mb/d) by 2040 mainly due to diesel-based freight transport. The country will also expand natural gas usage in industries and city gas distribution. Nonetheless, affordability and infrastructure pose challenges for both oil and gas.

India's transition towards cleaner energy has important implications for its energy security, economic development, and environmental sustainability. The report suggests that if India follows sustainable development practices highlighted in one scenario - including leveraging renewable

resources like abundant solar power, enhancing energy efficiency measures, diversifying its fuel sources, and fostering innovation alongside partnerships - it could pioneer a model for low-carbon inclusive growth. By pursuing this path, the country has an opportunity to reduce fuel costs by up to 1.4 trillion dollar by 2040, reduce CO2 emissions by 60 percent, and improve air quality.

Finally, the report emphasizes that India's energy choices will significantly impact not only its own energy system but also global climate outcomes

**Conclusion:** India's energy transition is crucial not only for its own economic advancement, energy security, and environmental sustainability but also for the global energy system and climate goals. A report by the International Energy Agency examines the potential opportunities and challenges that lie ahead for India's energy sector in the coming decades. The report presents four scenarios outlining India's future energy landscape. It emphasizes that India has a distinct chance to lead the way in low-carbon growth that is inclusive, by utilizing its abundant renewable resources, improving energy efficiency, diversifying its fuel sources, and promoting innovation and collaboration.

## 2.10 Assessment of economic benefits for EV owners participating in the primary frequency regulation markets.

Author(s): Nataly Bañol Arias, Seyedmostafa Hashemi, Peter Bach Andersen, Chresten Træholt, and Rubén Romero.

Year: Sept 2020.

Electric vehicles (EVs) are being recognized as a promising solution for transitioning to sustainable energy systems. One potential application is their participation in primary frequency regulation (PFR) markets, which can provide additional income for EV owners while also contributing to grid stability. To optimize power bids for EVs in PFR markets, a heuristic method has been proposed. Three operation strategies have been analyzed: complete pause, over-fulfillment, and the preferred operating point (POP) mechanism. Results indicate that the POP strategy is the most effective, allowing EV owners to bid with the charger's nominal capacity and make an annual profit of up to C1100, regardless of the EV battery capacity. However, taking into account daily operations and customer preferences can significantly reduce potential benefits. Other studies have also examined the potential advantages of electric vehicles (EVs) participating in PFR markets. For instance, EVs

can offer valuable frequency regulation services, which could potentially decrease reliance on traditional power plants. Furthermore, EVs can contribute to greenhouse gas emissions reduction and enhance grid stability. While vehicle-to-grid (V2G) technology for power frequency regulation (PFR) markets holds promise, there are important challenges and limitations to its widespread adoption. One such challenge is the limited availability of electric vehicles (EVs) for PFR markets due to factors like battery degradation and the need for frequent charging. Regulatory frameworks and market structures may also require adaptation to accommodate V2G-enabled EVs. The effectiveness of EVs in PFR markets is influenced by factors such as the size of the EV fleet and the availability of charging infrastructure. Electric vehicles (EVs) offer significant potential benefits in primary frequency regulation (PFR) markets, but there are also challenges and limitations that need to be addressed. A promising approach to optimizing power bids for EVs participating in PFR markets is the proposed heuristic method.

**Conclusion:** Electric vehicles (EVs) have the potential to make a significant impact in primary frequency regulation (PFR) markets. This not only provides EV owners with additional revenue opportunities but also contributes Grid stability is crucial in optimizing power bids for electric vehicles (EVs) participating in PFR markets. The proposed heuristic method offers a promising approach towards achieving this goal. However, it is important to note that there are also challenges and limitations to widespread adoption of vehicle-to-grid (V2G) technology for PFR markets, such as battery degradation, the need for frequent charging, and regulatory frameworks. The involvement of electric vehicles (EVs) in PFR markets is a research field with great potential to offer substantial advantages for both EV owners and the electric grid.

## 2.11 Level 1 vs. Level 2 vs. Level 3 Charging Explained

This article explores the impact of different charging levels on electric vehicle (EV) charging time, cost, and convenience for EV drivers. It examines three specific charging levels - L1, L2, and L3 - discussing their power rating, voltage, compatibility, availability, and charging speed. Level 1 (L1) charging is the most basic and slowest method of charging for electric vehicles (EVs). It requires a standard 120-V outlet and comes with a free cable that is included with every EV. L1 charging can restore up to 5 miles of charge per hour, which may be sufficient for drivers who have limited daily driving needs or have access to L1 chargers at their workplace or school. However, it is not suitable for long trips or drivers who cover high mileage. The most widely used and adaptable charging

level for electric vehicles (EVs) is Level 2, which operates on a 240-V circuit. This level of charging requires a dedicated charger that can be installed at home or accessed in public locations. A Level 2 charger can replenish approximately 12 miles of charge per hour, making it capable of fully charging most EVs overnight or within a few hours[1][1]. Additionally, Level 2 charging is compatible with all EVs utilizing the SAE J1772 plug[2][2]. Level 3 (L3) charging is the most rapid and costly option available. It operates on a 480-V or 1,000-V circuit and employs a direct current (DC) charger. L3 chargers can typically be found in high-traffic areas for convenience. They have the capability to recharge up to 80 percent of battery capacity in under an hour. However, it's important to note that L3 chargers are not universally compatible and may require different plug types.

**Conclusion:** If you're an electric vehicle (EV) driver, understanding the various charging levels is essential for a smooth driving experience. This guide offers valuable insights into how different charging options can impact your EV usage. It emphasizes the importance of considering your driving habits, budget, and vehicle capabilities when selecting a charger that suits your needs. Additionally, it highlights that the availability and accessibility of chargers play significant roles in promoting widespread adoption of EVs.

## 2.12 Reducing EV Charging Infrastructure Costs.

Author(s): Chris Nelder and Emily Rogers.

Year: Jan 2020

In the technical report titled "Reducing EV Charging Infrastructure Costs," the authors delve into strategies to decrease the expenses associated with EV charging infrastructure. The report focuses on identifying key factors that contribute to high costs, such as equipment, installation, and ongoing operation. To address these challenges, the authors propose public-private partnerships as a potential solution. By sharing both risks and costs involved in establishing and maintaining charging stations, these partnerships can help alleviate financial burdens associated with EV infrastructure development. The high expenses associated with EV charging infrastructure can mainly be attributed to the costly equipment involved. However, there are potential solutions to lower these costs. The report recommends that through economies of scale, as the production of charging equipment increases, the cost can be reduced. Furthermore, adopting standardized charging equipment and installation practices can enhance efficiency and minimize customization

requirements, leading to cost reduction. The installation cost plays a significant role in the expensive EV charging infrastructure. To mitigate this, the report proposes using innovative installation practices such as pre-fabricated charging stations that can be quickly and easily installed. Furthermore, implementing smart charging technology can optimize the usage of charging stations and minimize the need for costly upgrades to the electrical grid. The report also examines the significant operating expenses associated with EV charging infrastructure, which contribute to the overall high costs. To address this issue, the authors propose utilizing renewable energy sources like solar power for charging stations. Furthermore, they suggest implementing demand response programs that encourage EV owners to charge their vehicles during off-peak hours, thus reducing operating costs.

**Conclusion:** To make EV charging more affordable and accessible, policymakers and industry stakeholders can tackle the factors that drive up costs. This includes exploring public-private partnerships, leveraging economies of scale, using standardized equipment, implementing innovative installation practices, adopting smart charging technology, promoting the use of renewable energy sources, and considering demand response programs. By addressing these key factors collaboratively, we can work towards making EV charging more cost-effective for everyone.

## 2.13 Democratizing EV charging infrastructure.

Author(s): Md Umar Hashmi, Mohammad Meraj Alam, Ony Lalaina Valerie Ramarozatovo, and Mohammad Shadab Alam.

Year: March 25, 2022

In this literature review, we will explore the WE charge business model, which seeks to make electric vehicle (EV) charging infrastructure more accessible by connecting EV owners with the most suitable charging resources. This innovative business model establishes a collaboration between private charger owners and EV owners. Its primary goal is to address the issue of under-utilized privately-owned chargers and provide accurate real-time information about public charging station availability during peak hours to EV owners. The paper introduces an innovative algorithm for matching charging resources based on consumer preferences and practical limitations. This algorithm ensures that the most appropriate charging resource is provided. Factors such as charger type, socket compatibility, charging mode, distance to the station, and wait time are all taken into consideration. Additionally, the algorithm aims to maximize the utility of electric vehicle

owners by prioritizing their needs. To illustrate the effectiveness of the WEcharge business model, a case study was conducted in Hasselt, Belgium. The study focused on a Nissan Leaf (2018) with a 40kWh battery capacity and an electrical range of 378 km. An algorithm was used to match the electric vehicle (EV) with 25 charging stations located at point x. The results showed that all chargers, except for charger 15, were compatible with the Nissan Leaf, ensuring that hard constraints were met. Table 2 presents performance metrics for the vehicle at point x, including wait time, normalized distance cost, normalized charge time, weight, and varying weight. The paper focuses on a common issue faced by electric vehicle (EV) owners when they travel to a destination and are not provided with up-to-date information about the availability of public charging stations during peak hours. To tackle this problem, the proposed business model suggests forming partnerships between private charger owners and EV owners. Additionally, the paper explores how this WEcharge business model has the potential to democratize EV charging infrastructure, making it more accessible to a broader range of consumers.

**Conclusion:** In summary, the document offers a thorough overview of the WEcharge business model, showcasing its potential to make electric vehicle (EV) charging infrastructure more accessible to everyone. It aims to bridge the divide between privately-owned chargers and EV owners. Additionally, the proposed adaptive infrastructure matching algorithm is outlined in the document.

