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Risk Assessment and Mitigation Strategies for Developing Electric Vehicle Charging Infrastructure Projects in New Delhi, India

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ABSTRACT:

The accelerated introduction of electric vehicles (EVs) in New Delhi has brought to light the necessity for a dependable charging infrastructure in order for the city to change to sustainable mobility. Nevertheless, the development of EV charging stations in the city involves various risks and challenges, including but not limited to financial, regulatory, technological, and even social enmeshments. This research explores the main risks of recent EV charging infrastructure development in New Delhi, taking a closer look at external macroenvironmental factors using the PESTEL framework (political, economic, social, technological, environmental, and legal). The analysis of these dimensions allows the study to identify the bottlenecks and blockers to effective EV infrastructure rollout, providing useful knowledge for policymakers, urban planners, and investors. Based on qualitative data obtained from interviews with project managers and secondary literature, this research offers practical risk mitigation strategies that are relevant to the urban development and regulatory environment of New Delhi. Findings enrich the knowledge of infrastructure risk management and provide a model for the successful implementation of EV charging networks in dynamically growing cities.

KEYWORDS: Electric Vehicle (EV) Charging Infrastructure; Sustainable Mobility Transition; New Delhi Urban Mobility; Risk Management in EV Infrastructure; Macroenvironmental Factors in EV Development; Urban Development and Risk Mitigation Strategies for EV Infrastructure.

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1 INTRODUCTION

1.1 Backgorund of the Study

People continue to use electric vehicles more often and this creates demand for strong EV charging systems globally. New Delhi significantly reduces its challenges in deploying EV charge posts due to its high population density, limited urban space, and complex regulatory environment (Straka et al., 2020). Insights about risks from developing charging infrastructure in highly populated urban settings remain scarce from current EV research (Machado et al., 2020). The growth of EVs in New Delhi offers researchers an ideal opportunity because the city supports numerous chargers through federal actions and highway problems. The Indian government launched FAME to boost EV development by supporting new industry and sales incentives. To work effectively, these plans need matching charging stations in place. Policies can help yet installing EV charging stations runs into many big problems (Singh et al., 2024).Putting up and running EV charging stations involves an enormous amount of money, plus investments and public-private collaborations become envisioned and returns on the investments are unpredictable. Technical issues are connected to the electric grid strength, how fast EVs can charge and how they can be compatible with different types of EVs (Venkatraman Ethirajan, 2025). Complexities with land acquisition, building permits, and environmental approvals make it more difficult to build EV charging stations. Investment in risk management during infrastructure setup helps transition smoothly toward green transportation.This research studies the main problems connected to EV charging infrastructure planning and develops efficient action plans and a breakthrough model for implementation in New Delhi. Our research results will extend present knowledge in risk assessment and management, which can help decision-makers directly.

1.2 Research Gaps and Aim

However, there is a dearth of studies on the risks of developing EV charging infrastructure. Although there have been numerous studies about the growth of the EV market, adoption of consumers, and environmental impact, there is a big gap regarding the multiple challenges related to infrastructure growth (Sachan & Singh, 2022). Studies

that do look at charging infrastructure usually focus on the technical elements, such as battery technology and grid integration and not the comprehensive risk identification (Singh et al., 2024).Another large gap in the research is the absence of location-specific studies. Urban areas similar to that of New Delhi have particular advantages, such as limited space, difficulty for regulations, and high energy demand, but the evolution is not fully embraced by the broad study (Omase et al., 2023). In addition, although risk management techniques are commonly mentioned in business and project management literature in general, specifically in the context of EV charging infrastructure, these are subject to little investigation.This investigation provides specific answers about infrastructure development solutions that New Delhi needs to achieve sustainable mobility.

1.3 Research Objectives and Question

The main aim of this study is to investigate and certify potential risks associated with the development of the infrastructure of the electric vehicle (EV) charging projects undertaken in New Delhi. The study aims to identify external macro-environmental factors of bottlenecks to efficient rollout of charging stations in the city. By identifying these barriers, the research will provide an overall view to the various stakeholders that play important roles in the EV infrastructure development.In addition, this study also intends to analyze the effect of external variables and ecological factors on the installation of EV charging point shelters. Political, economic, social, technological, environmental, and legal influences (PESTEL) impact the viability and sustainability of these ventures. Therefore, it is necessary to understand how external elements akin to government rules, urban real estate, power requests, and regulatory requirements motivate the increase of EV infrastructure to make strategic choices.In addition, this research aims to generate advice on the identified risks and the planning and delivery of EV charging infrastructure projects. By combining project risk management (PRM) and outlier analysis of external factors, the investigation can provide an effective action-item list to raise the efficiency and sustainability of EV charging networks. The results are expected to help develop more effective risk management practices and inform policymakers, urban planners, and investors on how to support the successful rollouts

of EV infrastructure in New Delhi.Based on these objectives, the central research question guiding this study is: **What are the key risks in developing EV charging infrastructure in New Delhi?**

1.4 Research Objectives and Question

This research specifically looks at New Delhi because of its high adoption rate of electric cars and serious infrastructure challenges. However, not even the results may offer guidance applicable to other cities, due to the variations in local zoning laws, the location of the place, and the local economy, which would contain it widely applicable (Sachan & Singh, 2022). A study primarily data on financial, legal, and technological risks associated with EV charging infrastructure development rather than personal behavior or the performance of the vehicle (Singh et al., 2024).

Instead, the research is based on qualitative data, such as interviews with experts and secondary literature, to examine the risks and solutions of the issue. But maybe the omission of private company information can cause gaps in financial & operational knowledge (Kumar et al., 2023). Moreover, the study concentrates only on the currently available EV charging technologies, discarding the experimental or novel techniques (Sharma et al., 2022).

Since risk assessments are defined for a 5- to 10-year time frame, longer-term technological developments and policy changes may not be fully included (Machado et al., 2020). Although these constraints exist, this study yields crucial data to comprehend the immediate and medium-term risk factors of EV charging infrastructure growth in a city like New Delhi.

1.5 Explanation of Key Concepts

The key concepts of this study are risk assessment and mitigation strategies for establishment of the Electric Vehicle charging infrastructure.

Concept	Explanation
Risk Assessment	A structured approach to identifying, assessing, and controlling the potential risks which may arise in EV charging infrastructure projects. These risks could be financial, technological, and regulatory uncertainties risks (Sachan & Singh, 2022; Hardinghaus et al., 2020).
Mitigation Strategies	Some identified risks at Solutions have undergone measures to reduce or remove their presence through policy adjustments and technological inventions along with investment opportunities (Straka et al., 2020; Alessandro Saldarini et al., 2023).
EV Charging Infrastructure	A simple network of charging stations that is needed to increase the adoption of electric vehicles, there are essential taxis vehicles with electric means (r Gaur, 2025).
Project Risk Management (PRM)	An approach utilized to oversee threats in the course of infrastructure innovation, characterized by way of financial practicality, lawfulness, and innovation (Agarwal & Virine, 2019).
PESTEL Analysis	Organizations use PESTEL analysis as a strategic tool to analyze macro-environmental factors which influence both projects and organizations through six elements including Political, Economic, Social, Technological, Environmental and Legal dimensions (Johnson et al., 2017; Yüksel, 2012).

Table 1: Explanation of Key Concepts

2 LITERATURE REVIEW

2.1 Types of Risks in Developing EV Charging Infrastructure

Implementation of electric vehicles (EVs) is a significant step in a bid to decrease city pollution and dependence on fossil fuels. New Delhi, with its planned EV adoption pursuant to Delhi EV Policy 2020, is looking at setting up a strong charging infrastructure. But creating such infrastructure comes with many risks, from financial and regulatory to technological and environmental ones. This chapter discusses the several risks connected with the establishment of an EV charging infrastructure in New Delhi.

Policy and Regulatory Risks

Policies and regulation outcomes are essential for the successful expansion of electric vehicle (EV) charge points. In New Delhi, as well as in other places, the rapid tightening of rules, combined with uncertain schemes, constitutes significant threats to EV framework investors as well as developers. These challenges can accommodate the prompt implementation, cost-effectiveness, and general feasibility of such schemes (Monteiro et al., 2024).One of the biggest challenges for New Delhi-based EV charging infrastructure setters is regulatory uncertainty in the segment. The Indian government has also made progress in encouraging electric vehicles under the various schemes, incentives, and tax exemptions. That for now policy framework is not running on wheels but by parts of the cycle journey, which undergo updates and revisions and can deliver in parts of the mess. For instance, import tariff changes for its components of EV, incentive changes, and new adoption of the state regulations, such as building regulations, can be in the timeline of the project or the operational cost. Investors are reluctant to pour massive amounts of funds into projects that are extremely policy-specific and heavily dependent on policies that often fluctuate within the political term due to higher financial risk and uncertainty (Bharadwaj, 2023). Some regulatory bodies may also not be consistent with one another in ensuring their approval of the development of the EV ecosystem. The discrepancies between national, state, and local regulations could lead to additional delays and complications. For instance, things like differing requirements for the refueling infrastructure or new vehicle emission changes

that could erode the uniformity and commonality of the charging network throughout the city. This volatility can decrease the consumer's confidence and stretch the time for installations of charging stations and can affect the growth of electric vehicle infrastructure (M et al., 2018).Also, acquiring the land to build EV charging stations in high-density cities, say New Delhi, is a huge hurdle. Getting land means navigating around a bunch of messy, time-consuming government agency approvals. Many a time developers face issues to get the land ready for an EV charging station that is compliant with zoning regulations. For instance, certain regions may face restrictive land use regulations, environmental concerns, or local resistance to the development of that infrastructure (Monteiro et al., 2024). In addition to the fact that you are only delayed to obtain the permissions and do the studies of the environmental impact, the whole process becomes more complex and longer. Any issues related to land ownership and disputes may prevent the start of a project in time and result in extensive delay in installing the charging stations. Zoning regulations often also restrict where business indulgences, like EV charging stations, can be placed, especially in residential and heavily populated city zones. Vacuum excavation challenges elevate the expenses, prolong the installments, and incorporate more financial risk for the developers (Channi, 2024).

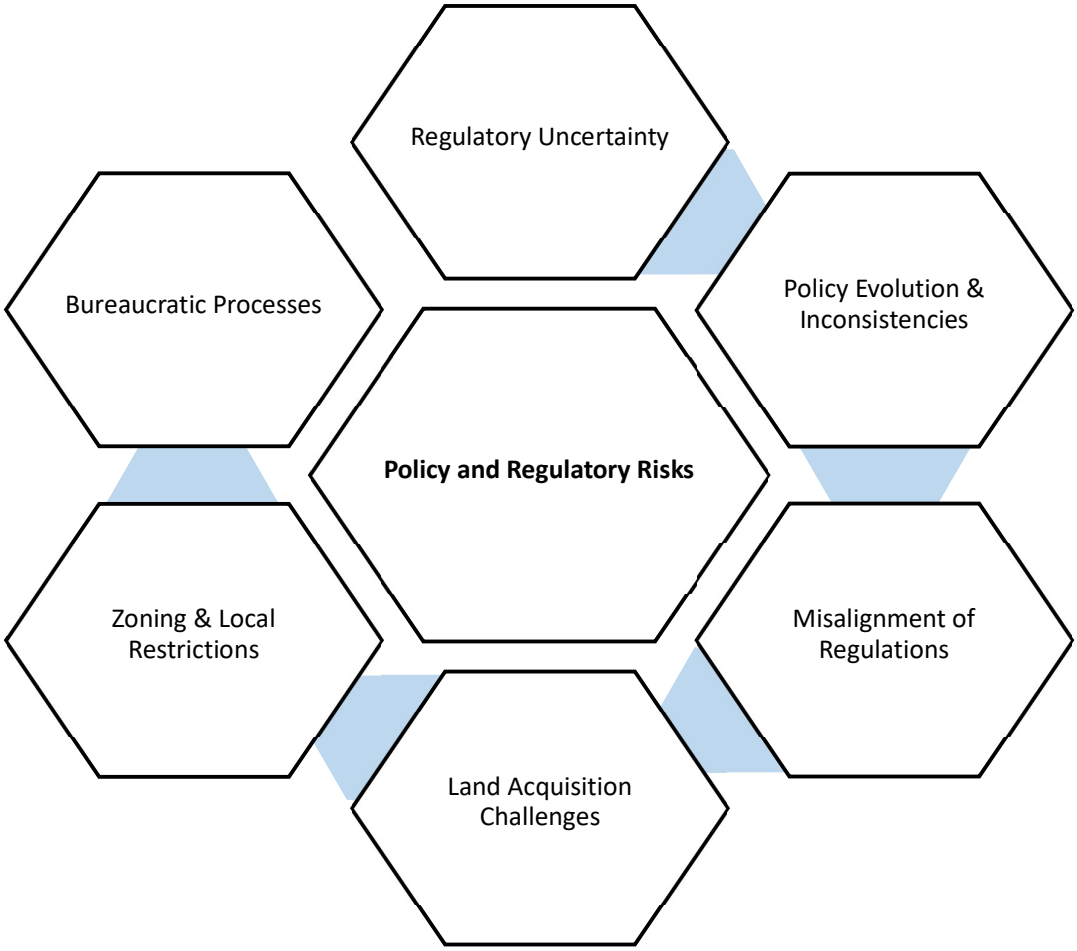

Figure 1: Policy and Regulatory Risks in EV Infrastructure

Market Demand and Utilization Risks

The financial viability of electric vehicle (EV) charging infrastructure mostly depends on two main factors. The market for electric vehicles and charger station usage rate. If the uptake of EVs does not deliver what was predicted, or if the charging stations are unused, it can lead to substantial financial losses for the developers and investors. This establishes a direct correlation between the EV adoption hurdle and the financial feasibility of the charger infrastructure deployments; New Delhi, as one of the biggest cities in the country and as a major player in the transition to electric vehicles, provides a particular instance of these challenges. While the Indian government has made considerable efforts in pushing the adoption of electric vehicles, the slow pace of EV

adoption and vagaries of consumer behavior threaten the financial viability of charging infrastructure (Vagropoulos et al., 2014).

