Understanding Optimal Designs of Public Electric Vehicle Charging Station for Fostering Electric Vehicle Adoptions: A Review Study

Dedy Atryomadepa[1,2], Fathiro Hutama Reksa Putra[1]

[1]Industrial Engineering & Management Department, Faculty of Industrial Technology, Institut Teknologi Bandung
[,2] PT PLN (Persero) Unit Induk Distribusi Jawa Timur
Email: 23422317@mahasiswa.itb.ac.id[1], fathiro@itb.ac.id[2]

Abstract. This study investigates the design and specification of Electric Vehicle Charging Stations (EVCS) located in rest areas and shopping malls (malls) in East Java, Indonesia. By employing conjoint analysis, the research identifies key consumer preferences and critical factors that influence the adoption and usability of EVCS. The design of Public Electric Vehicle Charging Stations (PEVCS) plays an important role in driving electric vehicle (EV) adoption by overcoming barriers such as "range anxiety," accessibility, and high infrastructure costs. Research shows the need for a data-driven approach to determine optimal locations, improve usage efficiency, and support dynamic subsidy policies that balance infrastructure investment and EV growth. Integration of PEVCS with fast charging technology, renewable energy, as well as global standards, can accelerate the transition to low-emission transportation. In addition, perceived accessibility to users, especially in dense and remote urban areas, is a key factor in increasing public trust in the charging network. A holistic approach involving governments, infrastructure providers, and vehicle makers is needed to ensure the sustainability of the EV ecosystem.

Keywords : *Public Charging Infrastructure, EVCS Design, User Preferences, Literature review*

1 Introduction

In the last decade, the growth of electric vehicles globally has shown a significant increase. Throughout 2018, the International Energy Agency (IEA) identified that the growth of electric vehicle (car) sales increased by 68% compared to 2017 or around 2 million units of electric vehicle sales for one year. The top three electric vehicle sales in 2018 consecutively occurred in China (1.1 million units), Europe (385,000 units) and the United States (361,000 units).

The rapid adoption of electric vehicles (EV) worldwide has created an urgent need for comprehensive charging infrastructure. In Indonesia, the government's push for clean energy solutions aligns with global efforts to reduce greenhouse gas emissions. The International Energy Agency reported a 50% increase in

Received _____, Revised _____, Accepted for publication _____

global EV sales in 2022, a trend mirrored by Indonesia's efforts to transition to EVs. However, the lack of accessible and reliable EVCS is a major barrier, with the current 842 EVCS far below the target of 3,000 units.

Rest areas and malls are two strategic locations identified for EVCS deployment due to high traffic and EV user engagement. This study aims to bridge the gap between user needs and existing infrastructure by proposing EVCS specifications that address consumer preferences and operational efficiency.Electric vehicle (EV) charging infrastructure plays a critical role in overcoming "range anxiety" which is a major barrier to EV adoption (Burra et al., 2024; Luo et al., 2022). The development of charging infrastructure must consider the need for strategic location and accessibility to support large-scale adoption (Metais et al., 2022; Y. He et al., 2022).

Governments in various countries have developed policies and subsidies to support the development of EVCSs, such as the "Dual-Credit Policy" program in China that encourages coordination between EV manufacturers and charging infrastructure providers. Dynamic subsidies are also being explored to ensure a balance between charging infrastructure investment and growth in EV adoption (Luo et al., 2022).

Challenges include high infrastructure costs, the need for integration with the power grid, and the lack of global standards for charging technologies (LaMonaca & Ryan, 2022; Mastoi et al., 2022). Innovations such as battery swap and fast charging are solutions for time and operational cost efficiency (Mastoi et al., 2022; Metais et al., 2021).

The perceived accessibility and potential public use of EVCSs are key factors in EV adoption decisions, especially in high-density urban areas (Y. He et al., 2022; Metais et al., 2021). An optimized design for EVCSs is essential to improve usage efficiency, expand the reach of EV adoption, and reduce barriers such as charging location uncertainty (Burra et al., 2024; Yulistio & Satino, 2024). Integrating EVCS design with users' specific needs, such as fast charging and access flexibility, will significantly increase EV adoption.

A data-driven approach is needed to determine optimal locations, reduce construction costs, and increase user confidence in the charging network (Metais et al., 2022; Y. He et al., 2022). This approach involves coordination between the government, infrastructure providers, and vehicle manufacturers to ensure the sustainability of the EV ecosystem. Improving EVCS accessibility in remote areas and integration with renewable energy will support sustainability and efficiency targets (LaMonaca & Ryan, 2022; Mastoi et al., 2022).