RephraseBy considering consumer preferences and hard constraints, the WEcharge business model offers the most appropriate charging resources. A case study conducted in Hasselt, Belgium highlights the effectiveness of this model and provides valuable insights into performance metrics for vehicle charging at a specific location.

## 2.14 Study on market sustainability and consumer behaviour towards electric vehicle (EV) in India.

Author(s): Priyanka Ranawat, Sashant Sharma, Mr. Suraj Kumar, Eric Molin, Bert van, Fanchao Liao, Peter Slowik, and Lingzhi Jin.

Year: July 2023.

In this research paper, a thorough investigation is conducted on the introduction of electric vehicles (EVs) in India and the factors that influence consumer attitudes towards them. The Indian government has established ambitious targets for EV adoption and infrastructure development for

charging stations, underscoring the growing significance of studying market viability and consumer behavior surrounding EVs. Numerous studies have investigated the effects of various factors on the usefulness of electric vehicles (EVs). Researchers such as Eric Molin, Bert van et al., and Fanchao Liao have explored this topic and identified key individual-related factors that affect a person's decision to choose an EV. The stated choice approach is often employed to examine how vehicle attributes and individual characteristics influence EV selection. The study utilized a research methodology that involved conducting individual interviews and distributing questionnaires focused on gathering demographic information. The sample size consisted of 40 participants, with demographics such as age, gender, and education level taken into account. The independent variables investigated were age, gender, and education level, while the dependent variables examined included annual income, marital status, factors motivating the purchase of electric vehicles (EVs), and factors discouraging the purchase of EVs. Consumers are increasingly recognizing and considering electric vehicles (EVs) as a more eco-friendly and sustainable transportation option, according to a study. Factors such as escalating pollution levels, government initiatives promoting EV adoption, and higher fuel expenses have contributed to this change in consumer perception. The study also highlights the important role of government programs and incentives in driving the uptake of EVs. Measures like tax breaks, subsidies, and the establishment of charging infrastructure have positively influenced consumer behavior and facilitated the growth of the EV market. While the study acknowledges the potential of the EV market in India, it also sheds light on the challenges that lie ahead. Concerns about range anxiety and limited charging accessibility still persist among consumers. To address these concerns effectively, additional policy support and investment in charging infrastructure are necessary. The study recommends that the government offer tax incentives and subsidies to incentivize EV adoption. Additionally, priority should be given to developing a robust charging infrastructure to ensure convenient access for consumers to charging stations.

**Conclusion:** In this research paper, we delve into the current landscape of the electric vehicle (EV) market in India and explore the factors that shape consumer opinions about EVs. Our study emphasizes the significance of government initiatives and incentives in encouraging the adoption of EVs. Furthermore, we address concerns surrounding range anxiety and charging accessibility by stressing the need for additional policy support and investment in charging infrastructure.

## 2.15 A Comprehensive Review on Developments in Electric Vehicle Charging Station Infrastructure and Present Scenario of India.

Author(s): Shubham Mishra, Shrey Verma, Subhankar Chowdhury, Ambar Gaur, Subhashree Mohapatra, Gaurav Dwivedi, and Puneet Verma.

Year: 2021

This study offers a thorough examination of the current state of electric vehicle charging station infrastructure in India. It consists of 5 articles that provide valuable insights and information on the latest developments in this field. The study provides an overview of the present scenario, offering comprehensive details on the existing electric vehicle charging stations in India. One of the articles analyzed in the study examines the advancements in electric vehicle technology and their impact on power grid integration. The article emphasizes the significance of having standardized electric vehicle systems, well-established charging infrastructure, and seamless integration of electric vehicles into the distribution network. Furthermore, it delves into exploring potential advantages that solar-powered electric vehicle charging systems may offer and investigates steady-state analysis of power systems when incorporating large numbers of electric vehicles. An additional article examined the difficulties in building electric vehicle charging infrastructure in India. It emphasized the absence of a well-defined policy framework, high initial costs, and limited public knowledge and acceptance of electric vehicles as major challenges to overcome. The main article highlights the primary challenges facing electric vehicle charging infrastructure in India. It acknowledges that the current state of this infrastructure is still in its early stages and faces considerable obstacles when it comes to accessibility and affordability. The study also offers potential solutions to make electric vehicle charging stations more accessible and affordable in India. One solution is utilizing renewable energy sources like solar power to operate the charging stations. Another solution involves the development of smart charging systems that can optimize charging times and alleviate strain on the power grid. Additionally, implementing government incentives and policies to promote electric vehicle adoption could contribute to enhancing the accessibility and affordability of these charging facilities in India.

**Conclusion:** This study offers a detailed look into the current state of electric vehicle charging infrastructure in India, as well as the challenges and opportunities that lie ahead. The importance of electric vehicle standards, charging infrastructure, and integration into the distribution network are

emphasized. Additionally, the study addresses the obstacles faced in developing electric vehicle charging infrastructure in India while offering potential solutions to improve accessibility and affordability of charging stations for electric vehicles.

## 2.16 Charging Infrastructure for Electric Vehicles An Indian Scenario.

Author: Shweta Kishore.

Year: May 2022.

The lack of visible infrastructure for charging electric vehicles in India is impacting consumer buying decisions when it comes to adopting EVs. Numerous studies have examined how potential customers perceive and are aware of electric vehicles (EVs). These studies analyze the benefits and drawbacks of EVs, including factors such as their low ownership costs and initial purchase price. This review highlights the significance of carefully analyzing these factors to comprehend consumers' purchasing decisions. The review also addresses the challenges that are impeding the growth of the electric vehicle (EV) market in India. These challenges encompass a scarcity of charging infrastructure, high initial costs, and restricted EV range. The study proposes a collaborative effort between the government and industry to tackle these obstacles and encourage the widespread adoption of EVs in India. In this literature review, the current state of EV charging infrastructure in India is examined, and the obstacles to promoting EV adoption are discussed. The authors highlight the importance of further research and collaboration between the government and industry in order to overcome these challenges and facilitate the expansion of the EV market in India. In conclusion, this study emphasizes the importance of charging infrastructure for the widespread adoption of electric vehicles (EVs) in India. The authors suggest that a collaborative effort between the government and industry is necessary to address the challenges and promote EV adoption in the country. This comprehensive analysis provides valuable insights for policymakers, researchers, and industry professionals interested in the growth of the EV market in India. It highlights government policies and industry commitment towards reducing carbon emissions and decreasing oil import bills through EV adoption. The study also underscores the need for an extensive network of charging stations across the country to support the increasing number of EVs on the roads. A significant drawback of electric vehicles (EVs) is their limited range compared to traditional internal combustion engine (ICE) vehicles. This study highlights the lack of charging infrastructure as one of the obstacles hindering the widespread adoption of EVs in India. The absence of readily available and visible EV charging stations affects consumer buying decisions, as

it creates concerns about inconvenience and range anxiety. Numerous studies have explored how potential customers perceive and understand electric vehicles (EVs). These studies examine both the benefits, like low ownership costs, as well as drawbacks, such as initial product expenses. An important aspect highlighted by this research is the need to thoroughly analyze these factors in order to gain insight into consumer purchasing decisions. The study also examines the challenges that hinder the growth of the electric vehicle (EV) market in India. These challenges include the inadequate charging infrastructure, high initial costs, and limited range of EVs. The study suggests that both the government and industry should collaborate to address these obstacles and encourage the adoption of EVs in India. This study offers important insights into the current state of EV charging infrastructure in India and the challenges that hinder the adoption of EVs. The authors highlight the necessity for increased research and collaboration between the government and industry to overcome these obstacles and drive the growth of the EV market in India.

**Conclusion:** In conclusion,this study highlights the importance of charging infrastructure for The growth and adoption of Electric Vehicles (EVs) in India can be accelerated through collaborative efforts between the government and industry. This study offers valuable insights for policymakers, researchers, and industry professionals who are interested in promoting the EV market in India.

## 2.17 Decoding Customer Concerns about Embracing Electric Cars in India Analysis of Audience Sentiments on YouTube Autovlogs.

Author(s): Vinish Pallikkara Prakash Pinto.

Year: Oct 2023.

This study examines customer sentiments regarding the adoption of electric cars in India by analyzing YouTube autovlogs. The findings reveal that there is a notable level of consumer apprehension and skepticism towards electric vehicles, as indicated by both positive and negative keywords used by the audience. Concerns mainly revolve around the perceived drawbacks and limitations associated with owning an electric vehicle, leading some customers to view conventional gasoline-powered cars as a more practical alternative. These findings align with previous research conducted by Wang et al. (2015) and Sierzchula et al. (2014), which also highlighted consumer apprehension and skepticism as significant barriers to adopting electric

vehicles. These studies found that issues such as the lack of charging infrastructure, high upfront costs, and limited driving range were primary concerns amongst consumers in China and the Netherlands when considering electric vehicle adoption. To address these concerns effectively, policymakers and industry stakeholders should work collaboratively to improve charging infrastructure, increase awareness about the benefits of electric vehicles, and provide incentives to encourage adoption. Additionally, showcasing upcoming products can be an effective strategy to raise awareness and generate interest in electric vehicles based on a study conducted by Hill et al. (2017). seeing a demonstration of its features and capabilities. Electric vehicles offer a solution to both consumer concerns and the pressing issue of climate change. According to a study by the International Energy Agency (IEA) in 2020, the widespread adoption of electric vehicles has the potential to significantly decrease global CO2 emissions. By adopting electric vehicles, we have the potential to significantly reduce global carbon dioxide emissions, with estimates showing a possible decrease of up to 1.5 gigatons per year by 2030. Additionally, this shift towards electric transportation could also lead to a reduction in local.