In spite of the Indian government's efforts in promoting the need for electric mobility by way of policy measures like tax incentives and subsidies and the vision of emission reduction, the adoption of electric vehicles has been more sluggish than anticipated (Kandpal & Trencher, 2025). This is best seen in New Delhi, where even the rate of adoption of EVs has not even met the initial targets. Several factors are making it hard for the pace of transfer to accelerate. The steep upfront prices of electric cars remain a hurdle for many buyers. Even though there are subsidies and incentives available, the price of EVs remains unaffordable to a whole segment of the population. A study by the India Energy Storage Alliance (IESA) observed that electric vehicles are, верно, generally Regarding cost, when operational costs are taken into consideration over the long run, the costs are rendered much cheaper, but the ongoing price differential remains the largest barrier (IESA, 2021).

In addition, the lack of easily accessible charging facilities further increases concerns about the range of a potential EV purchaser. Although the government has attempted to make available an additional network of EV charging points, the infrastructure remains inadequate to satisfy the increasing demand of the EV market. As of 2021, New Delhi managed only about 350 charging stations, a tiny part of what is necessary to fulfill the needs of EVs with the city's quest for a cleaner mobility (MoRTH, 2021). The insufficiency of charge-postarians (i.e., charging points) contributes to consumer worries about the dependability and practicability of simply accessible conditions of the public car-providing infrastructure. This in turn influences the utilization rate of the existing charging stations, since upfront EV purchasers may put off their purchase or simply buy hybrids, which are not restricted by similar charging constraints. The slow take-up of EVs results in a situation in which charging stations operate at a fraction of their full capacity, at the expense of the investors, who have put up large amounts of capital to get these projects off the ground. For example, a case study referred to by EV Charging Solutions India (2020) pointed to an early-stage EV charging operator in New Delhi having a high-quality infrastructure put in place in well-connected areas and seeing substantial

underutilization on account of their limited base of the vehicles on the road. This misuse prolonged the time before repaying the costs, rendering the complex economically feasible only in the long term.In addition to slow adoption, the demand for charging services also depends on consumer attitude and behavior. Aside from the convenience, the willingness of EV owners to rely on public charging will depend on a number of things, such as range anxiety, convenience, and trust in the charger. Classic range anxiety concerns fear that a vehicle on electric is extended by limited travel distance and by the absence of charging stations. A study by the Centre for Science and Environment (CSE) in 2020 discovered that range anxiety was a major obstacle for the adoption of EVs in New Delhi, as consumers expressed concerns over the limited number of charging stations (CSE, 2020). Therefore, buyers are unwilling to switch and are therefore dismissed due to no access to the charging ports on their long trips. Furthermore, charging convenience and trust in the facilities are very important for consumers. Reliability of charge points, the ease of Payment and the speed of charging are key factors that will determine whether customers will use public charging stations at all. A pilot analysis for an EV charging station network for Bangalore, India (2021) revealed that EV charging stations situated in key and congested locations were utilized better but the stations not offering fast charging and witnessing the problem of uptime had lower demand (Goswamy et al., 2023). It indicates that the quality of charging station operations and user experience are just as important as the location of the charging station. The doubt about consumer behavior and demand even more impedes the ability of charging infrastructure builders to foresee use patterns and profit. According to Goswamy et al. (2023), one of the key obstacles they identified in EV is understanding consumer behavior. About 50% of the surveyed Indian EV owners in the study preferred to charge their vehicles at home over public charging points, citing it was more convenient and cheaper, the study said. This affinity for home charging does so by decreasing the number of people that are relying on public infrastructure, so therefore that hurts the profitability of publicly available charging spots. The situation becomes even more complicated due to the non-existent data on EV usage patterns as well as the charging habits of consumers. Given the low number of EVs on the road, developers may

struggle to tell how many people need charging to estimate the revenue streams that are needed to justify the infrastructure investment.Several case studies illustrate the market demand for utilization risk faced by EV charging infrastructure projects in India. For example early stages of development of EV charging infrastructure in the cities of Pune and Mumbai have shown how slow implementations and poor demand can kill them financially. In Pune, though 55+ charging inductors were installed, few would be underutilized, leading to elongated payback durations and putting the prompting of initial revenues on hold (WRI India, 2020). The slow rollout of EVs in these cities, along with public charging stations being a non-growth area compared to private charging points at the expense of consumer interest, has created significant financial strain for charging station operators. In contrast, a case study from New Delhi in 2021 offers a somewhat more positive alternative. A private developer teams up with a big retail company in order to set up the network of high-speed charging stations at the key locations. Through the additional services, which included free Wi-Fi and a premium model for moveable proprietors, the developer was capable of attracting a consistent different accessions, which increased check numbers and resulted in proceeds. Yet, this success had a precondition of a solid population of EVs in the area and the developer to make a hassle-free user experience, including on-time charging, convenient payments, etc. (Ahmad & Bilal, 2023).

Figure 2: Market Demand and Utilization Risks in EV Infrastructure

Capital Investment and Financial Risks

The growth of electric vehicle (EV) charging infrastructure is crucial for a mass-scale adoption of electricity in India, especially in big cities such as New Delhi. But building this infrastructure is a capital-intensive process, the financial risks of which are high because of the high capital cost required, long cost recovery, and the problems of commercializing finance. These fiscal hurdles need to be oversaw carefully so the EV charging setting is established and maintained meanwhile. This chapter looks at the financial risks involved with installing EV infrastructure in New Delhi in terms of the highest capital cost, lengthy payback periods, and difficulty in securing sufficient finance.

At the same time, it underlines the influence of sluggish EV uptake on the viability of charging stations and showcases facts and instances that demonstrate the hurdles encountered by developers in New Delhi and other metropolitan sites (Sunanda & Parchure, 2025).

Installing charging stations for EVs in New Delhi requires a substantial upfront investment of capital. This consists of the cost of land acquisition, installation of charging equipment, connecting to the grid, civil works, and adhering to local standards. For a city like New Delhi, land acquisition is one of the major expenses. Finding suitable locations for charging stations is often problematic, in particular in commercially and frequently used areas and subsequently the land prices in these areas are out of reach. Furthermore, the installation of fast charge stations that are designed to replenish electric cars in under 30 minutes entails top-notch and pricier hardware capable of handling the high-power requirements of urban areas. The India Energy Storage Alliance (IESA) reports that the cost of setting up a single fast-charging station in India goes between ₹10 lakh and ₹50 lakh based on location, power requirements, and use of chargers (IESA, 2021). Additionally, integrating grid power supplies to ensure the charging stations have sufficient electricity required another layer of cost, especially if existing power infrastructure needed upgrading to allow for the higher demand. In conjunction with these physical infrastructure expenses , builders of locations in New Delhi must even address municipal guidelines and environmental studies, in addition to protection criteria, as well as the extra energy expenses that normally add to this cost. Since developers are out a lot of money in the beginning, they take a substantial financial risk, as any delay in ROI jeopardizes the entire project. High initial expenses make it difficult to optically develop synthesizer understanding of hedging infrastructure metaphors and rolling waistlines without defined directional subunits and occupation rates. For instance, the Delhi Electric Vehicle Policy 2020 set a target of setting up 18,000 charge points in the city by 2024. Although this bold plan has received some government incentives, the costs are so high that the implementation of such infrastructure has been slow to take off. The slow uptake of EVs and low consumer awareness of electric mobility have helped deter private sector developers from entering the charging market with full

enthusiasm. So a great deal of debt hangs over developers from the government-supported installation and despite that, any new developments are currently expanding much slower than expected (Ahmad & Bilal, 2023).

However, there is another main financial risk in the creation of the EV charging infrastructure: a long payback period till the initial costs. Profitability of charging stations is also heavily influenced by the frequency of usage, which, in turn, is correlated to the adoption rate of electric vehicles. With the pace of EV adoption in New Delhi slower than expected, charging points may remain underutilized for a long period amounting to several years and therefore stretch the payback period and delay return of investment. In New Delhi, developers may call 5-10 years to recover the costs of establishing a charging station. It is additionally compounded by the operational expense of operating a charging station, like energy costs, upkeep and maintenance, staffing and the cost to change outdated hardware since innovation is continually refreshed. Not to mention the heavy and long adoption pace; the charter with regard to future demand for EV charging services might be difficult, which in turn restricts to foresee the usage pattern to retain profitability. If the stations don't reach the anticipated usage levels, there could be a funding problem for the project. Slow progress of electric cars in Indian cities such as New Delhi is not unusual. Similar issues have been seen in the other cities like Pune and Mumbai (Ahmad & Bilal, 2023). WRI India was also referenced with a report stating that charging stations in Pune initially faced low EV traffic to charge points, resulting in longer payback periods and financial losses due to underutilization (WRI India, 2020). In Mumbai, many investments in stations remained unpaid for years since they failed to get a large number of vehicles, ultimately facing the problem of financial stress. These cases demonstrate the financial strain that can be caused by the slow progression of EV adoption, which, particularly in scenarios where remaining undissected for a long time and then unfused, then resulted in occasional underuse of the charging infrastructure. Besides the slow growth of EVs, the financing of big EV charging infrastructure projects is a major issue. Though some government incentives, including the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, are available to tempt walk-in prospective customers to charge at EV charging stations, these incentives rarely

are sufficient to meet the full upfront capital costs of setting up the charging stations. Followers, henceforth, have to rely on private money to fund their ventures. However, borrowing money typically involves loans that impose high interest rates and financial burdens on the developer. On top of this, the absence of specific financing vehicles for EV infrastructure development worsens the issue, with traditional financial institutions being wary of putting money into a sector yet in development. Private developers in New Delhi have faced difficulties in securing funds at competitive rates because of the reluctance of financial institutions to bear costs and risks associated with financing large-scale infrastructure projects. This absence of ordered financial aid has hindered the fast development of charging stations, despite the Delhi government's lofty expectations (Kore & Koul, 2022).

Some private developers have looked at alternative financing options such as public-private partnerships (PPP), but these have not taken off as quickly in New Delhi. PPPs are a means of risk mitigation and resource sharing but they also need good governance and management, which has been feebly done. The plight of securing sufficient funding has restricted developers from expanding their businesses and hence, it has delayed the adoption of charging infrastructure for electric vehicles. As the government keeps pressing for electric mobility, it will be essential to work out more robust financial models and structures to ensure the growth of the charging infrastructure network in New Delhi and across the country (Sabyasachi et al., 2024).In total, the construction of EV charging infrastructure in New Delhi is in full danger financially as well, mainly because of high initial investment expense, lengthy payback periods, and difficulties financing. The big upfront costs associated with the acquisition of land, the installation of the system and grid integration and regulatory compliance are a big cost to a developer. Additionally, the sluggish adoption of electric vehicles (EVs), in addition to the underutilization of charging stations for the first several years of operation, greatly increases the payback period, which makes it challenging to achieve any profitability reasonably soon. The inadequate financing structures, together with high expenses for private investors, make it more difficult to address these factors (Sunanda & Parchure, 2025; IESA, 2021; Ahmad & Bilal, 2023; WRI India, 2020; Kore & Koul, 2022; Sabyasachi

et al., 2024).Then, the developers must tactically identify charging stations, the optimal operation of efficiency, and engage consumers to increase the utilization rate of the station. Furthermore, the government needs to enhance the financing options by offering low rates of interest on loans, broadening subsidy schemes, and empowering public-private partnerships. The long-term sustainability of EV charging infrastructure in New Delhi along with the electric driving system depends on successful financial solutions to these challenges (Sunanda & Parchure, 2025; IESA, 2021; Ahmad & Bilal, 2023; WRI India, 2020; Kore & Koul, 2022; Sabyasachi et al., 2024).