Good EVCS design is crucial to support the transition to low-emission transportation, while addressing the technical, economic, and social challenges in the electric vehicle ecosystem.

2 Literature Review

Electric vehicle (EV) adoption is increasing along with awareness of sustainability and carbon emission reduction. Research shows that consumer preferences for electric vehicle charging infrastructure, particularly Public Electric Vehicle Charging Stations (EVCS), are strongly influenced by factors such as convenience, charging speed, and ease of access. Consumers tend to prefer EVCSs located in strategic locations such as shopping centres, commercial areas, and public places they frequently visit. In addition, the importance of the availability of adequate charging facilities, as well as transparency on pricing and charging capacity, are crucial aspects in driving EV adoption. Various studies have shown that the ease of finding EVCSs that can be accessed easily and quickly will accelerate the transition to electric vehicles (Huang et al., 2021; Chen et al., 2022).

The EVCS design desired by consumers leads to a more user-friendly and innovative experience. Consumers want EVCS designs that can accommodate different types of electric vehicles with high flexibility, as well as easy-to-understand and attractive displays. Fast charging is also a highly desired feature, as it allows drivers to charge in a short time without interrupting their activities. In addition, consumers expect a simple, app-based payment system that is integrated with other services, such as navigation and charging slot booking. The development of EVCSs that consider these design factors can improve consumer convenience and satisfaction and accelerate the adoption of electric vehicles (Sweeney & Murphy, 2020; Zhang & Liu, 2023).

The availability of electric vehicle charging infrastructure (EVCS) is a major factor in increasing EV adoption, with the need for fast charging, strategic placement, and integration with existing transportation systems to increase user confidence (Patel et al., 2024). Consumer preferences tend to focus on accessibility, cost-effectiveness, and advanced technological features, such as fast charging and reliability, especially in locations close to main routes (Kumar & Alok, 2020; Yulistio & Satino, 2024). Research also shows the importance of location-specific design, especially in urban and peripheral areas, with a focus on facilities in shopping malls and rest areas to maximize the potential for EV adoption (Mastoi et al., 2022; Metais et al., 2021; Haryadi et al., 2023).

3 Material and method

According to Baumeister & Leary (1997) in their book "Writing narrative literature review", literature review can be done using the narrative review method. A narrative review is used to provide an overview of a topic based on various literature sources. It uses a descriptive approach to synthesize information and focuses on introducing concepts, theories, and trends in a particular field.

The steps that can be taken are Identification of review objectives, Search for relevant literature from various databases (e.g., PubMed, Scopus), critical analysis of research results and their implications and synthesis of information to provide comprehensive insights.

This study used a scoping review approach in accordance with the methodology proposed by Arksey and O'Malley (2005) and the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines. This approach was chosen to broadly explore the available literature related to electric vehicle (EV) adoption and public electric vehicle charging station (EVCS) infrastructure development.

The main questions focused on in this research are:
a. What are the key trends related to electric vehicle (EV) adoption?
b. How does EVCS infrastructure development affect EV adoption?
c. What are the existing research gaps in the literature related to this topic?

A literature search was conducted using several major academic databases, namely: Scopus, Web of Science, PubMed Google Scholar. The keywords used in the search were: "electric vehicle adoption", 'charging station infrastructure', 'EVCS AND EV adoption' and 'policy AND electric vehicles'. These keyword combinations were organized using Boolean operators (AND, OR) to ensure comprehensive search coverage. The literature included in this review was selected based on the following criteria:

1. Inclusion criteria:
   a. Journal articles published in English or Indonesian.
   b. Studies published between 2019 and 2024.
   c. Articles that address electric vehicle adoption or EVCS infrastructure.
   d. Empirical studies or literature reviews relevant to policy, technology, or consumer perception.
2. Exclusion Criteria:
   a. Articles that were not available in full text.
   b. Studies that only focused on four-wheel electric vehicles without discussing EVCS infrastructure.

c. Literature in the form of opinions, editorials, or news articles without empirical data.

The literature selection process followed the following steps:
1. Identification: Relevant articles were identified through keyword searches in the database.
2. Screening: Titles and abstracts of the articles found were screened to ensure compliance with the inclusion criteria.
3. Eligibility Assessment: Articles that passed the screening were evaluated based on the full text to ensure relevance.
4. Synthesis: Eligible articles were collected for descriptive and thematic analysis.