**Conclusion:** In conclusion, this study emphasizes the significance of recognizing customer concerns and sentiments during the shift towards electric vehicles in India. By addressing these concerns, policymakers and industry stakeholders can collaborate to encourage the adoption of electric vehicles, ultimately creating a transportation system that is more sustainable and efficient. Moreover, the widespread adoption of electric vehicles can play a crucial role in combating global climate change by reducing CO2 emissions and enhancing public health.

## 2.18 Charging Infrastructure for Commercial Electric Vehicles: Challenges and Future Works.

Author(s): B. AL-HANAHI,I. AHMAD, D. HABIBI,M.A.S. MASOUM.

Year: Aug 2021.

This study offers a thorough examination of the best placement for charging infrastructure for commercial electric vehicles. It summarizes the main findings from various studies conducted on this topic, including the creation of models to determine ideal refueling locations along routes, overall corridor models, and optimization models for pinpointing charging stations. These models strive to optimize traffic flow, minimize costs, and maximize coverage area while taking into

account factors such as EV range limitations and charging station capacities. The cost of electric vehicles presents a significant challenge in the commercial vehicle electrification efforts. Despite the growing interest in electric vehicles, their high price tag continues to deter many commercial fleets from adopting them. Furthermore, the limited range of certain electric vehicle models poses an additional obstacle for commercial vehicles that need to cover long distances without frequent recharging stops. To tackle these challenges, researchers have conducted numerous studies to devise effective strategies for optimizing the placement of charging infrastructure. For instance, one study developed a model that identifies the ideal locations for charging stations by taking into account traffic patterns and limitations on electric vehicle (EV) range. Another study focused on creating a corridor model that considers how charging stations are spatially distributed along a specific route. Additionally, a third study formulated an optimization model aimed at minimizing costs while maximizing coverage area. Even with these challenges, there are potential future advancements in charging infrastructure for commercial electric vehicles. Improvements in battery technology and charging infrastructure have the potential to increase range and significantly reduce charging times, making electric vehicles more practical for commercial use. Furthermore, the use of renewable energy sources to power charging stations could greatly reduce the carbon footprint associated with commercial electric vehicles. Standardization is a crucial aspect to consider when building charging infrastructure for commercial electric vehicles. By establishing standard protocols, we can lower costs and enhance interoperability between various charging stations and electric vehicle models. Well-known organizations like the International Electrotechnical Commission (IEC) and the Society of Automotive Engineers (SAE) have already developed standards for electric vehicle charging infrastructure.

**Conclusion:** This study offers a thorough analysis of the existing charging infrastructure for commercial electric vehicles. It covers both the obstacles faced in this field and potential future advancements. As the demand for electric vehicles increases, it becomes crucial to tackle these challenges and create innovative solutions for charging infrastructure. Standardization and collaboration among industry stakeholders will play a vital role in promoting widespread adoption of electric vehicles and their associated charging infrastructure.

## 2.19 Energy Management of a Grid-Intergrated Hybrid Peer-to-Peer Renewable Charging Station for Electric Vehicles.

Author(s): Lindiwe Bokopane, Kanzumba Kusakana, Herman Vermaak.

Year: Oct 2018.

This study offers a thorough examination of the current status of electric vehicle charging stations (EVCS). It explores various control strategies, charging schemes, and models for peer-to-peer energy sharing. The study also highlights the challenges faced by the EVCS industry, such as the absence of a centralized battery bank for additional power during high-demand periods and the lack of a peer-to-peer energy sharing model among EV owners at charging stations in dynamic power demand and pricing conditions. This study examines the advantages of a hybrid renewable energy system for charging stations. The system combines a grid-integrated setup that utilizes renewable energy sources (RES) like The proposed system includes incorporating wind and PV energy sources, a central battery bank (CBB), and enabling peer-to-peer sharing of energy among electric vehicles (EVs) at the EV charging station (EVCS). The primary goal is to lower the operational cost of the EVCS while ensuring uninterrupted energy supply, grid stability, and maintaining optimal battery levels. This will ultimately result in reduced charging costs for EV owners. The study delves into the coordination of charging and discharging schemes for electric vehicles (EVs) in response to demand from the utility grid. It also explores charging activities at stations. Additionally, the study discusses the development and simulation of a closed-loop optimal control model for energy management. This model utilizes a peer-to-peer energy sharing system among EVs. The study emphasizes the importance of a well-coordinated charging system for electric vehicles at a charging station. It is crucial to optimize the charging and discharging process of the central battery bank, manage power distribution from the grid, and incorporate wind and PV charging stations. The suggested hybrid renewable energy system, combined with peer-to-peer energy sharing among EVs, offers a potential solution to address challenges in the EVCS industry. The study also examines the current state of electric vehicle charging stations (EVCS) in South Africa, including their control strategies and available charging options. It delves into optimal charging schemes and control strategies within an EVCS, as well as peer-to-peer sharing among electric vehicles. Furthermore, the study sheds light on ongoing research regarding grid-integrated PV or wind charging stations, and the use of a centralized battery bank to supplement power during peak hours or when the demand for charging exceeds the available renewable energy sources at the

station.

**Conclusion:** This study offers a detailed examination of the obstacles and remedies related to electric vehicle charging infrastructure. It emphasizes the importance of implementing a hybrid renewable energy system that incorporates peer-to-peer energy sharing among EVs. Such a system presents a viable solution to the issues confronting the electric vehicle charging industry.

## 2.20 Evaluating the factors affecting EV adoption considering the sustainable development level.

Author(s): Ehsan Javanmardi, Mahmudul Hoque, Abdul Tauheed, Muhammad Umar.

Year: May 2023.

This study offers a thorough analysis of the factors that influence the adoption of electric vehicles (EVs), taking into account the impact of the COVID-19 pandemic and the level of sustainable development. The research emphasizes the significance of sustainable development in driving the adoption of EVs. By focusing on social, economic, and environmental aspects, sustainable development will ultimately promote the utilization and acceptance of EVs as a crucial infrastructure. Electric vehicles (EVs) have the potential to reduce greenhouse gas emissions and improve air quality, which are essential for sustainable development. However, there is ongoing debate among researchers regarding the extent to which EVs can contribute to sustainable development. Despite this, the development of EVs remains crucial in achieving sustainable objectives. Unfortunately, the COVID-19 pandemic has significantly impacted the automotive industry and created obstacles for the EV sector. Travel restrictions, factory closures, disrupted supply chains, and decreased demand have all adversely affected the viability of the industry. It is therefore important to analyze the factors that drive demand for EVs, as they play a significant role in determining future trends—especially considering how the pandemic has influenced this demand. Researchers have been studying the factors influencing the adoption of electric vehicles (EVs) in countries like India and China, which are experiencing rapid growth in EV markets. Key factors impacting EV adoption include vehicle power, battery range, charging method and capability, warranty policies, and overall battery performance. These factors are commonly researched by accessing online car specification databases to collect relevant model data for analysis. The study also acknowledges the need for more research on the impact of electric vehicles (EVs) on social

welfare and user experience, which presents a significant challenge. To bridge this gap, the study employs grey econometric methods and examines secondary data to identify factors that influence EV demand. The analysis will involve best-subset grey regression, best-fit regression methods, and ANOVA analyses. To ensure model accuracy, tests such as lack of fit test, Durbin Watson statistics for remnant independence testing, and Variance Inflation Factor (VIF) will be employed. The MINITAB software will be utilized for these analyses.

**Conclusion:** In conclusion, this study offers a thorough examination of the various factors that influence the adoption of electric vehicles (EVs). It emphasizes the significance of sustainable development and calls for additional research on how EVs impact social welfare and their users.

# Chapter 3

# Flow and Working

## 3.1 Project Flow

The project flow for this project is as follows: When the user opens the app and signs in, they'll be greeted by a map showing all the available chargers. From there, they can easily select a charger and view detailed information about its location, type, and availability. Once they've chosen a charger, they can proceed to book a slot. With the booking secured, the user simply needs to drive to the selected charger and charge their vehicle

## 3.2 Working of the Project

The app is developed using Java and Android Studio, with Firebase as the backend for storing user data, authenticating users, and displaying chargers on a map using a Firebase database. The app utilizes various libraries, including: Firebase provides user authentication functionality, allowing users to securely login and access their accounts. The Realtime Database feature enables the storage of user data and charger information. Additionally, the Google Maps API is utilized to display a map and indicate the location of chargers.

### 3.2.1 Use of Firebase

Firebase, a cloud-based platform by Google, offers various services for mobile app development. These include authentication, real-time database functionality, and storage. In our project, we utilize Firebase for the following purposes: For user authentication, we utilize Firebase Authentication. This service not only authenticates users but also generates access tokens. To store user data and charger data in real-time and ensure data synchronization across all devices, we rely on Firebase Realtime Database. Lastly, for displaying the map and indicating charger locations, we integrate Google Maps API into our system.

### 3.2.2 Java Development

The app is developed using Android Studio, a comprehensive integrated development environment (IDE) specifically designed for building Android applications. With features like a code editor, debugger, and various tools, developers can easily create and test their apps in Java.

### 3.2.3 Challenges Faced

One of the challenges we encountered during this project was the inability to display public chargers on the map. This limitation arose from the unavailability of free APIs for India, leaving us with only costly options. The project also presented a budget constraint, requiring us to be mindful of resource allocation and make necessary compromises.