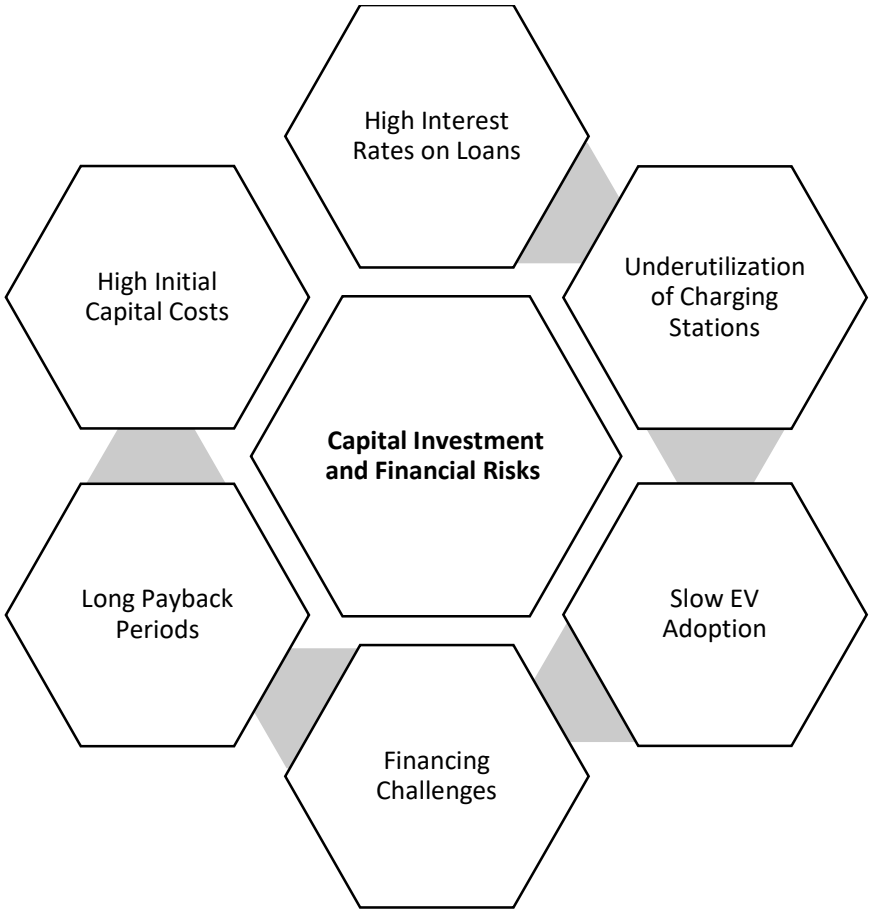

Figure 3: Capital Investment and Financial Risks in EV Infrastructure

Technological Advancements Risks

The rapid advancement of electric vehicle (EV) technology and charging infrastructure poses a significant challenge for engineers: this swift innovation brings considerable functional risks related to both technological obsolescence and apparent competitive issues. As charging technology develops, then current infrastructure might also become obsolete, risking extra bucks to upgrade or exchange. Current charging stations are expected to become obsolete because ultra-fast charging and wireless charging and new efficiency standards for EV chargers are developing the market (Ahmed Taher Zentani et al., 2024). Developers putting money into charging networks need to take into consideration the uptimes of today's know-how and anticipate the shifts in industry standards. Not doing so would lead to stranded assets and great financial resources needed to modernize or replace obsolete facilities. However, as an example, the upgrade from Level 2 standard chargers to high-power DC fast chargers highlights the financial burden that fast technological progress causes on infrastructure developers. Stakeholders remain at risk of obsolescence because a flexible design alone cannot guarantee future-proofing without an explicit strategy in place (Zentani et al., 2024).

The development of EV charging infrastructure faces more difficulties when compatibility issues arise. People buying EVs today face various charging port types, like Combined Charging System (CCS) and CHAdeMO, as well as Type 2 connectors, since each car maker works in different areas based on research by Das et al. (2019). New vehicle model releases in the growing EV market might create supplementary charging standards or adapt existing standards. Charging station operating costs increase and profitability decreases for stations requiring costly device modifications to support different EV models because of a single connector system (Nienhueser & Qiu, 2016). Large infrastructure projects need to monitor vehicle technology evolution because the compatibility issue impacts their daily operations. However, while universal adapters used with multi-standard charging stations lower risks, they also introduce additional financial costs that create challenges (Safa Hamdare et al., 2024). The developers build perfect charging systems to cover sustainability while achieving economic stability, doing this because of the continuing innovation of EVs.

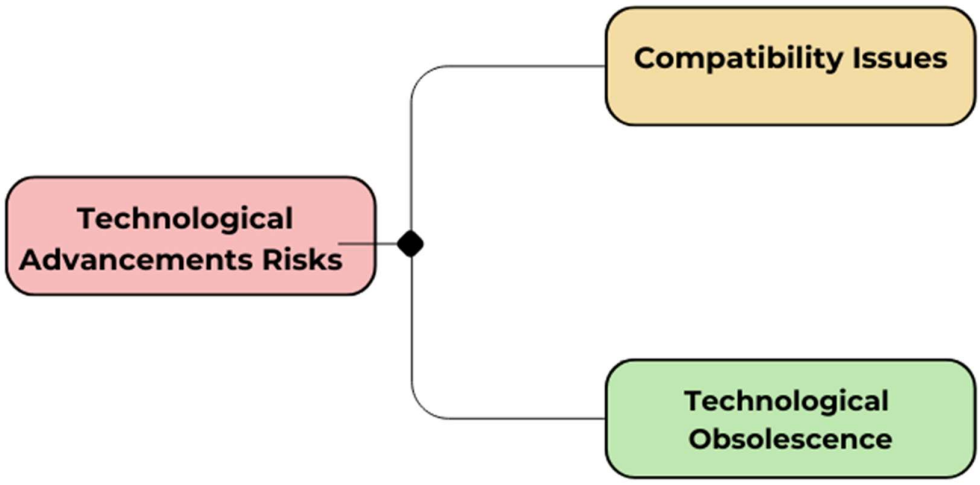

Figure 4: Technological Advancements Risks in EV Charging Infrastructure

Grid Integration and Power Supply Risks

However, among key developments for EV infrastructure is the inclusion of electric vehicle (EV) charging units into the existing grid. New Delhi's power grid, which is undoubtedly robust but may struggle to accommodate the new load of a growing number of EV charging stations. The higher the required level of charging services, the greater the load on the grid, especially during peak hours. The growing need might require upgrades to the grid that are expensive and resource intensive. In some cases, general electric deficiency can cause unavailability for charging stations, diminishing their reliability and impacting the respective customer experience. To address these challenges, smart grid technology, together with the interests and necessities of demand-based management strategies, can assist in boosting power distribution and speeding up the power grid. In addition, there are techniques for smart network load balancing and off-peak incentives can achieve that, which can be done without charging stations to charge the significant infrastructure upgrades (Singh et al., 2024).

Another major issue is voltage and stability of charging stations, as electric vehicles require consistent and uninterrupted power while charging stations require stable and continuous power to enable the user to charge their vehicle quickly and efficiently. Power surges, voltage changes, or frequent blackouts can work against the charging

stations, leading to potential losses for the investors (Thangaraj Yuvaraj et al., 2023). Overreliance on the grid can also cause downtimes in instances where power supply is stopped, especially in places where power outages are often experienced. To mitigate these threats, using renewable energy avenues like the solar-powered charging station as well as the battery energy storage system (BESS) can enhance the grid and make it more resilient and decrease its dependence on the traditional sources of power. In addition, incorporating V2G technology can facilitate bidirectional energy flow, at peak hours with excess EV power that can be fed back to the grid, making up grid stability and its functioning better (Shinde & Verma, 2020). As New Delhi advances in building out its EV infrastructure, integration of advancements in technology, regulatory structures, and a smart-grid approach through strategic investment will become necessary for constructing a well-wheeled and effective EV charging environment (Singh & Sandeep Bhongade, 2024).

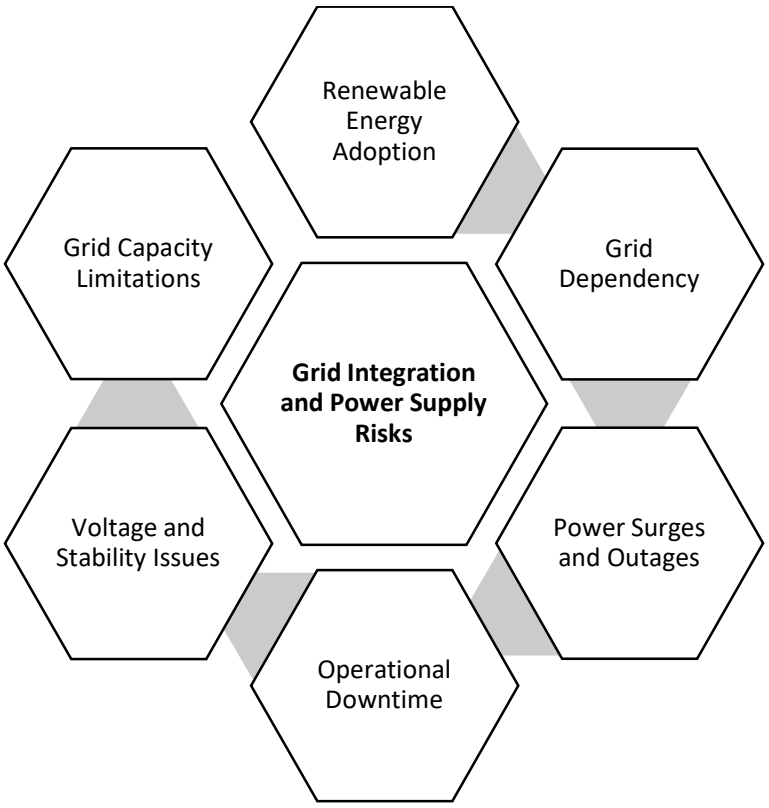

Figure 5: Grid Integration and Power Supply Risks in EV Infrastructure

Operational and Maintenance Risks

Once the electricity delivery infrastructure for EV charging stations is developed, operating and maintaining the infrastructure involved several issues related to profitability risks. One of the key concerns is maintenance expense, which is necessary to keep charging stations running and meeting client expenses. Constant maintenance is also necessary for charging gear, electrical components, and other associated infrastructure to have. If maintenance is not done, charging stations can be unproductive and can result in lost revenue and harm to the service provider's reputation. Moreover, unforeseen maintenance issues such as fixing or replacing a faulty charger, software updates, or addressing the wear and tear can substantially upsurge the operational cost. These expenses can add up and eventually compromise the cost-effectiveness of running charging stations. Additionally, environmental aspects like harsh weather conditions can worsen this trouble, so increasing maintenance needs. As technology improves, older hardware might need expensive upgrades to stay compatible with newer EVs, adding one more strain to the budget (Rezaei & Peng, 2024).

Staff and operational expenses also are major factors in the economics of EV charging stations. Proficient personnel to handle customer service, technician support, and operations are required for excellent charging station management (Fescioglu-Unver & Yıldız Aktaş, 2023). In certain instances, on-site personnel may even be needed to help agree on the troubleshooting solutions, adding more costs to the staff. Further, as with the growth in the number of EV users, there is the expectation that demand for customer support service will grow, so too will resources. Also, another great cost factor is power consumption, which takes a large part of the operating cost. Electricity prices and peak demand charges can cause unexpected variations in the overall profitability. On the other hand, operational costs of network management, cybersecurity, etc., also result in financial risks. Consider cybersecurity threats, as payment processing, updating of software, and real-time monitoring all rely on digital connectivity of the charging stations. A cyberattack could bring down operations, leading to financial penalties and harm to an organization's reputation. To survive in the long term, there is therefore a

need to ensure a balance between efficiency and fairly paced charges spent on EV charging infrastructure (Pourmirza & Walker, 2021).

Figure 6: Operational and Maintenance Risks in EV Infrastructure

Environmental and Social Risks

The electric vehicle (EV) infrastructure development is shaped by a variety of environmental and social factors, primarily in a densely populated and eco-sensitive area like New Delhi. One major environmental IO consideration is following very strict environmental rules. New Delhi is having bad air quality and any development project needs active environmental compliance. The city has a very stringent approach to emissions and air quality improvement policy and all the EV infrastructure projects to

meet these environmental regulations. Developers need to obtain required environmental clearances, conduct environmental impact assessments, and get done with minimal effect on the existing ecosystems. Ignoring these regulations can lead to the postponement of projects, charges, or even the spot cancellation of projects, badly damaging the viability for expansion by building out EV infrastructure. Also, land is a major issue in New Delhi, where the space for the city is not very available and land use is highly regulated. Finding suitable spots for charging stations but not at the cost of current land usage remains a problem for policymakers and independent investors (Fajar Nurrohman Haryadi et al., 2023).