Step	Description	Number of Journals/Articles
1. Identification	Article Search: The search was conducted in several databases such as Google Scholar, Scopus, IEEE Xplore, SpringerLink, ScienceDirect. The search used keywords related to EV adoption and EVCS development.	180
2. Screening	Initial Screening: Screening based on title and abstract to assess relevance. Articles that were not relevant or did not fulfil the inclusion criteria (year published, full access) were removed.	120
3. Eligibility	Full Text Screening: Read articles that passed the screening stage and ensured that they were relevant to the research focus (EV adoption and EVCS).	60
4. Inclusion	Final Inclusion: Articles that met the inclusion criteria and were relevant to the research question were included in further analyses.	15

4 Results

Electric vehicle (EV) adoption is highly dependent on the availability of reliable and accessible charging infrastructure. Key challenges such as “range anxiety” and limited public charging networks can be addressed through the development of fast-charging EVCSs with equitable distribution. Research also shows that higher income groups adopt EVs faster than other groups, so it is important to ensure equitable access to infrastructure in urban and rural areas. In addition, the development of data-driven policies to understand consumer behavior across different segments is necessary to encourage widespread EV adoption (Burra et al., 2024; Patel et al., 2024; Metais et al., 2021).

Consumer preferences for EVCSs include charging speed, strategic location such as shopping centers or rest areas, and affordable cost. Users also prioritize convenience of access, especially in densely populated areas. The technical design of EVCS that takes into account connector compatibility, innovative charging methods such as inductive, and renewable energy integration is critical for system efficiency and sustainability. This points to the need for a holistic approach that combines technical aspects and consumer preferences to ensure relevant and effective infrastructure development (Mastoi et al., 2022; Kumar & Alok, 2020; He et al., 2022).

In addition, the optimal location of EVCSs can increase EV adoption, especially in urban and suburban areas. Studies in Indonesia, for example, highlight the importance of locating EVCSs in shopping centers and rest areas to support the EV ecosystem. However, development in developing countries often faces regulatory and funding constraints. To address this, collaboration between the public and private sectors, as well as the implementation of technology-based dynamic incentive policies, can accelerate sustainable infrastructure development and support the transition to low-emission transportation (Yulistio & Satino, 2024; Haryadi et al., 2023; Metais et al., 2021).

Previous research consists of how EV adoption in each country, how important EVCS is for EV development and how user preferences in EVCS development. In this study, the researcher will try to provide EVCS specifications according to user preferences in toll rest areas and shopping centers (malls) using the conjoined choice analysis method, from user choices, weighting and making combinations of EVCS specifications desired by consumers and even potential EV consumers.

No	Peneliti	Judul Penelitian	Metode	Parameter			
				adoption factors of EV	Customer preferences of charging station	Design charging station	Context/location specificity
1	Patel et al. (2024)	EV adoption in India : barriers and policy solutions from manufacturers and consumers perspective	Analytic Hierarchy Process (AHP)	Faktor utama dalam adopsi EV adalah ketersediaan SPKLU, harga EV, insentif kebijakan dan keandalan tekhnologi	konsumen mengutamakan aksesibilitas, keandalan dan waktu pengisisan yang lebih singkat	mempertimbagnkan desaian yang meliputi kompatibilitas, penggantian baterai dan standarisasi SPKLU	berfokus di negara india dan menyarankan untuk membangun yang spesifik di region tertentu
2	Kumar & Alok (2020)	Adoption of Electric Vehicle : A Literature Review and Prospects for Sustainability	Tinjauan Integratif terhadap literatur	faktor adopsi EV yaitu dengan ketersediaan SPKLU, manfaat lingkungan, insentif kebijakan dan biaya konsumen	konsumen mengutamakan aksesibilitas, kecepatan pengisisan di SPKLU dan kenyamanan lokasi	desain adaptif dengan pengisisan cepat	fokus global