### 3.2.4 Conclusion

Despite the challenges we encountered, we managed to successfully create a functioning prototype of the app. This app enables users to easily access and reserve both private and semi-public chargers. Our team is actively working to add support for public chargers and making the app more user-friendly with new features in development. We believe that this app has the potential to greatly contribute to the increased adoption of electric vehicles in India. By providing users with a user-friendly platform to locate and reserve chargers, we can alleviate charging anxiety and make electric vehicles more feasible for everyday use in India.

### 3.2.5 Diagrams

**Activity diagram :**

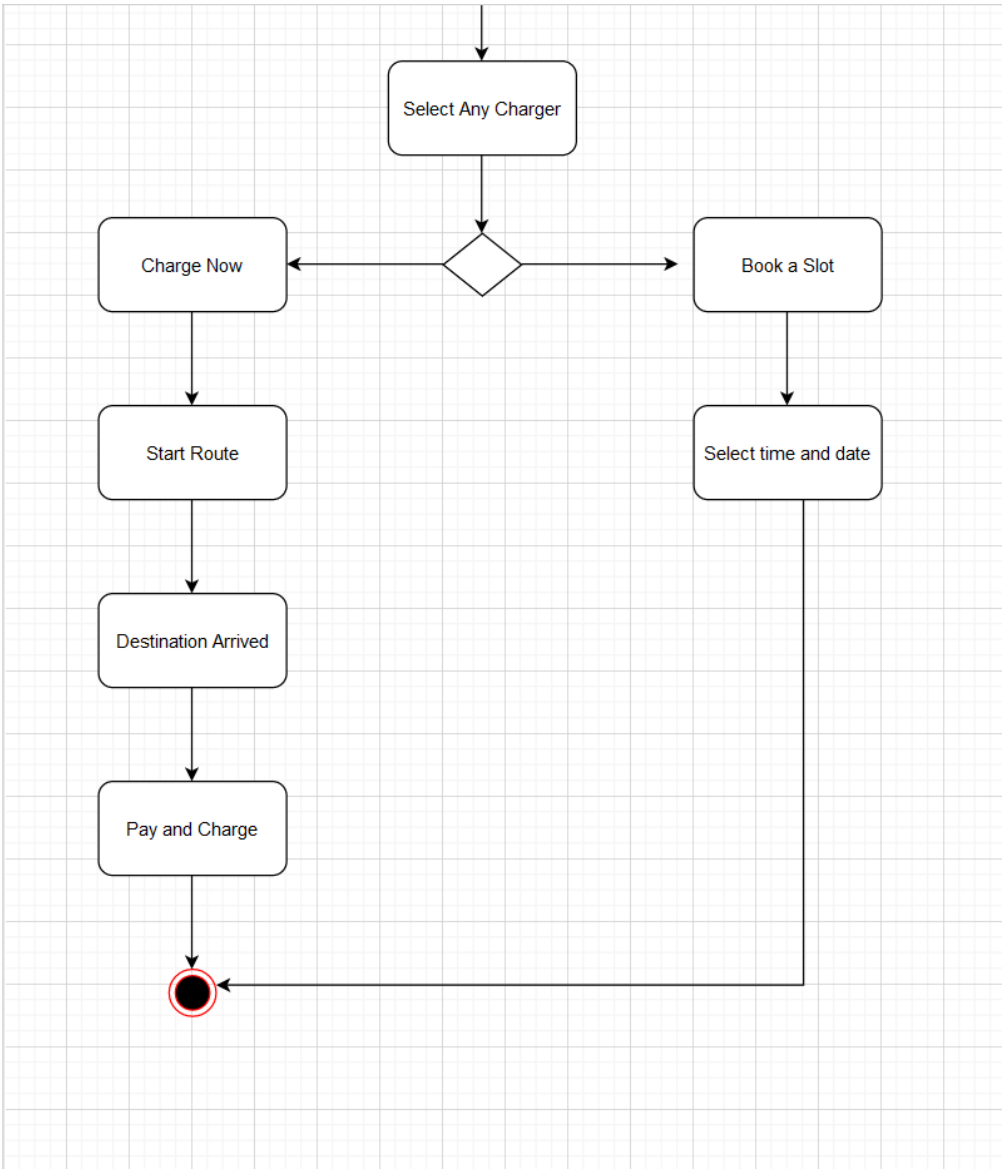


Figure 3.1: Activity Diagram for User

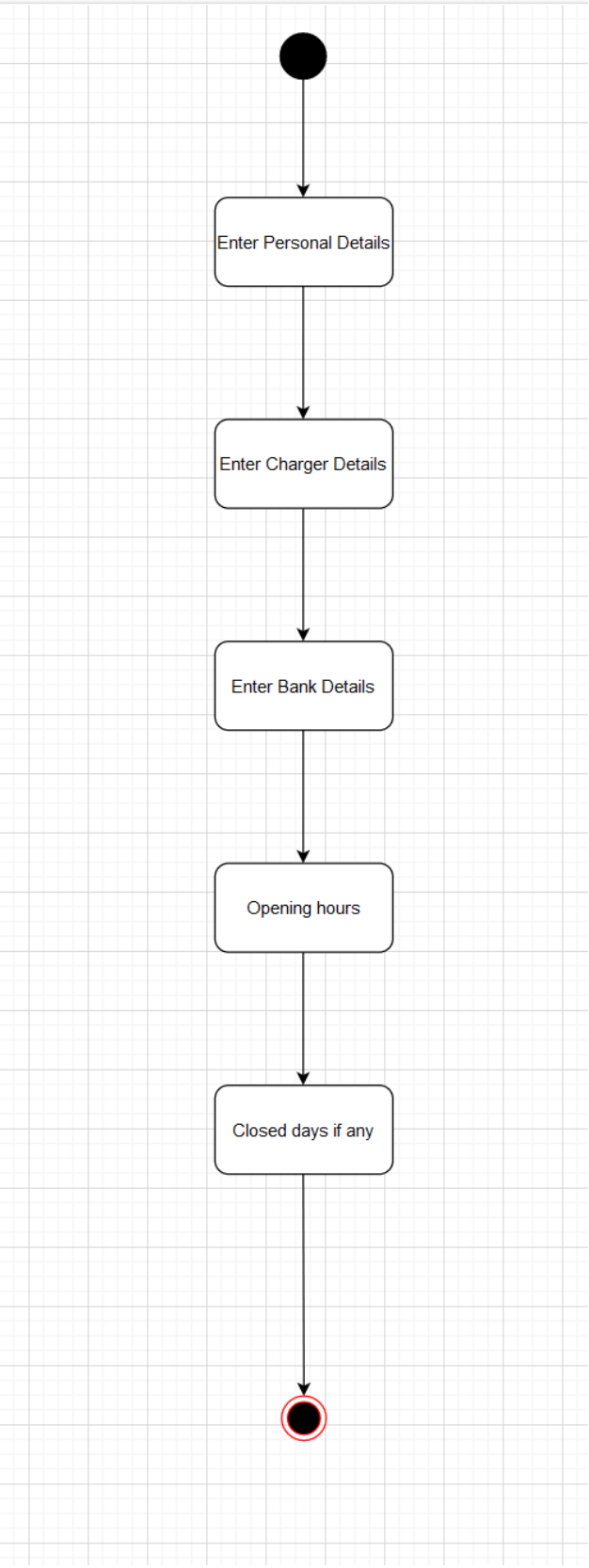


Figure 3.2: Activity Diagram for Admin

### 3.2.6 Use Case Diagram :

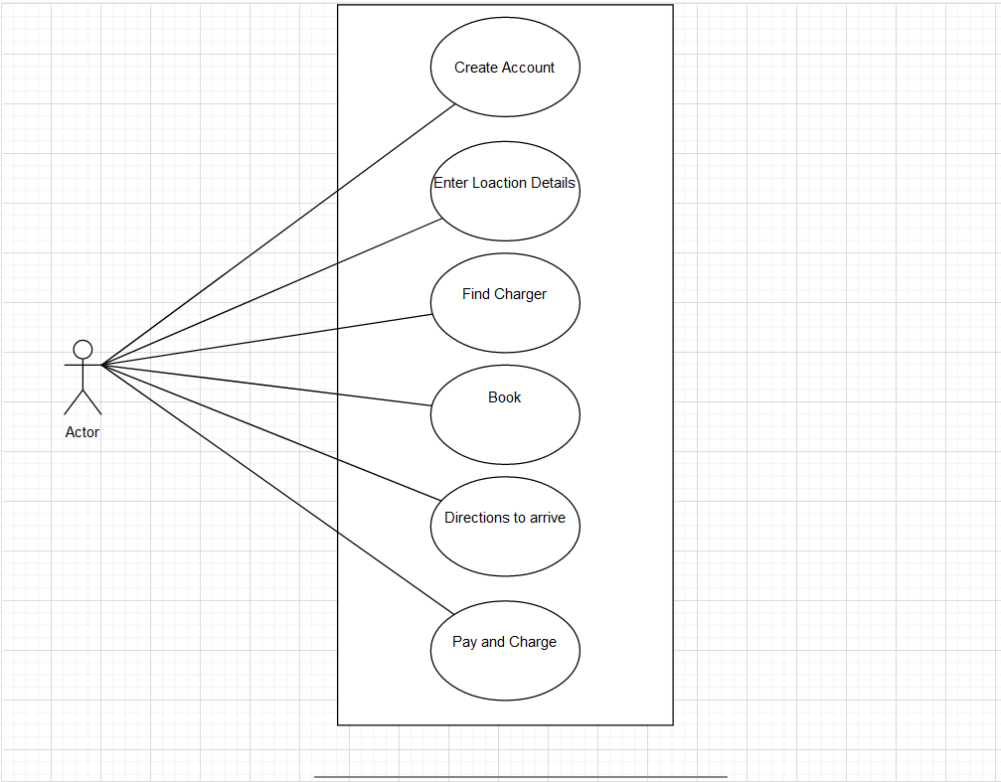


Figure 3.3: Use Case Diagram

### 3.2.7 Flow Diagram :

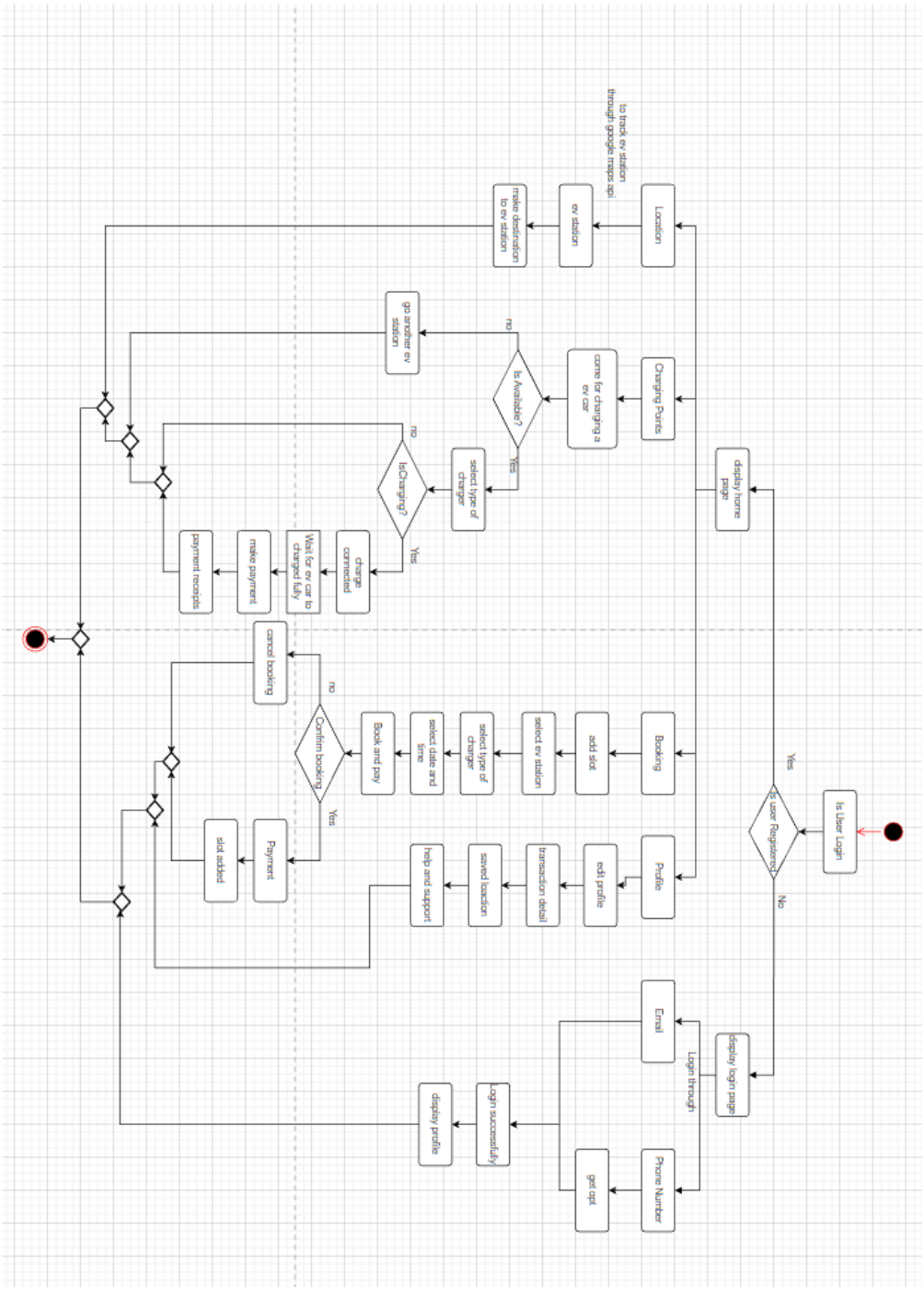


Figure 3.4: Flow Diagram

### 3.2.8 Implementation of Work

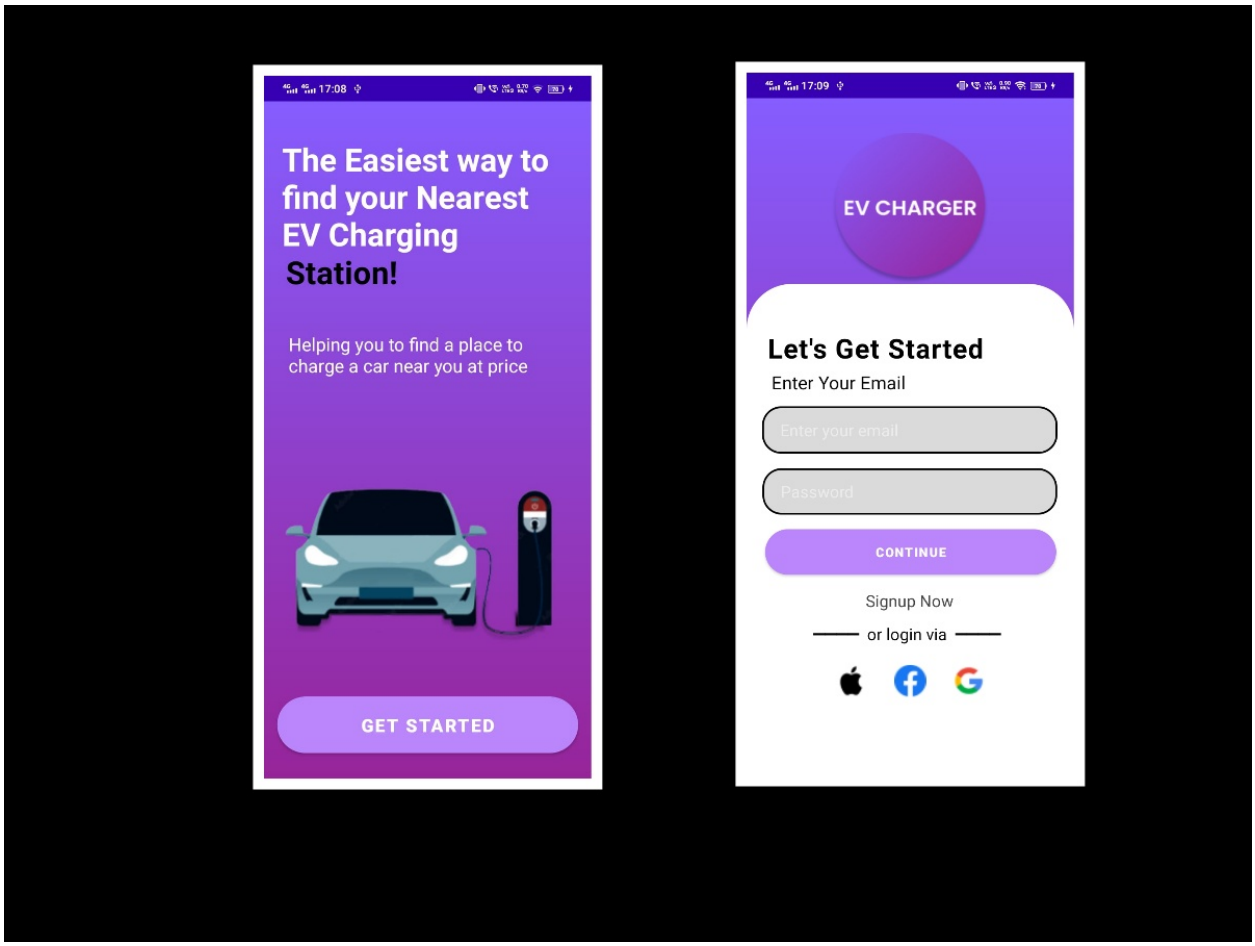


Figure 3.5: Login Page

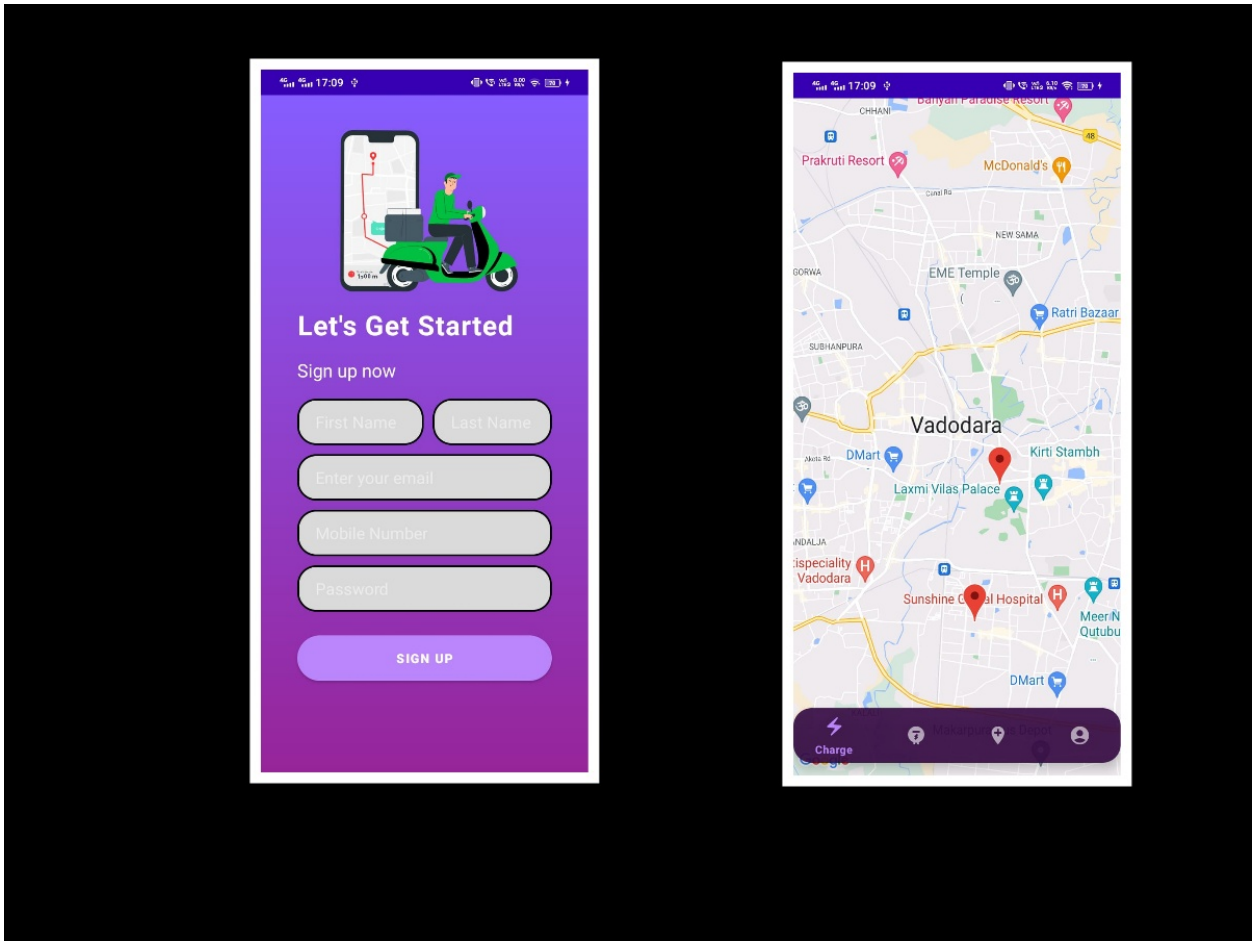


Figure 3.6: Charging Station

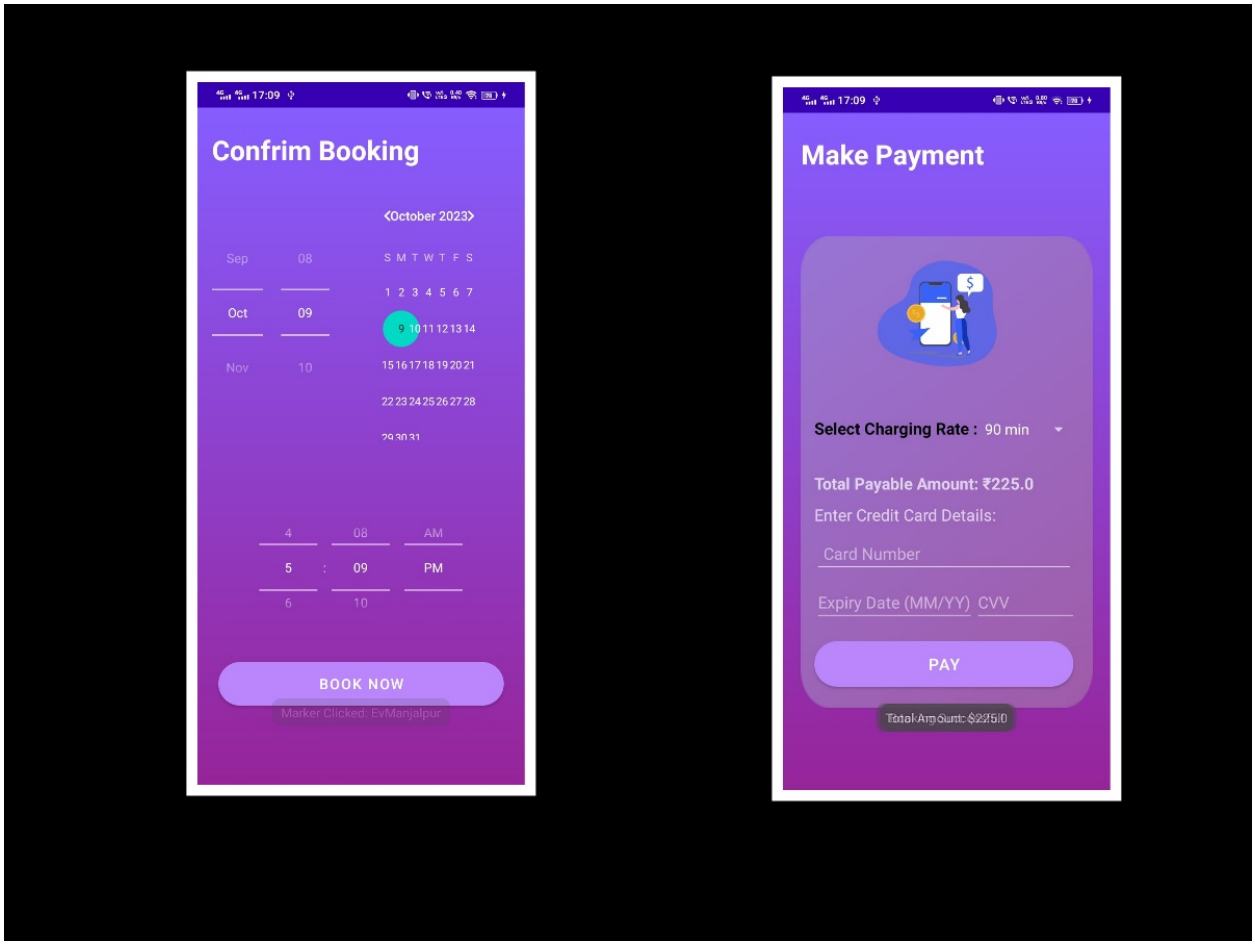


Figure 3.7: Booking and Payment Page

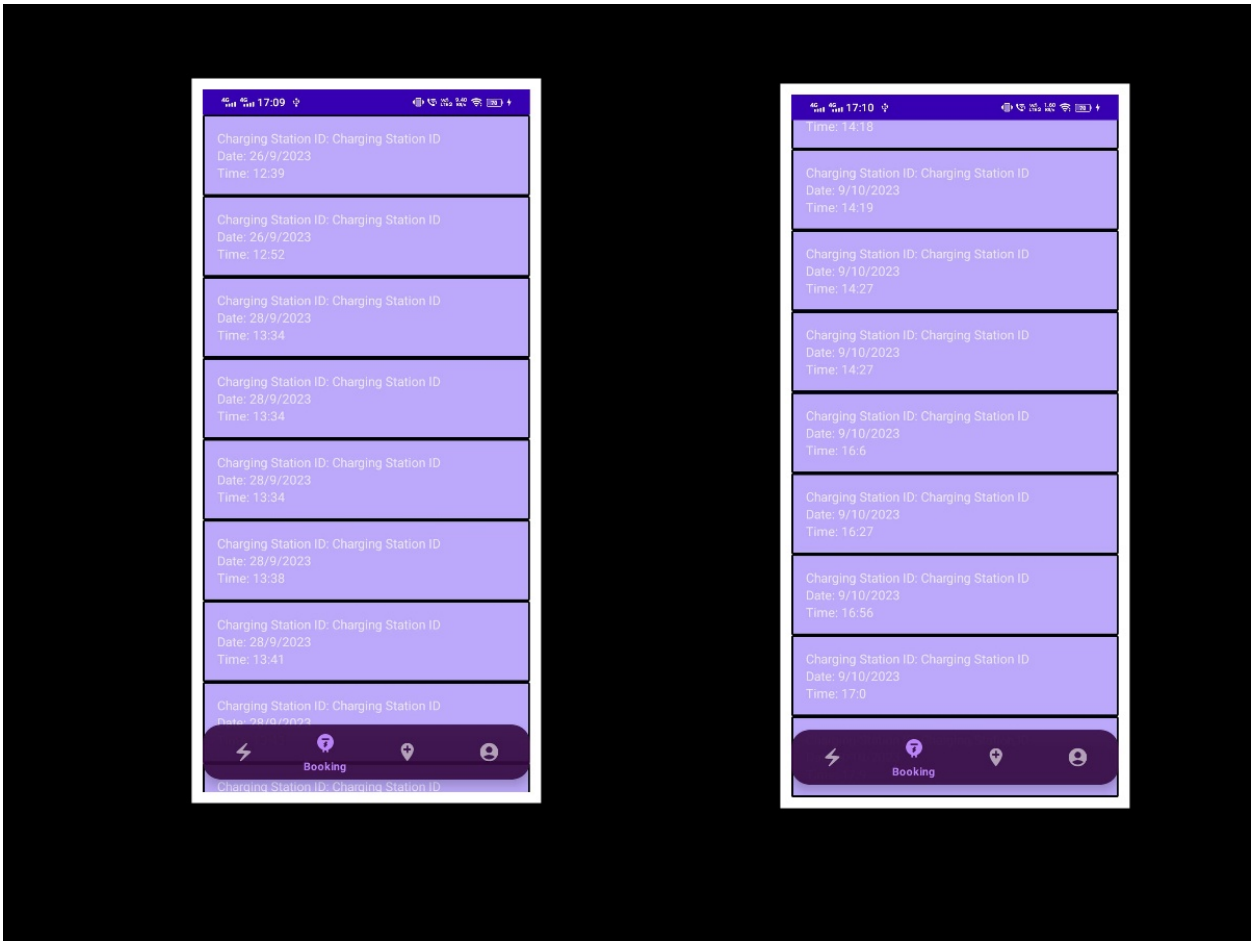


Figure 3.8: Booking List

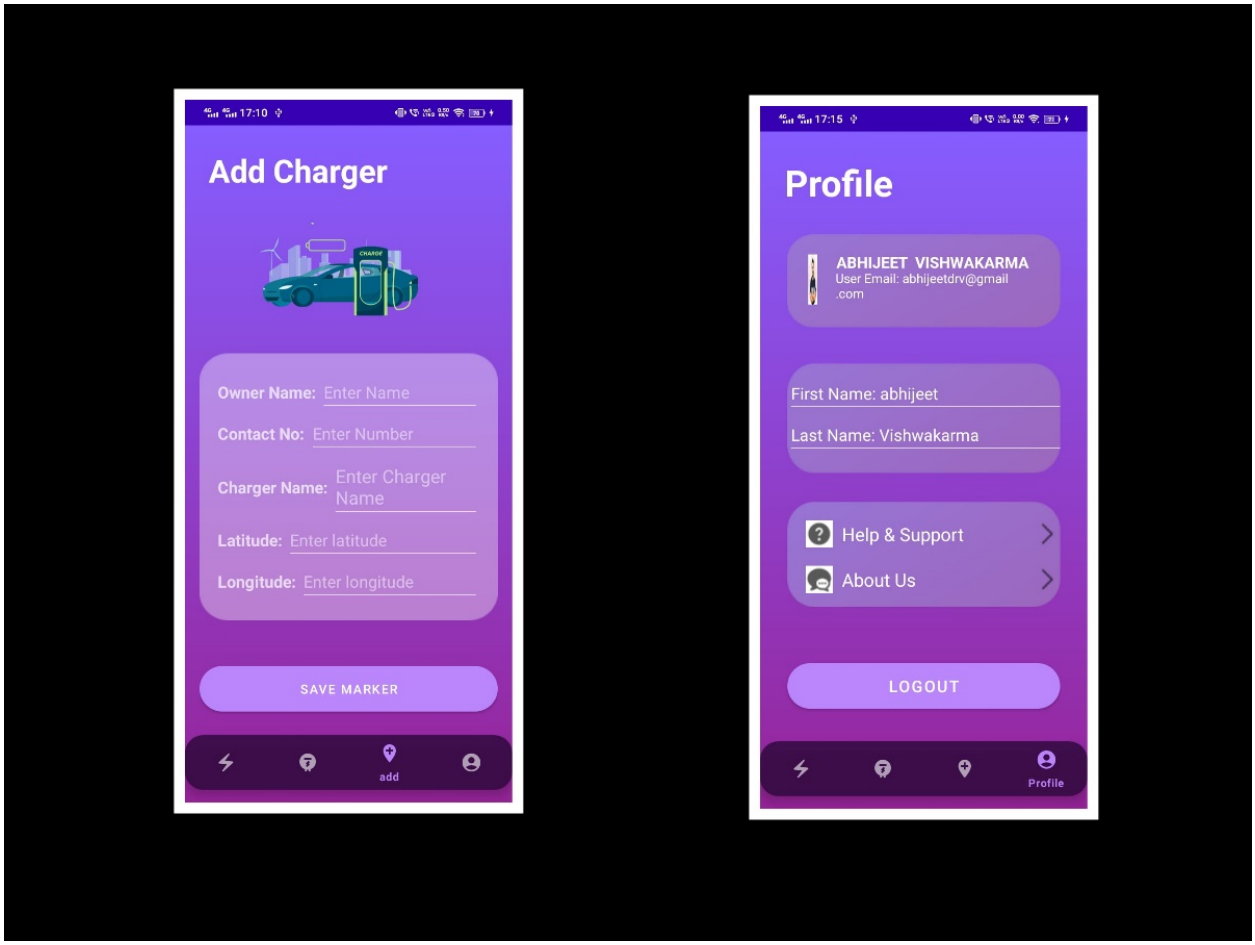


Figure 3.9: Add Charger Point and Profile Page

# Chapter 4

# Methodology

## 4.1 Project Planning and Requirement Gathering

To begin our project, we took the essential step of planning and gathering requirements. This involved identifying the project goals and defining the target audience. We then proceeded to brainstorm a comprehensive list of features that we aimed to incorporate into the app. During this stage of development, we encountered a few challenges. One challenge was understanding how to integrate the Google Maps API with Firebase in order to display chargers on the map. Additionally, we had to make a decision about which database to use for our app. We evaluated Firebase, Appwrite, and Supabase and ultimately chose Firebase because it best met our requirements. After finalizing the project plan and collecting all the necessary requirements, our next step was to gather the required resources. This involved finding capable developers, designers, and QA testers. Additionally, we needed to acquire a domain name and hosting for the application.