Yet another key component of the EV infrastructure project's success rate is social acceptance. Public perception also naturally has a very important role to play in how effectively and widely charging stations are used and accepted, so local communities might resist new stations from being installed if they are worried about them straying over land usage, concerned about detrimental electromagnetic wave emissions, or simply imagining a danger. Community public backlash can lead to cost increases and time delays of a project, as developers must carry out their community outreach and negotiation prior to approval (Moh. et al., 2024). Besides this, good governmental support and incentives can also shape public perception by bringing out how many advantages there are to EV infrastructure, which are reduced emissions and urban sustainability (NITI Aayog, 2021). Promoting equitable public artery charging to cherish palms in unusual general public socio-economic classes along with adding solid public acknowledgment, resembling specifications that make an ecosystem. In general, resolving these environmental and social problems is crucial to the successful execution of EV infrastructure projects outdoors in New Delhi, which needs a joined-up strategy from government departments, company groups, and local people (Moh. et al., 2024).

Figure 7: Environmental and Social Risks in EV Infrastructure

In summary, the infrastructure for charging electric vehicles (EV) in New Delhi is exposed to significant risk across a number of areas, which can markedly delay progress. Policy and regulatory risks are challenged because of expansive changes in government incentives, import tariffs, and local zoning legislation, which are interruptions to projects against the regular schedule and the cost. Additionally, challenges in land acquisition and zoning issues prolong charging station development. Market demand and utilization risks are mainly driven by low EV adoption, with high charged battery prices deterring the potential buyers. Poor utilization of charging stations, linked to low EV penetration in the market, leads to financial stress and reduces the payback period, compounded by consumers' preference for home charging. Additionally, capital investment and financial risks are considerable because the costs of land, capital spending, and grid integration

are all high, concentrating the financial deployment of large-scale infrastructure. Slower EV adoption further stretches payback periods, while financing challenges, including excessive-interest loans, raise further pressure. Technological progress brings the danger of obsolescence, because the quick development of charging technology could result in backward-consistency issues, forcing owners to spend money on updating to keep their habits on top of changing standards. Additionally, grid integration and power supply risks are high, as New Delhi's grid may overstretch fulfilling increased loads from EV charging stations during peak hours. This might necessitate the costly upgrading of the grid. Power surges or outages can impact station reliability. To reduce these risks can be done with integrating V2G technology, smart grid technologies, and renewable energy sources for grid stability. Operational and maintenance risks are substantial; moreover, huge losses on maintenance, high staff, electrical power consumption, and cybersecurity-related stability influences unreliability (Hua et al., 2021; Sun et al., 2022). Environmental and social risks increase the complexity; adherence to strict environmental regulations and land acquisition in a densely populated city, herein referred to as New Delhi, has posed significant concerns. Public existence often proves on earth that land use and safety might shutter projects, although government offers and equitable connections to infrastructure can remedy perception of the public and extend adoption. Innovative strategies for a holistic benefit discussion through implemented technical innovations and citizen tracking are necessary for the successful and prospective implementation of a public electricity charging system in New Delhi.

Of the numerous threats associated with the deployment of electric vehicle (EV) charging infrastructure in New Delhi, financial threats appear to be the greatest and most urgent. The focus of this study is on financial risks, as they are one of the significant obstacles to setting up or upgrading EV charging networks, especially in a densely populated city like New Delhi. Financial barriers are present in some form; otherwise, installation and operational costs are high, whereas there are uncertainties regarding the return on investment (ROI) and securing sufficient finances for big infrastructure projects. These costs impede widespread EV charging network development, which is indispensable to the growth of the EV market in India.

The large initial investments required to install an auto charging station are among the biggest financial hazards. The development of the charging infrastructure, including the acquisition and installation of the charging units, site preparation, and grid. These costs are further magnified in New Delhi by land acquisition, which is a complex and very costly activity due to the limited availability of land in Delhi. In addition, fulfillment of environmental rules and local building permits would also contribute to the ecological and financial burden. Hence, private sector investors and corporations may be reluctant to invest in projects such as these without based financial incentives or a solid return on investment.The unpredictability of return on investment represents a crucial financial risk. Due to being in its early development phase in India, the market for electric vehicles creates a significant amount of doubt regarding long-term charging station demand. EV infrastructure represents a market that displays unpredictable volatility because new companies face trouble predicting their possible revenue streams. The substantial financial requirements concern investors because the benefits may take multiple years to recover. Charging station operators also encounter unique challenges with regard to forecasting a return on investment because they encounter changes in electricity costs and subsidies, as well as changes in behavior by consumers about their usage.Public-private partnerships must be implemented for EV charging station development because they involve significant financial risks. The high cost of building infrastructure explains why governments usually join forces with private companies to spread the financial responsibility of these projects. Obtaining partnerships has its own set of challenges. Public-private partners are facing a long-time negotiation and time-taking process. The government needs time to come up with the incentives that are compatible with private needs. The lack of standard regulation of the joint venture between governments and private entities in New Delhi makes for more confusion. Sufficient financial models are necessary to avoid imminent failure in case of installation of the charging stations.

Such a business structure of operating EV charging stations is associated with a high level of economic challenges for engineers. The cost of electricity, along with personnel and maintenance costs, underpins the profitability of EV charging operations. The operating costs of the grid and charging system go up when obsolete infrastructure or charging

technology contributes to increased use of energy and increased maintenance requirements. The goal of any charging network stability is to ensure normal passenger flow; however, this is hampered by ongoing financial expenses as demand development does not keep pace with projections.

Financial risks pose the greatest hindrances to the development of New Delhi's EV charging infrastructure. The successful implementation and deployment of charging infrastructures in the city has to overcome these issues through a strategic planning of the financial requirements and the government's financial support offered through collaboration initiatives. In New Delhi, sustainable urban mobility can be achieved through investment of resources in financial risk assessment and mitigation along project development.

2.2 Types of Projects and Role of Project Manager

The Globally the shift towards Electric Vehicles (EVs) in India has gathered pace owing to concern for environmental sustainability and to decrease carbon emissions. New Delhi, the capital city of India has been witnessing a growing need for Electric Vehicle Charging Infrastructure (EVCI) projects to support the rising automobile of EVs on the road. In this scenario, knowing about the kinds of EV charging infrastructure projects and the function of project managers to deliver them is critical for assuring sufficient installation and growth of EV stressing terminals (Li, 2024).

This literature review the various types of projects being undertaken for the development of EV charging infrastructure particularly with focus on New Delhi and roles and responsibilities of the project managers in these initiatives. It outlines the main duties, problems and approaches that are needed to carry out effective project administration within EVCI.

Types of EV Charging Infrastructure Projects

The creation of an electric vehicle (EV) charging network is crucial for the switch to electric cars. In a city like New Delhi, where urbanization is happening at a fast pace and air pollution is getting increasingly serious charges, the city needs to have a strong EV charging infrastructure. These projects can be separated into four principal types: public charging points, home charge points, rapid charging networks, and workplace charge points. Each discipline presents its own specific requirements of technical, financial, and logistical, each of which the project managers must handle during the phases of planning and execution (Unterluggauer et al., 2022).

Installing electric vehicle (EV) charging infrastructure is crucial to promoting electric transportation in the New Delhi poll-choked, traffic-strained nation. Public charging stations, home charging products, fast-charging networks, and workplace charging facilities all contribute to a total proposition that allows electric mobility to become more accessible and user-friendly for the city residents. Public charging stations, commonly in high-traffic locales such as shopping centers, government buildings, and highways, are the most seen and straightforward kind of charging infrastructure. The Delhi government has put in a lot of money to amplify the network of these stations to satisfy that booming demand for EVs (Kumar & Bansal, 2021). All these stations come with slow and fast chargers, and as an EV owner, you can charge your car with either option as per your convenience. Whereas slow chargers provide a full charge in a few hours, fast chargers give it in half an hour to a couple of hours (Mastoi et al., 2022).

However, several obstacles stand in the way of installing public charging stations. Buying property in very populated spaces like New Delhi is an elaborate and lengthy process. On top of this, getting permits and ensuring that the electrical grid can support the extra load have turned out to be big challenges. Installation of these stations is likewise subject to safety and environmental rules; therefore, project managers experience numerous logistical and technical worries. Public-private partnerships (PPPs) are commonly utilized for these resources, where the government combines resources along with private companies for cost and responsibility. Apart from enabling the

efficient operation of projects, this model also enables the laying of accessible charging stations for the public (Unterluggauer et al., 2022).

On the other hand, home charging solutions are becoming an increasingly important part of the broader EV infrastructure, providing EV owners with a more convenient option. These charging units are usually installed in residential areas, including individual houses or apartment complexes, and are easier to install than public charging stations. Although minimized regulatory and land acquisition challenges, home charging solutions attended solely to reliable electrical grid connectivity and suitable infrastructure. As a public station is coming up at a place with very few individuals, if not even any persons/commerce, in such a scenario, when is an open place available to put a module that is at a public place, like a mall, college, office, etc.? Coming to the current topic about the Indian market with decent population density, low cost allows owners to charge vehicles overnight and lower, of course, than any public charging stations. The change to home charging is a trend that is increasing with support from many of the EV manufacturers and private companies offering bespoke installation services. The comfort and flexibility that home charging provides make it an essential part of New Delhi's broader goal to convert into electric mobility (Usman et al., 2024).

The emergence of fast-charging networks and workplace charging facilities adds to making EVs more feasible and attractive for daily usage in New Delhi. Fast-charging stations are built to charge cars quickly, usually in 30 minutes to an hour or so, using higher voltage and more cutting-edge technology. These networks play a significant role in long journeys and city-to-city transport, particularly in congested cities like New Delhi, where time effectiveness is very required. Especially if they are high-usage vehicles in the electric car fleet, such as electric buses and fleet vehicles for ride-sharing services, which are treated as essential parts of cities' e-vehicle infrastructure because when they are in the fast-charging station. But the creation of those networks requires substantial investment in specialized technology and upgrades of the city’s electrical delivery system to accommodate the higher level of consumption of electricity. These developments require project managers to manage and keep the fast-charging stations

scalable, reliable, and performing at a level meeting the needs of the growing EV user base. (Sharma & Aggarwal, 2022).

Workplace charging points are another key component of the all-important county EV infrastructure jigsaw. The facilities, often located in office parking lot areas, serve employees who are likely driving to and from work in EVs. In New Delhi, many private sectors, particularly those in the IT and service sectors, are pioneering the way by installing these stations to encourage the employees to shift to EVs. Workplace charging is a way to better support the corporate sustainability objectives and lower the carbon footprint of organizations. It also supports the overall drive toward electric mobility with practical as well as convenient charging solutions on the job site. For project managers, workplace charging projects require managing across multiple stakeholders, such as facilities management, electrical engineers, and utility providers, to make them fit in with the existing electrical infrastructure. The installation and the maintenance sites are normally offered by the companies, while the government subsidies and incentives might contribute to reducing the monetary burden (Sarda et al., 2024).In conclusion, building EV charging infrastructure in New Delhi is a complex process of design and step-by-step implementation. Public charging points, home charge solutions, fast charging networks, and workplace charging facilities each help the adoption of EVs in their own way. Project managers need to address the challenges associated with each of these project types and thus deliver results, products, or services on time, on budget, and to regulatory standards. These infrastructure projects will be critical to the creation of a sustainable, easy-to-access future for transportation as the city of New Delhi moves towards its electric mobility aspirations.

The Role of Project Managers

The electric vehicle charging infrastructure (EVCI) in New Delhi is a challenging and multifaceted process and requires project management during all stages. The primary responsibility of a project manager would be planning & feasibility analysis of the project. That means site selection of a charging station, a full site survey, socket load calculation, and assessment of electrical grid capacity to fit additional load. The manager must also

work with local authorities, utility companies, and urban planners to ensure integration into the existing urban environment. This work in collaboration is critical to ensure that the infrastructure is matched to both city needs and regulatory requirements. This, for example, is the case for Delhi, where the Delhi Electric Vehicle Policy (2020) sets out clear guidelines for public charging post installations that project managers need to keep in mind during the planning phase (Knowles, 2013).