## 4.2 UI/UX Design

To create various UI/UX designs and prototypes, we utilized Figma. These prototypes were then tested with users to gather feedback and implement necessary enhancements. Our main focus was to design an interface that is easy for users to navigate and understand. We also prioritized creating a visually pleasing app with an intuitive layout.

## 4.3 Development and Coding Practices

For development, we utilized Android Studio. In terms of methodology, we opted for Agile, which is an iterative and incremental approach to software development. This approach enables us to receive frequent feedback from users and make necessary adjustments to the app accordingly.

## 4.4 Testing and Quality Assurance

We are currently testing the app to ensure that it functions correctly. Our testing process includes both manual and automated methods to thoroughly evaluate its performance.

## 4.5 Deployment

Our plan includes launching the app on the Google Play Store and creating a dedicated website for users to access more information about the app and download it.

## 4.6 User Feedback

We plan to collect user feedback through a variety of channels, such as surveys, in-app feedbackforms, and social media. We will use this feedback to improve the app over time.

## 4.7 Conclusion

We are thrilled to introduce this app that aims to assist users in locating and booking electric vehicle chargers throughout India. We strongly believe that this app has the ability to play a crucial role in promoting the widespread adoption of electric vehicles across the country.

# Chapter 5

# Future Work

We are committed to continuously updating and enhancing the app to ensure its security, stability, and user satisfaction. We will carefully consider user feedback and incorporate new features and improvements accordingly.

## 5.1 Make public chargers visible

Our plan is to include public chargers in the app so that users can easily find them. Currently, we are facing budget limitations, which means we cannot utilize any paid API that provides data for all the public chargers in India. Nonetheless, we are actively investigating alternative options including open-source data and potentially developing our own API.

## 5.2 Add more customization to UI

We have exciting plans to enhance the UI with additional customization options, including the ability to change themes and font sizes. Furthermore, we are working on adding new features that will allow users to filter chargers based on type and availability. Stay tuned for these exciting updates!

Other possible future work includes:

Adding support for multiple languages We are dedicated to enhancing the app and providing the best experience for our users. One way we're doing this is by establishing partnerships with charger operators to offer exclusive discounts and benefits to our app users. We value user feedback, and it plays a crucial role in driving our development and improvement efforts.

# Chapter 6

# Plagiarism Report

0% Plagiarised

100% Unique

| | |
|---|---|
| Date | 2023-10-12 |
| Words | 488 |
| Characters | 3620 |

**Content Checked For Plagiarism**

The International Energy Agency (IEA) has released a report that analyzes the future of India's energy sector. The report explores different scenarios for energy demand, supply, emissions, and security in India based on various assumptions and policy goals. It also highlights India's potential to lead the way in global energy transition and achieve low-carbon, inclusive growth[1].
Here is a detailed
summary of the main points
of the report:
India, the world's third-largest energy consumer, has experienced significant growth in population, urbanization, and industrialization. As a result, its energy consumption has doubled since 2000 and is projected to increase by 35-50% by 2040. Despite substantial efforts to expand access to electricity and promote renewable energy sources, India continues to face numerous challenges. These include ensuring reliable and affordable power supply, reducing dependence on imported fossil fuels, improving air quality,
and enhancing overall energy efficiency.