Additionally, the successful implementation of EVCI projects requires effective coordination among various layers. Since these projects involve numerous parties such as government entities, utility suppliers, and electric vehicle manufacturers, the project manager must serve as a primary communication point. He must even juggle the conflicting interests of all of the stakeholders when signing contracts, funding the project, and maintaining relationships, especially in public-private partnerships (PPPs). This kind of coordination is very important, particularly for massive undertakings such as fast charging a massive or quite a lot of public charging stations. In addition to coordination, project managers must assume the responsibility of budgeting and finance management. Controlling the capital-intensive nature of these projects requires providing detailed Excel formulas for usage and budget setup, matching a sponsorship or funding plan, and making sure of the most effective utilization of financial resources for the total lifecycle of the project. However, in New Delhi, the funds are usually funded by government subsidies and private investment and there are incentives that are primarily industry funds that manage these projects and ensure transparent monitoring and reporting of funds (Midler & Navarre, 2007).

Risk management is also a key function of the project manager in the course of EVCI projects. Much like with any massive infrastructure project, the growth of EV charging stations in New Delhi has its risks, including anything from technical failures and delays to regulatory and financial issues (Mousavi et al., 2023). Project managers must detect possible risks as soon as possible and build risk mitigation tactics to minimize their effect. Additionally, the question of the application of cost-compliant elements, at least for charging network projects, is that network reliability of the technical scalability of

meeting growing demand is considered and solved carefully. By foreseeing these challenges, project managers ensure the long-term sustainability of the infrastructure and help the city go electric (Midler & Navarre, 2007).

Additionally, regulatory affairs and environmental concerns are of top priority in New Delhi, where environment and sustainability play a major role. The charging infrastructure has to comply with the government regulations, such as government norms and the Delhi Electric Vehicle Policy (2020), said project managers. This includes hitting installation targets, integrating renewable energy as and where practicable and reducing environmental impact. Moreover, the manager of the project also makes sure that the charging stations follow safety rules and environmental laws so they can participate in a sustainable urban mobility system (Mousavi et al., 2023). Lastly, to the point that once infrastructure is placed in the project director's firearm, a vital quality control and practical application troubled role. This involves managing the performance of the charging stations to guarantee that they are meeting up with the agreed uptime and operational efficiency and to solve customer issues. In New Delhi, performance is measured through digital platforms that provide real-time data on the availability of charge stations, which therefore guarantees the maximum service delivery (Midler & Navarre, 2007).

In conclusion, for the successful conclusion of EVCI projects in New Delhi, project managers play a key role in their development. Ranging from planning and feasibility studies, stakeholder management, budgeting, risk management, and performance monitoring, project managers assure successful distribution of charging infrastructure. Although New Delhi is only just beginning to develop its EV ecosystem, project managers will be crucial in identifying challenges and ensuring that the city’s transition to electric mobility is both smooth and sustainable.

2.3 Theoretical Framework

The PESTEL framework was initially stated to be PEST analysis in the early 1960s by Francis J. Aguilar (1967) and after that, it was, it was developed to incorporate natural

and legitimate factors. The model provides a structured approach to forecasting and identifying the macro-environmental forces that affect any organization so that strategic decisions can be construed on knowledge of those wider external factors.

PESTEL analysis is mainly employed as part of an environmental scanning process to find out and document external elements that could impact the organization. These variables can be grouped into the six categories:

Political factors comprise the effect of government policies, regulations, political stability, tax policies, and trade restrictions. Stability of the political system or political stability, is very important for corporations because an unstable political environment can lead to risks for corporations like expropriation, sudden changes of policies, and changes of the tax laws, which can affect the aspirational future for a business. Additionally, such as inflation rates as well as economic growth rates, interest rates, exchange rates, and business strategies, form for many years. For instance, a recession may alter the consumer behavior and so impact the demand for products and services. Also, changes in interest rates can have an influence on the shipping company budget. Social factors are demographic, cultural, lifestyle, social, and consumer attitudes and trends. These factors massively influence the consumer spending behavior and companies should be aligned with these shifts in social preferences. Sustainable living is another illustration; the rising behavior has surged the call for eco-friendly products (Kotler & Keller, 2016). Technological advancements, for example, innovations in digital and automation technology, innovation, and development, have a significant impact on the business world. The advent of technologies that are like artificial intelligence, blockchain, and big data analytics in their adaptation to all fields of business has strongly transformed operational actions by bringing forth the heights of speed and the efficiency of the proposed strategies, opening up at the same time more difficult challenges (Christensen, 1997). Also, environmental factors, which comprise the ecological matters, for example, environmental issues, ecological provisions, ecological dependability concerns, and natural resource limits. Today, businesses have to face the institutional pressures to reduce their carbon footprints and environmentally conscious practices to comply with environmental regulations (Porter & Van der Linde, 1995). Also,

legal factors include the laws and regulations that the businesses operate on at all the applications, including labor law, consumer protection law, intellectual property, and health & safety regulation. Compliance with legal rules is vital so as to stay away from legal lawsuits, which will intrude into organizational activities (Friedman, 2017).

2.3.1 PESTEL Analysis for Finanicial Risk Assessment

Electric vehicle (EV) charger infrastructure development is a crucial part of the country-wide transition towards environmentally friendly transportation and widespread usage of electric vehicles (EVs). Since the path of the traditional internal combustion engine cars' shift to electric vehicles (EVs) is gaining speed, creating reliable and available charging infrastructure is very important to support the number of EVs growing on the road (Weber et al., 2018). But there is no plain sailing for EV charging station deployment in terms of financial hurdles to regulatory roadblocks. PESTEL (political, economic, social, technological, environmental, and legal) analysis, an organized framework to examine the macro-environmental circumstances impacting the achievement of infrastructure projects, helps investigate and can conquer these challenges.

PESTEL analysis serves as an effective tool. Political factors that can influence the development and expansion of EV charging networks include government policies, incentives, and political climate. The financial viability of such projects is largely influenced by economic suspects answering for installation cost, long-term profitability, and possible investment risk. Social factors like co-public perception and the will to leap to EVs decide the demo and suggest the price of charging points and their to-be-situated rate (Kumar, 2024).

Technological progress is also significant in the growth of EV charging infrastructure, as combined with the integration of changing technologies and smart grid systems, efficient user experiences for charging systems. Environmental effects, especially with regard to shortcomings of the power probes used in EVs, affect long-run prospects of the transition to electric propulsion. Legislative frameworks, for instance, land acquisition specifications, zoning ordinances, and government motivations add to the procedure of development and upkeep of EV charging foundations (Chen et al., 2020).

This literature review is specifically confined to the financial and regulatory risks faced in the development of EV charging infrastructure, which are core findings from the interview questionnaire for this study. Main problems highlighted include investment obstacles, acquisition processes for land, and availability of government incentives, which, upon processing, can be a hindrance or a facilitator to such projects. By conducting a PESTEL analysis of these factors, this review aims to identify strategies that can help bypass the barriers to the successful operation of EV charging networks.

Political Factors

Political elements significantly influence the development trajectory of Electric Vehicle (EV) charging infrastructure. The expansion and operation of EV charging stations heavily depend on the government policies that exist in the region. Political backing, especially via subsidies, tax benefits, and direct investment, is needed to deal with financial worries related to building up and installing charging infrastructure (Singh et al., 2022). Cohen and Kietzmann (2020) declare that political support serves as an essential factor since it reduces setup expenses, thus enabling both private and public organizations to start investing in infrastructure development. At its biggest, government can enhance the attractiveness of EV charging infrastructure with friendly policies that seduce long-term expansion and sustainability.

At the same time, the political landscape often establishes formidable obstacles to navigation. The combination of unstable political conditions and weak policies works as barriers that prevent the private sector from investing in EV infrastructure, primarily in rising economies. When the policies are unclear or frequently changing, then the investors may be reluctant to devote resources, worried because it will be taken that the ultimate reprieve of their investments might possibly reduce because new regulations constitute the whole desired government attention. The inconsistency of political support creates a situation where project stakeholders cannot properly plan or carry out mega infrastructure projects (Singh et al., 2022).

For the development of EV charging infrastructure, political stability and strong government support are essential prerequisites for reducing the risks associated with

funding and investment programs, enabling these projects to become financially viable. Lack of political will or bad policy changes may also meet regulatory status capable of causing delays in approval or restructuring compression of compliance with changing standards. The continuous changes in financial prospects of these projects, coupled with public doubts about their reliability and availability, will work against the wider adoption of EVs (Singh et al., 2022).

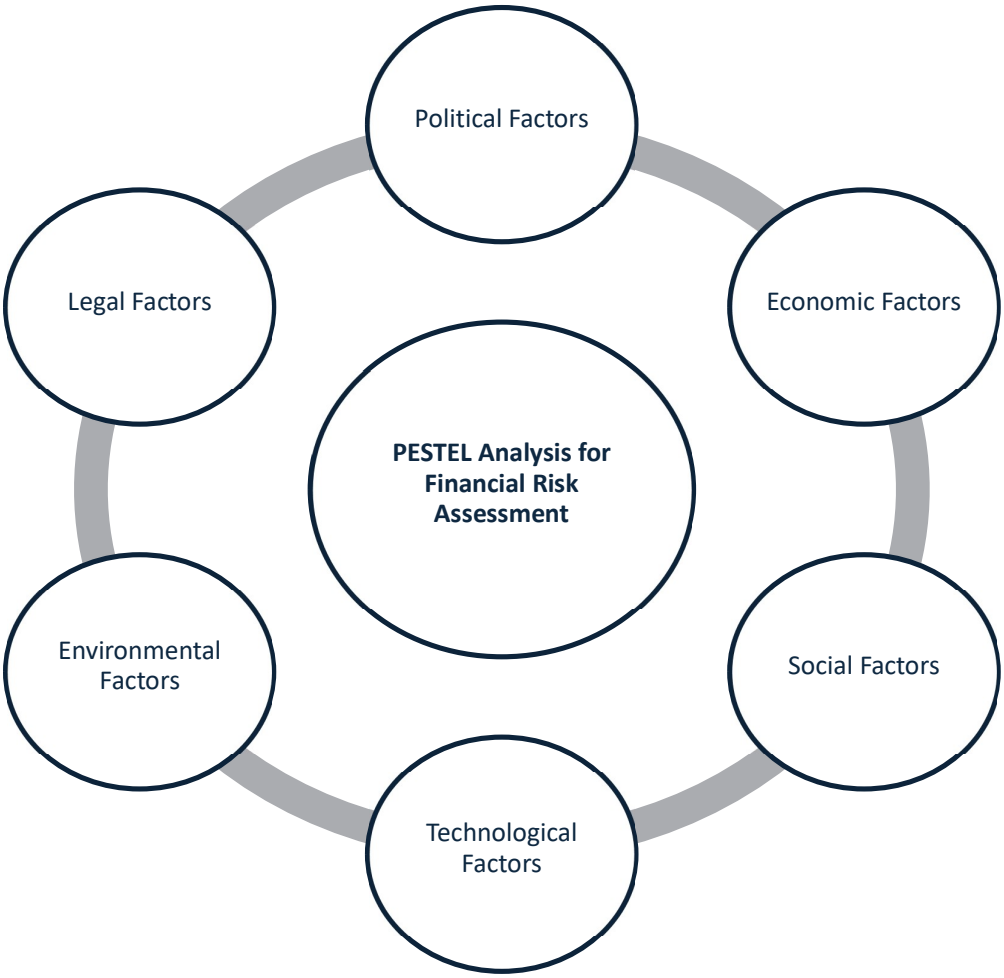

Figure 8: Financial Risks Associated with EV Charging Infrastructure Development

Economic Factors

The success of electric vehicle (EV) charging infrastructure projects depends heavily on three main elements: the initial capital outlays and long-term return on investment (ROI)

together with the market adoption of electric vehicles. One of the main financial problems of this industry is that the high installation cost of charging stations constitutes most of the financial troubles for stakeholders in this sector. While it will require a substantial initial capital investment to construct EV charging infrastructure, this cost can be recouped from increasing vehicle requirements to travel more miles. Suppose somewhere between 1.5% and 2.0% of all current cars are electrified; the long-term return on investment for investments in EV and EV-type filling up is a lower expenditure on materials, corresponding to perhaps 5000 times the outlay originally embedded in the infrastructure. The growing uptake of electric vehicles creates a dire necessity for, more expensive charging infrastructure that will drive financial gains for investors (Goel et al., 2021).

Social Factors

Social factors, such as consumer behavior and consumer acceptance of electric vehicles (EVs), and electric vehicle charging infrastructure are critical to the success of the EV chargers. According to Jensen et al., consumer comfort with EV technology and the availability of charging stations are two of the most important tricks to overcome when it comes to the mass embrace of electric vehicles (2020). People are more inclined to accept electric vehicles when they feel that charging stations offer easily accessible and reliable as well as convenient infrastructure. Additionally, the ease of use and strategic placement of charging stations greatly influence the user experience, so infrastructure developers must keep these aspects in mind when laying down new stations (Gupta, 2024).