The National Institutes of Health warns that the COVID-19 pandemic, being a traumatic experience, can lead to a range of mental health problems. Many individuals report worsening symptoms of anxiety and depression. Although most people will eventually recover, it takes time, and some may require treatment for conditions such as post-traumatic stress disorder (PTSD) or major depressive disorder.

Regarding India's energy future, the report presents four scenarios: the Stated Policies Scenario (STEPS), based on current policy settings; the India Vision Case, reflecting a more complete achievement of India's policy goals and faster economic growth; the Delayed Recovery Scenario, considering prolonged impact from COVID-19; and the Sustainable Development Scenario, based on increased clean energy investment and achieving net-zero emissions. Regardless of the scenario, solar power is expected to drive India's transformation in the power sector by 2040.
India is also projected to become a global leader in battery storage with 140 to 200 GW capacity by 2040. However, coal will still play a significant role in industry and transportation while remaining a major emitter of CO2 and air pollutants.

India's oil demand is anticipated to increase by 1 to 4 million barrels per day (mb/d) by 2040 mainly due to diesel-based freight transport. The country will also expand natural gas usage in industries and city gas distribution. Nonetheless, affordability and infrastructure pose challenges for both oil and gas.

India's transition towards cleaner energy has important implications for its energy security, economic development, and environmental sustainability. The report suggests that if India follows sustainable development practices highlighted in one scenario - including leveraging renewable resources like abundant solar power,
enhancing energy efficiency measures,
diversifying its fuel sources,
and fostering innovation alongside partnerships - it could pioneer a model for low-carbon inclusive growth.
By pursuing this path,

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the country has an opportunity to reduce fuel costs by up to $1.4 trillion by 2040,
reduce CO2 emissions by 60 percent,
and improve air quality.