In addition to consumer trust, social responsibility and the increased attention to climate sustainability also continue to increase the demand for sustainable transportation. Greater public awareness of the eco-benefits of EVs as well as worries about climate change have created a greater embracing of electric mobility. This socially driven shift to sustainability also impacts the need for EV charging infrastructure, as more and more consumers are looking at alternatives that are more eco-friendly than

conventional vehicles. Given increasing environmental concern about transportation, demand for EVs (and thus charging stations) will grow (Gupta, 2024).

Wang et al. (2020) suggest that the societal 'green energy ethos' and convenience directly influence the ultraefficiency of EV charging infrastructure projects. When charging stations are embedded in communities in alignment with these values, they are more likely to see community support, thereby making these assets more likely to be financially sustainable over the long term. By thinking socially and designing the charging infrastructure to meet the needs of consumers, the chance to create higher EV adoption and a strong charging network will be realized.

Technological Factors

Technological progress has made a significant contribution to maximizing the efficiency and lowering the operating expenses of electric vehicle (EV) charging stations. Advances in the technology of charging infrastructure also led to enhancements in charging and energy management and maintenance systems, requiring a lower long-term cost of operating this station. Smart grid technology and advancements in battery storage can positively impact the operational efficiency of chargers. By optimizing energy usage and improving the way electricity is managed, these technologies decrease both energy usage and the associated costs, therefore making the infrastructure more sustainable in the long run (Wu et al., 2022).

In addition, improvements in ever-evolving technology as well as energy management systems can transform the charging experience. Fast charging solutions can help decrease the time needed to charge EVs, which is crucial for growing customer satisfaction and increasing the throughput of charging stations. Additionally, energy management systems that monitor, balance, and adjust electricity contribute to the reliability and stability of the charging network by securing steadier fluctuations in energy consumption. Digital innovations, more than any other factor, not only reduce costs but also enhance overall performance and user experience, making electric vehicle

charging stations more appealing to both consumers and investors (B. Kavya Santhoshi et al., 2025).

As we continue to see change in the technological space, it is probable that the adoption of new technologies will lead to further cost efficiencies and improvement of the efficiency of EV charging infrastructure, therefore supporting the mass take-up of electric vehicles.

Environmental Factors

One major reason for the rise of electric vehicle (EV) charging infrastructure is environmental worries, especially in urban areas, where factors like air quality and emissions are real problems. Electric vehicles benefit the environment by lowering greenhouse gas output while simultaneously fighting pollution in the air. The growth of the EV charging network is consistent with world environmental goals, and global efforts to combat climate change therefore play an integral part in attempts to decarbonize transport (Zaino et al., 2024).

The rollout of EV infrastructure, too, is a critical plank in meeting wider environmental objectives. As more cities and nations work to reduce their dependence on coal, which leads to improved air quality, there is a crucial need for an extensive and effective charging framework to ensure that the transition to cleaner and more efficient energy use occurs. Almost every large-scale infrastructure project becomes more acceptable to political actors and public stakeholders as it starts implementing sustainable environmental standards. Such projects not only serve environmental objectives but also ensure the long-term sustainability of infrastructure to meet the increasing public demand for green and sustainable solutions. Diminishing understanding of the contribution of environmental factors to transport-plant systems illustrates the need for policy that favors the development of viable infrastructure for EV charging. Environmentally friendly practices in the design and implementation of charging stations are crucial in persuading authorities and the public to ensure their long-term success (Zaino et al., 2024).

Legal Factors

The regulatory context for the rollout of electric vehicle (EV) charging infrastructure can have a big impact on both the rate and cost of installation. The following legal problems include land grabs and zoning laws and building codes, which can hinder planning and installation of charging stations. According to Baker and Liu (2020), land tenure of ownership and property rights play a role in restricting the excavation of charging infrastructure; in densely populated city districts, accessible studs are limited and highly regulated. Such legal barriers can cause significant delays and increase costs in deploying charging stations, which may hinder the large-scale deployment of electric vehicles.

Also, if the law is unclear or inconsistent, regulatory compliance can be costly. Zaino et al., (2024) believe that standardization of charging station technology or rules is needed to limit these legal uncertainties. A transparent and consistent application of laws prevents charging stations from being widespread and unplanned, ensuring that they are well conducted and comply with safety, operational, and environmental requirements, which facilitates smooth project delivery. Besides, the standardized rules can protect against conflicts of interest and mix-ups between stakeholders, developers, statutory bodies, and consumers, and they can also streamline the approval process for new infrastructure.

Creating an efficient legal structure therefore plays a major role in the rollout of EV charging infrastructure. By tackling land use and regulatory issues and making sure that rules are consistent with new technologies and goals for the environment, policymakers can encourage speeding up the installation of charging infrastructure and help make the switch to sustainable transport.

Risk Mitigation Strategies

Several methods are suggested to minimize financial, regulatory, and operational risks associated with Electric Vehicle (EV) charging infrastructure projects. One major tactic requires making sure the government has incentives in place that can greatly decrease the cost for someone who is going to invest in that sector. Government tax credits,

grants, and subsidies make it easier for developers to finance the costs of building charging networks. Another way to minimize financial risks is by adopting flexible financing approaches, such as public-private partnerships. Partnering between the public and private sectors can help to reduce upfront capital costs, together with providing a better financial settlement for backers and making sure that each agreement party contributes to the main financial hazards and benefits (Akomea-Frimpong et al., 2021).

Technological advancement is also an important factor in managing the risks. However, the use of cutting-edge technologies, such as smart grids and fast charging systems, will make charging stations more efficient and reduce their costs. By making sure that EV charging infrastructure moves in step with technology changes, developers can improve the long-term viability and reliability of the infrastructure. In addition, establishing environmental and regulatory requirements for charging stations can help resolve legal and regulatory issues. Through following standard regulations and being proactive when interacting with local governments as well as regulatory agencies, the permits and development permits process can be fast-tracked, ensuring compliance with the legal requirements (Somashekarappa M, 2019).

To conclude, the interplay of various risks that are connected with EV charging infrastructure tasks is adequately reflected in the PESTEL model of business environment analysis. By looking at political, economic, social, technological, environmental, and legal (PESTEL) factors together, stakeholders can create a tailored plan to address the specific challenges of setting up vehicle charging stations. Financial and regulatory risks in particular are relatively amenable to effective management with the intermix of government backing, new financial models, and strategic alignment with the pace of technological developments. Implementing such strategies based on industry research and top-ranked recommendations is essential for fully succeeding in the development and improvement of EV charging networks.

3 RESEARCH METHODOLOGY

3.1 Philosophical Foundation of the Research Methodology

Philosophical backbones of research methodology have a significant effect on building, interpreting, and comprehending the knowledge. The two main research philosophical perspectives, positivism and interpretivism, provide different ways of understanding reality and building up knowledge. Positivism, a part of the legacy of the natural sciences, stresses objectivity and observability of phenomena. This paradigm is most closely related to quantitative methods of research that focus on measuring and analyzing phenomena through structure and empirical methods (Creswell 2014). Positivistic investigators proclaim that social phenomena may be observed and studied similar to natural phenomena, by way of factual statistics and objective data and their aid to assure universal laws. Central to this view are objectivity, generality, and replicability (Bryman, 2016).

On the hand, interpretivism highlights the subjective sectional controls of human deals to uzavř a emphasis on the meanings that individuals or units ascribe to their actions, behaviors, and social scenes. Interpretivists argue that social reality is constructed by society and hence can only be understood through the viewpoints and interpretations following a scenario by the individuals within it (Schwandt, 2014). Unlike positivism, which tries to discover universal laws, interpretivism attempts to achieve a more profound, prescriptive comprehension of phenomena by examining the detailedness and particularities of separate experiences. As such, qualitative research techniques, such as interviews, case studies, and ethnographic research, are widely used inside of the interpretivist paradigm in order to study the participant's life experiences and cognition in their own context (Patton, 2015).

The research adopts an interpretivist paradigm, which is most suitable to study the subjective experience, perception, and decision-making of project managers working on electric vehicle (EV) charging infrastructure projects in New Delhi, India. The goal of the study is to ask the question: What are the impacts of the external environment on the

construction of EV charging infrastructure in New Delhi, especially concerning the PESTEL environment for macro-environmental factors, including political, economic, social, technological, environmental, and legal? The interpretivist approach allows for an analysis of how these broader macro-environmental factors affect the practices, behaviors, and strategies project managers use when deploying the EV charging infrastructure. This philosophical posture goes hand in hand with the scope of the study, which is driven by the study's target to arrive at a profound and well-understood understanding of how the outside environmental factors contribute to the progress of the Electric Vehicle Charging Infrastructure Project in New Delhi.

By applying an interpretivist viewpoint, this research offers a delicate, context-specific research into the numerous tactics that project managers philosophize in ways that alleviate function risks. It provides rich, in-depth insights into the challenges and complexities attached to developing electric vehicle charging infrastructure projects in New Delhi. This approach is commensurate with the wider form of qualitative investigation, which aims at conceiving existence by exploring humans' lived realities with the reasons why context, sense-making, and motivation have been crucial issues in defining quality social occurrences and their actions (Denzin & Lincoln, 2011).

3.2 Theory Development in Inductive Approach

Induction as a crucial methodology in qualitative research is the journey of grounding generalizable theoretical and conceptual ideas and entities in thousands of empirical data. Unlike the deductive method, which is the hypothesis or theory to be established by the empirical evidence (Creswell & Poth, 2018), the inductive method is a bottom-up approach, which begins from the particular to the general. It focuses more on the construction of ideas and insights from the data rather than forcing a preconceived theoretical model onto the results. This methodology is well fitted to guide the research on complex and interrelated fields such as human behavior, social interactions, and organizational factors, posing the concerns to delve deep into the intricacies of the researched material (Thomas, 2006).

In qualitative research, the inductive methodology is used to identify and discover new themes, relationships, and patterns in the data, based on no preconceived theoretical statements. This approach, according to Braun & Clarke (2013), offers great advantages when developing new theoretical frameworks rather than appraising existing theories. By allowing “data to speak for itself,” the inductive consequently gives a deeper, more elaborated view on the research problem with new ways to read the lived experiences and views of the research participants.

The research adopts an inductive approach to examine external environmental risks of developing electric vehicle (EV) charging infrastructure in New Delhi along PESTEL macro-environmental spectra. The study initiates research steps by conducting semi-structured interviews with project managers who actively participate in the EV charging infrastructure development for New Delhi. The interviews represent the foundation for original data collection because they deliver detailed personal stories about the problems that developing electric vehicle (EV) charging infrastructure in New Delhi.

In conducting the analysis of the information from the interviews, the researchers followed an inductive process, recognizing recurring themes, patterns, and modes of thought within the responses. The researchers gather and organize information by using a methodical coding system to sort it into categories that highlight key aspects of developing EV charging infrastructure, such as identifying and managing risks and assessing PESTEL factors. The study's data analysis results will guide the development of the theoretical framework dedicated to understanding risk management behavior in EV charging infrastructure development for New Delhi. This phenomenon allows the builders of conceptual models based on direct experiences of project managers and offers new perspectives for risk mitigation best practices and successful strategies.

The inductive approach proves key in developing theory right from the collected data that provides effective understanding of EV development risks and charging infrastructure processes in New Delhi's emerging electric vehicle environment. This

approach consolidates with the aims of qualitative research overall, which tries to bring contextually rich and theory-grounded knowledge of social phenomena (Charmaz, 2014).

3.3 Questionnaire Design Process

Creating an effective questionnaire stands as the key step to obtain relevant information about financial risks in New Delhi, India, regarding electric vehicle charging infrastructure development. Since the study is qualitative, the questionnaire will be developed to encourage in-depth discussion and obtain rich information from stakeholders like project managers and employees of XYZ company. A total of 10 questions were developed using PESTEL framework analysis principles as described by Yüksel (2012). These survey questions aim to evaluate financial risks related to EV infrastructure by sorting them into categories based on the six PESTEL factors. Total risk assessment follows six categories: political, economic, social, technological, environmental, and legal. For example,

PESTEL Category	Interview Focus
Political Factors (e.g., Government Policies)	Influence of government policies, incentives, and regulations
Economic Factors (e.g., Cost, Funding, ROI)	Financial risks, ROI uncertainties, funding challenges
Social Factors (e.g., Public Perception)	Consumer adoption, social resistance, behavior patterns
Technological Factors (e.g., Charging Speed)	Technological advancements, grid integration challenges
Environmental Factors (e.g., Land, Compliance)	Environmental regulations, land acquisition issues
Legal Factors (e.g., Zoning, Permits)	Regulatory compliance, land use, and zoning laws

Table 2: Link between PESTEL Framework and Interview Focus for Research Study

Every question within the survey has been crafted to encourage stakeholders to provide significant responses, which helps create an in-depth understanding of financial risks associated with EV charging infrastructure developments. The research utilizes the PESTEL framework to organize the questionnaire for capturing complete project viability

information from macro-environmental elements. The data collection process will use thematic analysis to sort information into categories based on the PESTEL framework, helping to examine important risk factors that impact the profitability of EV charging infrastructure projects (Braun & Clarke, 2006).