Finally, the report emphasizes that India's energy choices will significantly impact not only its own energy system but also global climate outcomes.

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This article examines the challenges and potential of electric vehicles (EVs) in India, as the country aims for a significant increase in EV sales by 2030. The Indian Venture and Alternate Capital Association (IVCA) report highlights that achieving this target is ambitious and reliant on various factors. These factors include the accessibility and affordability of charging infrastructure, battery costs, performance improvements, and investments in research and development. Furthermore, the article presents data and examples to illustrate the current state and future prospects of EVs in India, with a particular focus on the two-wheeler segment.
The article begins by introducing the
case of Pravinbhai Parmar, a farmer in Gujarat state who has been using solar power for irrigation and selling the excess electricity to the state's grid1. He is
one of the thousands of farmers who have been encouraged to take up solar power
in the state, which has reduced its
coal share from 85 percent to 56 percent in the last six years. However,
Gujarat is an exception among Indian states, most of which have
installed less than 50 percent of their renewable
energy targets for 20222.
The article highlights a contrast between India's goal of achieving net zero emissions by 2070 and its ongoing dependence on coal for electricity generation. It emphasizes that India has installed 168 gigawatts of coal-fired generation between 2001 and 2021, which is almost double the capacity added in solar and wind power combined. The article also mentions that India's electricity demand is projected to increase by up to 6 percent annually over the next decade, making it challenging to decrease the reliance on coal.
The article emphasizes the potential advantages of renewable energy for India's economy, environment, and energy security. It references a report from the Global Energy Monitor that positions India among the top seven countries worldwide in terms of prospective renewable power. The report states that by 2025, the planned expansion of solar and wind power to reach 76 gigawatts will prevent nearly 78 million tonnes of carbon dioxide emissions.
The coal industry could save up to 1.6 trillion rupees (approximately 19.5 billion dollars) annually by producing and utilizing tons of coal.
This article explores the challenges that hinder the widespread adoption of renewable energy and electric vehicles (EVs) in India. These obstacles include difficulties with land acquisition, necessary policy reforms, energy storage options, and the financial stability of electricity distribution companies. However, there are also progressive policies in place to support clean energy development, such as a government scheme worth 2.6 billion dollars that incentivizes the production of solar energy components.
The article primarily discusses the growing popularity of electric vehicles (EVs) in India's two-wheeler segment, which represents over 80 percent of the country's vehicle sales. It highlights how EVs are increasingly favored by urban commuters who aim to reduce expenses associated with fuel and maintenance. Additionally, it mentions successful EV startups like Ola Electric, which intends to release its electric scooter in the near future.
In conclusion, the article offers several suggestions for expediting the shift towards clean energy. These include increased investment in battery storage, green hydrogen technologies, and policy reforms. The article also expresses optimism about

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India's clean energy future, predicting a significant surge in renewables and the affordability of storage technology and green hydrogen in the near future.

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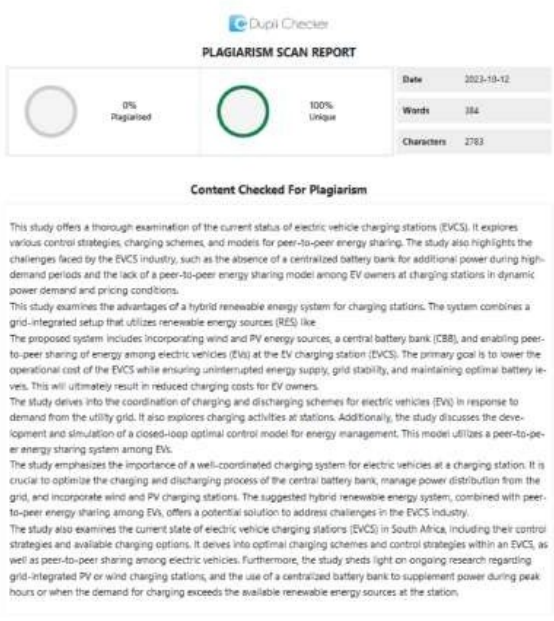

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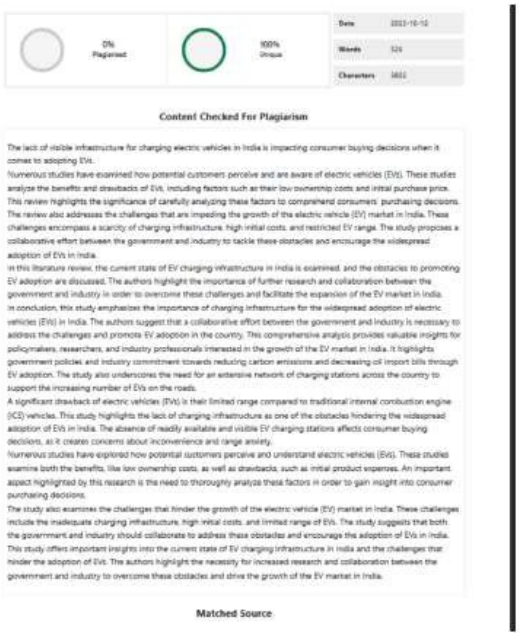
This study offers a thorough examination of the current status of electric vehicle charging stations (EVCS). It explores various control strategies, charging schemes, and models for peer-to-peer energy sharing. The study also highlights the challenges faced by the EVCS industry, such as the absence of a centralized battery bank for additional power during high-demand periods and the lack of a peer-to-peer energy sharing model among EV owners at charging stations in dynamic power demand and pricing conditions.
This study examines the advantages of a hybrid renewable energy system for charging stations. The system combines a grid-integrated setup that utilizes renewable energy sources (RES) like
The proposed system includes incorporating wind and PV energy sources, a central battery bank (CBB), and enabling peer-to-peer sharing of energy among electric vehicles (EVs) at the EV charging station (EVCS). The primary goal is to lower the operational cost of the EVCS while ensuring uninterrupted energy supply, grid stability, and maintaining optimal battery levels. This will ultimately result in reduced charging costs for EV owners.
The study delves into the coordination of charging and discharging schemes for electric vehicles (EVs) in response to demand from the utility grid. It also explores charging activities at stations. Additionally, the study discusses the development and simulation of a closed-loop optimal control model for energy management. This model utilizes a peer-to-peer energy sharing system among EVs.
The study emphasizes the importance of a well-coordinated charging system for electric vehicles at a charging station. It is crucial to optimize the charging and discharging process of the central battery bank, manage power distribution from the grid, and incorporate wind and PV charging stations. The suggested hybrid renewable energy system, combined with peer-to-peer energy sharing among EVs, offers a potential solution to address challenges in the EVCS industry.
The study also examines the current state of electric vehicle charging stations (EVCS) in South Africa, including their control strategies and available charging options. It delves into optimal charging schemes and control strategies within an EVCS, as well as peer-to-peer sharing among electric vehicles. Furthermore, the study sheds light on ongoing research regarding grid-integrated PV or wind charging stations, and the use of a centralized battery bank to supplement power during peak hours or when the demand for charging exceeds the available renewable energy sources at the station.



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The lack of visible infrastructure for charging electric vehicles in India is impacting consumer buying decisions when it comes to adopting EVs.
Numerous studies have examined how potential customers perceive and are aware of electric vehicles (EVs). These studies analyze the benefits and drawbacks of EVs, including factors such as their low ownership costs and initial purchase price. This review highlights the significance of carefully analyzing these factors to comprehend consumers' purchasing decisions. The review also addresses the challenges that are impeding the growth of the electric vehicle (EV) market in India. These challenges encompass a scarcity of charging infrastructure, high initial costs, and restricted EV range. The study proposes a collaborative effort between the government and industry to tackle these obstacles and encourage the widespread adoption of EVs in India.
In this literature review, the current state of EV charging infrastructure in India is examined, and the obstacles to promoting EV adoption are discussed. The authors highlight the importance of further research and collaboration between the government and industry in order to overcome these challenges and facilitate the expansion of the EV market in India.
In conclusion, this study emphasizes the importance of charging infrastructure for the widespread adoption of electric vehicles (EVs) in India. The authors suggest that a collaborative effort between the government and industry is necessary to address the challenges and promote EV adoption in the country. This comprehensive analysis provides valuable insights for policymakers, researchers, and industry professionals interested in the growth of the EV market in India. It highlights government policies and industry commitment towards reducing carbon emissions and decreasing oil import bills through EV adoption. The study also underscores the need for an extensive network of charging stations across the country to support the increasing number of EVs on the roads.
A significant drawback of electric vehicles (EVs) is their limited range compared to traditional internal combustion engine (ICE) vehicles. This study highlights the lack of charging infrastructure as one of the obstacles hindering the widespread adoption of EVs in India. The absence of readily available and visible EV charging stations affects consumer buying decisions, as it creates concerns about inconvenience and range anxiety.
Numerous studies have explored how potential customers perceive and understand electric vehicles (EVs). These studies examine both the benefits, like low ownership costs, as well as drawbacks, such as initial product expenses. An important aspect highlighted by this research is the need to thoroughly analyze these factors in order to gain insight into consumer purchasing decisions.
The study also examines the challenges that hinder the growth of the electric vehicle (EV) market in India. These challenges include the inadequate charging infrastructure, high initial costs, and limited range of EVs. The study suggests that both the government and industry should collaborate to address these obstacles and encourage the adoption of EVs in India. This study offers important insights into the current state of EV charging infrastructure in India and the challenges that hinder the adoption of EVs. The authors highlight the necessity for increased research and collaboration between the government and industry to overcome these obstacles and drive the growth of the EV market in India.

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