3.4 Data Collection Procedures in Empirical Research

Data acquisition through empirical methods involves observing and interacting with actual settings and people to collect data. This is a basic approach in qualitative research where the main aim is to obtain a thorough understanding of a participant's view and to collect detailed, rich, and contextual information on multielemental phenomena (Silverman, 2016). The collection of data in qualitative research mostly relies on interviews and focus groups since they prove effective for obtaining detailed and personalized participant responses (Kvale, 2007).

In this research, semi-structured interviews were the primary method used for data collection. Semi-structured interviews provide research investigators with the ability to study pre-determined themes while maintaining the freedom of flowing conversations (Cohen & Crabtree, 2006). The method provides a more profound understanding of how participants feel about building electric vehicle charging facilities in New Delhi. The method helps researchers maintain consistency when comparing interviews because of its critical value (Bryman, 2016).

Ten project managers from various EV firms based in New Delhi participated in interviews. Researchers created two distinct sample groups. Expert participants included EV charging infrastructure development managers and financial risk management professionals across different organizations. Through open-ended, semi-structured interviews, the participants extended their discussions, which helped researchers gain critical information about project managers' risk mitigation approaches for EV charging infrastructure development in New Delhi.

Also, the Secondary Data such as government records, industry publications, market research documents, company records, and reputable databases, was analyzed to

support the primary data. The secondary data helped in contextualizing the interview results, thus providing extra validation and detailed explanations of the EV charging infrastructure development factors in New Delhi along with its financial risk management aspects. The integration of primary and secondary data can bolster the trustworthiness and intricacy of the examination (Merriam & Tisdell, 2016).

This mixed-methods approach, combining qualitative interviews with secondary document analysis, matches the research goal of looking into actual techniques and frameworks put up by project managers in New Delhi's EV business to mitigate financial risks associated with the building of EV charging installments. By using both direct interview information and other sources, the study seeks to provide useful insights about how outside factors, especially political and economic rules and technology systems, affect the development of EV charging infrastructure and the success of projects in this rapidly changing field.

3.5 Structuring the Case Study Approach

The case study research design enables researchers to deeply comprehend individual occurrences by studying complex phenomena within their natural environments, according to Yin (2017). The method shows excellent results when researchers study complicated subjects whose development depends on multiple settings. A detailed study evaluates the risk management approaches for building electric vehicle charging infrastructure in New Delhi's ever-changing political, economic, social, and technological environment. The development process as well as risk management strategies experience vital influence from the combination of political, economic, technological, environmental, social, and legal factors (Creswell, 2014).

Through a case study method, researchers can examine the intricacies that characterize the EV market of New Delhi because different project management approaches interact with government policies, economic fluctuations, and social expectations (Stake, 1995). This study involved ten key stakeholders, including project managers and contractors, who were members of the research through semi-structured interactions to explore

their process of risk management and vendor selection and negotiations. In these interviews, researchers get deep qualitative data that allow them to uncover options for project managers' management of risks and uncertainties (Yin, 2017).

Data analysis will reveal important patterns about external factors such as policy changes, the sway of economics, technological changes, and their impact on the results of the projects. Using the data analysis will provide a demonstration of how strategies on EV charging infrastructure development are rolled out in New Delhi as well as emphasize the importance of the strategies with reference to financial and operational risks (Creswell, 2014). This paper shares the important knowledge on how to control the risks associated with the EV sector by looking at the fundamental strategies critical to ensuring successful EV charging infrastructure growth in New Delhi.

3.6 Thematic Analysis of Empirical Data

The study of risks and the mitigation of them for the electric vehicle (EV) charging infrastructure development project in New Delhi, India, uses thematic analysis as the qualitative data analytical approach. The recognition of recurring patterns and themes in the data assists in understanding the contributing factors to risk management for these projects, following Braun and Clarke's (2006). Organizational flexibility allows thematic analysis to articulate the complex web of risks that exist within the EV infrastructure because it can admit numerous environmental, economic, and policy aspects interacting within the same setup.

The research applies the PESTEL framework to break down the external macro-environmental factors into the following: political, economic, social, technological, environmental, and legal. The study looks at the data carefully using this model and creates themes from these six areas to provide clear insights into understanding risks and finding solutions.

During the initial phase, the researcher conducts a thorough review of data stemming from interviews with project managers who work alongside EV charging infrastructure stakeholders. The research questions lead to data extraction from the interview

transcripts, which undergo detailed reading and manual coding by the researcher. The process of initial coding extracts individual points of data that researchers later combine into higher-level categories that align with PESTEL dimensions (Braun & Clarke, 2006).

The Political Factors theme demonstrates how government policies with incentives affect the development of EV charging infrastructure. Utilizing subsidies for electric vehicle companies and charging station deployments either stimulates or blocks the advancement of these projects. The study will analyze financial obstacles related to funding infrastructure development, focusing on the economic factors theme, as well as ROI volatility and the total capital expenditure required for charging station installation. Strategic pricing and procurement become difficult because of uncertainties related to inflation along with currency devaluation.

The Social Factors theme demonstrates how consumer acceptance and public understanding of EVs shapes the need for new charging stations directly. The lack of knowledge about electric vehicles and doubts over charging station availability could push back the general adoption of EVs among the public. The success of electric vehicle infrastructure depends heavily on fast-charging technologies that the technology factors must explore. Deciding how to incorporate these technologies into present power grids as well as large-scale EV battery charging operations' technical viability stands out as a key element in project management.

Project timelines and costs come under environmental regulation and land acquisition challenges as part of the Environmental Factors theme analysis. The process of fulfilling regulatory standards for emissions and sustainability demands extra funding and forces designers to change project characteristics. The Legal Factors theme investigates both zoning permits and legal requirements for charging station establishments. Obtaining needed permissions along with ensuring regulatory compliance typically involves a drawn-out and demanding set of procedures.

The analysis of themes reveals how different factors connect to influence risk mitigation approaches for EV charging infrastructure development projects. The implementation

of public-private partnerships and flexible regulatory frameworks represents responses to political and economic risks, but technological innovations solve social and environmental challenges (Braun & Clarke, 2006).

Project managers in New Delhi use thematic analysis to derive significant insights about charging infrastructure challenges while they develop EV charging projects and implement risk management across PESTEL model dimensions.

3.7 Validity and Reliability in Research Design

The current research relies heavily on valid and reliable research methods to build robust, credible findings. Research validity defines accurate outcomes, while research reliability defines consistent repeatable processes.

Different strategies within the research design work together to strengthen validity. Triangulation is a primary research method that uses various datasets and methodologies to confirm study results. This study uses semi-structured interviews in conjunction with secondary data analysis through government reports and market research documents and internal company records to gather its information. By analyzing multiple data sources through triangulation, researchers gain a comprehensive understanding of their subject while safeguarding the study against single-source biases. The research credibility strengthens when Merriam and Tisdell (2016) explain that different data types confirm common patterns between them.

Semi-structured interviews create flexibility across the interview process through predetermined themes and their ability to respond to new topics that arise during interviews. The flexible research design allows the study to include views from various sources, which improves its accuracy by providing a deeper understanding of the topics being studied.

Reliability of research results depends upon using a uniform method for data collection. A standardized interview guide enables researchers to pose consistent questions to each participant, which maintains consistency between the interviews. Thematic analysis

functions as a structured data analysis procedure to assign interview responses into the categories defined by the PESTEL framework (political, economic, social, technological, environmental, and legal factors). By structuring the analysis procedure, researchers can enhance the internal reliability because it reveals similar themes within different data sources (Merriam & Tisdell, 2016).

The research design method of this study creates an improved validity-to-reliability result. By using data-driven theme development, the research prevents unwarranted biases while maintaining its foundation in participant-based empirical data. Qualitative research applies an inductive methodology to discover new knowledge through analyses of genuine field data (Merriam & Tisdell, 2016).

Multiple methods, including triangulation along with semi-structured interviews and consistent procedures and inductive analysis, help build validity and reliability within the research project as a whole. The research methods deliver credible, consistent findings that deliver significant knowledge about New Delhi's EV charging infrastructure development.

3.8 Ethical Considerations in Research Methodology

Any research study needs ethical values that preserve its research integrity and authenticity. This research about electric vehicle (EV) charging infrastructure development in New Delhi follows various essential ethical standards.

The research protects participants' ethics by getting their voluntary agreement for participation before studying begins. All participants received complete information about the study objectives and procedures together with their freedom to participate willingly before conducting interviews. The process's transparency enables participants to understand the intended use of their data and freely provide their consent. Additionally, strict confidentiality measures are in place. For the sake of the participant’s privacy, research ethics require cleaning the study data of any personal information (Creswell & Poth,2018). The research introduces protective measures for avoiding participant damage through the provision of professional and comfortable spaces for

interviews. The study did not include questions that would adversely affect either the professional or personal welfare of any participant. Studies related to sensitive topics such as project manager challenges in EV infrastructure development require this ethical principle because financial and regulatory issues are involved in these cases. Both participants of each study were assured that those responses would be used only for academic study by the researchers. The integrity of data is a crucial aspect of ethics in the research. It becomes the researchers' obligation to share scientific findings with honesty and present the information in the right manner. All interview data and secondary data collection findings were reported without alteration or modification. The research increases the reliability and validity of its findings since it integrates primary data from interviews and secondary data from government and industry reports (Merriam and Tisdell 2016). With utmost documentation of research procedures and even methods of data collection and analysis and interpretation processes, the research ensures its level of transparency. The process of open research procedures makes it possible for persons who are occupying the academic field to subject the scope of the research process to a close scrutiny and close scrutiny since its documentation ensures accountability. Secure attribution and citation are key tools in ensuring that the research observes ethical obligations; therefore, proper citation and use of sources such as government reports and industry studies are useful in enabling the research to achieve its ethical obligations of attribution and citation (Merriam & Tisdell, 2016).

The research follows a broad ethical system that ensures proper ethical performance and value received by participants and responsible behavior toward academic officials and public readers. These ethical concepts serve to support both the reliability of the research as well as the responsible implementation of EV infrastructure across New Delhi.

4 RESULTS AND DISCUSSION OF RESEARCH

4.1 The Empirical Results from Case Company

The following section analyzes data received through the questionnaire about electric vehicle (EV) charging infrastructure development in New Delhi. The collected responses reveal fundamental problems and obstacles that affect stakeholders in their efforts to build EV charging stations in New Delhi. Risks encompass not only financial and regulatory aspects, but also technological challenges and political and economic instability. The analysis focuses on studying the collected responses against the core research inquiry. What key challenges and risks does developing electric vehicle charging stations in New Delhi face?

The following analysis displays the diverse nature of obstacles that confront the development of EV infrastructures. Research findings from participants show that capital expenditure irregularities and investment return payments and delays in acquiring land ownership and permits spread across the full spectrum of difficulties, while the current electricity network creates technical barriers and external political changes influence implementation. The survey data includes actionable suggestions that focus on establishing public-private collaboration in EV development, speeding up regulations, and promoting technological convergence to tackle these difficulties.

The findings from stakeholders in the EV infrastructure network highlight the barriers to developing New Delhi's EV charging network and propose additional strategic solutions for improvement. Several risk categories will be examined in detail through respondent direct quotes, which present authentic challenges from the real world.

Financial Risks (Respondent Insights):

Multiple respondents in New Delhi highlighted financial hurdles that stopped their success in installing electric vehicle charging stations. Cofounders encounter integration expenses, unpredictable ROI calculations, and challenges in securing capital necessary for the successful development of EV charging stations.

High Upfront Costs: The respondents echoed their concerns about the excessively high costs of building EV charging stations because of emphasizing fast charger installations (including Respondents 1, 4, and 5). The actual costs surpass estimated startup expenses because investors need to pay for grid work and transformer expenses alongside land purchase expenses, which creates high risk in the project. According to Respondent 1, many projects do not start development during the initial phase because of this high initial cost requirement.

Uncertainty in ROI: The unclear nature of future market demand and revenue produced concerns for investors, which delayed investment decisions. According to Respondent 9, future demand data shows unreliable results, which makes it difficult for investors to determine investment returns.

Bureaucratic Delays: The respondents explained that government funding delays coupled with financial incentive delays added to companies' financial burden. According to Respondent 4, "The central government's funding distribution processes take too long and result in delays in executing EV infrastructure development."

Regulatory and Compliance Risks (Respondent Insights):

Regulatory hurdles became a fundamental risk factor. The process of obtaining permits as well as complicated zoning rules keeps appearing in multiple reports.

Land Acquisition Issues: The acquisition process for suitable land in New Delhi becomes both expensive and slow based on reports from respondents, including Respondents 2 and 6. Respondent 6 stated, "Another significant issue during land acquisition arises in large cities like Delhi due to the presence of multiple landowners."

Governmental Bureaucracy: The respondents found that delays and disagreements between different government bodies create multiple obstacles during project implementations. According to Respondent 7, the slow working of bureaucracy results in lengthy delays that affect all related processes.

Technological and Infrastructure Risks (Respondent Insights):

The study revealed that numerous participants identified two main technological issues related to grid compatibility and fast-moving charging technology developments.

Outdated Grid Systems: Respondents, including Respondent 1, 4, and 10, indicated that New Delhi's old power grid struggles to meet the high electrical power requirements of EV charging units. New charging equipment faces operational challenges when it attempts to operate with New Delhi's outdated electricity distribution networks, according to Respondent 1.

Technological Uncertainty: The worry about lightning-fast equipment technology replacement emerged as a key issue during the interview phase. According to Respondent 3, "The rapid decline in technological value of contemporary advanced equipment results in high-speed replacement rates."

External Factors and Political Risks (Respondent Insights):

Political stability and economic certainty often served as correlating reasons for delayed investments and delayed planning decisions.

Political and Economic Instability: According to Respondent 1, "Political turbulence combined with economic unpredictability weakens the duration of active planning efforts and results in decreased investor trust." According to Respondent 9, the influence of political dynamics together with economic elements and worldwide energy price variations establishes both sources of funding and the market targets.

Government Policy Shifts: Multiple respondents reported government priority shifts and an array of inconsistent regulations as barriers to investment. The regular changes in policies create business uncertainties that generate additional administrative complexity, according to Respondent 4.

Strategic Recommendations (Respondent Insights):

Multiple suggestions emerged to lower the identified risks while advancing the development of EV charging infrastructure.

Respondents 7 and 10 suggest strengthening the implementation of public-private partnerships to manage costs and accelerate project execution. Private companies need to join forces with governmental entities and deployment guidelines for EV infrastructure across the country, according to Respondent 7.

Streamlined Regulatory Process: The approval processes needed to become faster and simpler to handle regulatory risks, according to interviewees. The need for stronger collaboration between public and private entities emerged as a vital proposal, according to Respondent 1 and Respondent 4 added that urban bodies should establish a specific EV infrastructure organization to simplify project approvals.

4.2 Discussion of Empirical Research Findings

Financial Risks

The financial challenges mentioned in the survey stand as primary barriers against developing EV charging stations. High initial expenses related to fast-charging infrastructure pose a significant challenge that discourages potential stakeholders from investing in EV charging stations. Investors are met with additional investment barriers due to charges associated with upgrading grids, buying transformers and obtaining land for infrastructure advancement. Financial uncertainty is made complex by the unclear ROI in a growing electric vehicle market and the charging infrastructure industry. High project costs as well as uncertain EV market growth pressure make investors wary of investing in charging stations. The financial problems become compounded as government agencies end up prolonging the approval schedules for funding and financial incentive applications. The rate of income getting to project developers is

determined by better streamlining the steps to get approval and funding support for such financial barriers.

Regulatory and Compliance Risks

It is highly difficult to establish the EV charging stations due to strict regulatory orders. The land acquisition processes in New Delhi are slow and costly due to outdated land ownership systems and ineffective bureaucracy. The creation of charging stations whilst being located in a certain city is surrounded with many difficulties from the side of zoning laws and so on the process of gaining the necessary permits for doing the construction has. The regulatory delays discovered retard project turnaround times as they affect the confidence of investors based on the respondents' responses. Psychological outcomes of respondents implied that the time-consuming nature of the implementation process of the project is the result of inconsistent policies and contradicting requirements caused by bureaucratic inefficiencies everywhere in different government divisions. The body of urban cities can empower the establishment of a task force or group that can oversee the development of EV infrastructure, leading to efficiency in approval for electric vehicle infrastructure.

Technological and Infrastructure Risks

Technological risks emerge as key issues in building the EV charging infrastructure. The most significant technical challenge that emanates from the power grid in New Delhi is its failure to deliver enough power for EV charging stations. Respondents pointed out that attempts to integrate advanced charging equipment with outdated electrical grids often lead to technical issues and impairments. The rapid development of EV charging technology increases the risk that the charging infrastructure may lose its value before the planned schedules. The rapid obsolescence of technology creates additional uncertainties for investors about the long-term value of their capital investments and project developments. The research indicates that additional technological progress is

needed alongside the modernization of the electricity grid, as the demand for EV chargers continues to grow.

External Factors and Political Risks

External factors, especially political instability and economic uncertainty, were also cited as major threats to the growth of the EV charging network. Politics and other economic uncertainty were viewed as top factors for investment decision-making, as they could damage the investor's confidence and disrupt long-term planning. The situation becomes more difficult when respondents report that changes in government regulations and policies lead to unstable business conditions because of regular policy shifts. Survey participants suggested that political and economic stability together with predictability would decrease risks and establish better conditions for developing EV infrastructure. Global energy prices, which fluctuate, emerged as an external factor affecting both the costs of EV charging infrastructure and the demand for electric vehicles.

Strategic Recommendations

Respondents proposed various strategic recommendations to tackle the hurdles in EV infrastructure development. Public-private partnerships (PPPs) stand as one of the recommendations with the strongest level of industry support. Collaboration between several entities in a partnership led to lesser capital expenditures in station installation and lesser process delivery time. The respondents advocated that combining efforts between the government agencies and private companies would lead to a coherent plan for EV infrastructure development that would guide stakeholders' coordinated actions. Research subjects advocate regulatory process simplifications to help with faster approval of EV infrastructure projects, with dissemination of the approval process being hastened too. Public authorities should develop a team mandated to manage an EV infrastructure to enable quick approvals complemented with implementation processing.

In conclusion, there are several challenges that prevent EV charging infrastructure development in New Delhi, with financial barriers as well as regulatory barriers, technological barriers, and external barriers. External stakeholders proposed practical answers to these risks using public-private partnerships along with more regulated ways of operating combined with modernizing the electric grid infrastructure of New Delhi. The implementation of solutions must be achieved through work in cooperation with government organizations and private industry companies and all stakeholders active in EV markets. To successfully create a strong, sustainable EV charging network in New Delhi, stakeholders must take actions to overcome the existing obstacles. Using such actions, the city will be able to achieve its vision of pollution reduction and the promotion of clean energy.

5 RESEARCH SUMMARY AND IMPLICATIONS

5.1 The Research Summary

The empirical observations from the questionnaire responses provide the key risks associated with electric vehicle (EV) charging infrastructure development in New Delhi. The research uncovers many critical challenges that EV charging station founders must face both financially and in terms of regulatory and technical hurdles and environmental barriers.

According to respondents, financial risks appeared as the major hindrance, as costly in establishing EV charging stations, especially in the fast charger infrastructure. Grid upgrades and transformer and land acquisitions add to the investment risk. Uncertainty in return on investment (ROI) in unpredictable market demand holds back possible investors from proceeding. The lengthy approval by the government of funding and financial incentives made it more financially burdensome for potential investments.

The vital regulatory risks of slow, expensive land acquisitions and complex zoning regulations emerged in New Delhi. The inherent failure of government departments and unusual government regulations had created immense bottlenecks that adversely affected project delivery periods. The respondents called for the establishment of an EV infrastructure task force operating under the umbrella of urban bodies to streamline both regulatory frameworks and operationalize project activities.

New Delhi's legacy electricity grid couldn't cope with the need to charge EVs, as technical risks were in the top five concerns. The implementation of advanced charging systems in current power system grids created operational instability. The rapid advancement of charging technologies presents this form of investment with a risk because they can become obsolete before the investors have realized a return on the money invested in them. The respondents suggested pursuing additional technological advancements through a deliberate upgrade of the electricity grid system.

Investor decision-making about the development and planning of EV infrastructure is influenced by factors such as political instability coupled with economic instabilities, which are confirmed by research findings. Market instabilities, along with reforms in government policy, make investors doubt their investments and this adds to business unpredictability. Respondents proposed that stable political and economic conditions and international energy pricing adjustments would make EV infrastructure projects feasible.

Several strategic proposals involve building public-private partnerships (PPPs) because these help distribute financial responsibilities between parties as well as optimize the project coordination process. The initiative suggested both speeding up regulatory clearance processes and drawing up a national framework for EV charging infrastructure to support development.

The study reveals the various risks that can impact the development of EV charging infrastructure in New Delhi. The research introduces functional solutions and essential partnerships alongside grid network modernization to minimize risks for establishing a sustainable electric vehicle charging network in the city.

5.2 Theoretical Implications

This study advances theoretical knowledge of risk management practices for electric vehicle (EV) charging facilities construction, particularly in developing metropolises such as New Delhi. The research framework combines inductive methods with PESTEL analysis to reveal new insights about the political, economic, social, technological, environmental, and legal challenges in risk management. The study delivers a fresh understanding of evolving external environmental risks, which enhances current knowledge about infrastructure development research. The research finds fault with traditional risk management practices while studying their application for present-day infrastructure projects, which are strongly influenced by outside elements.

5.3 Managerial Implications

According to this research investigation, project managers need to concentrate on specific primary areas, which will lead to successful EV charging infrastructure development. Managers need to address financial uncertainties, including high initial costs and unclear returns on investment, by implementing public-private partnerships along with government-supported incentives. The study shows the significance of quick regulatory processes while advocating for specialized groups to handle approval processes effectively. Managers who implement these strategies together actively reduce both project-timing risks and project-cost risks for better execution of construction projects. Managers need to monitor their infrastructure continuously while adapting to technological advancements to face obsolescence risks and ensure its long-lasting sustainability.

5.4 Policy Implications

The study maintains substantial significance for authorities who build EV infrastructure systems. Research findings argue that solid, consistent policies must exist to provide a steady framework for investors and developers. According to respondent interviews, policy changes that occur frequently create confusion, which impedes development progress. Policymakers must prioritize the creation of sustained critical plans for EV infrastructure development and ensure that these plans are consistent with local and national guidelines. The government should establish clear incentives through tax breaks and subsidies that are properly aligned to more effectively support developers in implementing high-cost, fast-charging stations. EV infrastructure development will receive a significant acceleration by establishing better coordination between state departments and local agencies to work alongside federal agencies on land acquisitions and permit processing.

5.5 Scope of Future Research

This research strongly possesses many limitations that may influence the generalizability of its findings. To begin with, the research only considers the electric vehicle (EV) charging infrastructure development in New Delhi, India, and hence excludes other

cities or regions that might have city-specific, economic, demographic-specific, or regulatory-specific challenges. The study mainly relies on qualitative data from project managers interviewed, which, though it provides detailed information, may be ridden with individuals' biases or have a narrow focus. Also, the research points at the existing technologies and trends on the market that may ignore such innovations as may appear or have appeared in the distant future and may impact the growth of EV infrastructure.

Further research may extend the geographical location of the present study to include other cities in India or around the world, and cross-comparative analysis of risk factors and mitigation strategies in different socio-economic and regulatory settings can be done. It would also be useful to investigate quantitative approaches to supplement the qualitative findings to get a wider view of the financial viability and attractiveness in the market of EV charging infrastructure. Moreover, research related to the long-term technological progress in terms of charging techniques, such as wireless or ultrafast techniques, may assist in the formulation of the needs for future infrastructure and investment in the future. Finally, analysis of the changing consumer behavior and acceptance patterns of electric vehicles may yield critical information for refining risk management strategy in EV infrastructure projects.

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Appendices

Appendix 1. Interview Questionnaire

1. What do you perceive as the primary financial challenges in establishing EV charging stations in New Delhi?
2. Can you elaborate on the impact of high upfront installation costs on the viability of EV charging infrastructure projects in the city?
3. How does the uncertainty surrounding return on investment (ROI) influence investment decisions for EV charging stations?
4. What are the key obstacles in securing adequate funding for large-scale EV infrastructure projects in New Delhi?
5. What extent do land acquisition issues in New Delhi complicate the development of EV charging stations?
6. How do government incentives and policies influence the financial viability of EV charging stations in New Delhi?
7. What regulatory or compliance challenges do you encounter during the planning and implementation of EV charging stations?
8. How do technological factors, such as the efficiency of the grid and charging technology, affect the operational costs of charging stations?
9. What external factors (e.g., political, economic, or environmental) do you believe significantly impact the development of EV charging infrastructure in New Delhi?
10. Based on your experience, what strategies or recommendations would you propose to mitigate the financial and regulatory risks associated with EV infrastructure projects in New Delhi?