No	Peneliti	Judul Penelitian	Metode	Parameter			
				adoption factors of EV	Customer preferences of charging station	Design charging station	Context/location specificity
3	Yulistio & Satino (2024)	Legal Transplantation anf Funding for Public Electric Vehicle Charging Station in Achieving Zero Emissions	Legal transplantations theory	aksesibilitas SPKLU, regulasi yang jelas, insentif ekonomi, dan keselarasan dengan tujuan NZE	lokasi yang dekat dengan area perkotaan dan jalan tol, kemampuan SPKLU fast charging, integrasi dengan infrastruktur	penempatan sesuai syarat setiap 60 km, SPKLU Fast Charging	fokus pada jalan nasional di indonesia, khususnya di lampung
4	Y. He et al. (2022)	Factors affecting electric vehicle adoption intention : The impact of objective, perceived, and prospective charger accessibility	Expectation Confirmation Theory (ECT)	aksesibilitas ke SPKLU, manfaat lingkungan, pengalaman sebelumnya dari EV	penempatan di area padat dalam jarak 5menit dari rumah/tempat kerja, SPKLU Fast cahrging dan layanan andal	SPKLU yang padat, integrasi dengan infrastruktur, fokus pada SPKLU Fast cahrging, kompatibel dengan tesla	di hongkong yang padat penduduk dan kerbatasnya home charging
5	Pamidimukkala et al. (2023)	Evaluation of barriers to electric vehicle adoption : A study of technological, enviromental, financial, and infrastructure factors	Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM)	biaya pembelian EV, kurangnya SPKLU, biaya penggantian baterai yang tinggi	ketersediaan SPKLU, SPKLU Fast charging dan layanan yang andal	meningkatkan kepadatan SPKLU fast charging, meningkatkan perawatan keandalan	fokus apda konsumen di Ameriaka Serikat
6	LaMonaca & Ryan (2022)	The statae of play in electric vehicle charging services - A review of infrastructure provision, players, and policies	public good vs. private asset perspectives in EV infrastructure, examining policy and market mechanisms essential for EV adoption	aksesibilitas ke SPKLU, infrastruktur yang andal, efektivitas biaya, kebijakan yang mendukung	keceptan pengisisan, kepadatan SPKLU dikota dan area tol, ketersediaan SPKLU Fast cahrging	disesuaikan dengan kebutuhan pengguna dan kecepatan pengisian	fokus global pada kebutuhan pengisisan perkotaan
7	Mastoi et al. (2022)	An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends	Analisa transisi kendaraan berbahan bakar fosil ke EV	aksesibilitas, keterjangkauan, manfaat lingkungan, infrastruktur yang andal, dan kebijakan yang tepat	mengutamakan SPKLU Fast charging, jaringan yang andal dan integrasi ke infrastruktur	fokus kepada model yang beragam, integrasi EBT dan dukungan berbagai standar kendaraan	fokus global untuk klaerah perkotaan dan pedesaan
8	Metais et al. (2021)	Too much or not enough? Planning electric vehicle charging infrastructure: A review of modeling options	Analyzes three main modeling approaches: node-based, path-based, and tour-based approaches, each with different applications depending on urban or highway needs and data availability	aksesibilitas SPKLU, keandalan ifrastruktur, biaya dan kepercayaan konsumen	kedekatan lokasi SPKLU, SPKLU Fast charging, efisiensi biaya	desain fleksibel	fokus global dengan menyoroti kebutuhan antar kota
9	Liu et al. (2023)	The impact of green consumers on electric vehicle charging station diffusion based on complex network evolutionary game	Combine complex network theory and evolutionary game theory	SPKLU yang mudah di akses, subsidi pemerintah, manfaat lingkungan, desain harga	harga SPKLU yang terjangkau, lokasi strategis, SPKLU yang andal	desain fleksibel	pasar EV di Tiongkok

No	Peneliti	Judul Penelitian	Metode	Parameter			
				adoption factors of EV	Customer preferences of charging station	Design charging station	Context/location specificity
10	Globisch et al. (2019)	Consumer preferences for public charging infrastructure for electric vehicles	Conjoint analysis by rating	kesadaran lingkungan	SPKLU fast cahrging dan lokasi yang nyaman	SPKLU Fast charging	preferensi bervarisai berdasarkan demografi
11	Haryadi et al. (2023)	Investigating the Impact of Key Factors on Electric/Electric-Vehicle Charging Station Adoption in Indonesia	Combination of exploratory factor analysis and binary logistic regression	aksesibilitas ke SPKLU, kenyamanan lokasi, biaya pengisisan,	dekat dengan tempat kerja, ketersediaan infrastruktur	lokasi strategis dengan infrastruktur memadai	fokus kota besar di Indonesia
12	Qian et al., (2023)	Dynamic Consumer Preferences for Electric Vehicles in China: A Longitudinal Approach	consumer behavior such as the diffusion of innovation theory, technology acceptance model, and value-attitude-behavior	kompatibilitas dengan SPKLU	kepadatan SPKLU Fast charging dan kemampuan homecharging	homecharging	kota2 kecil
13	Qian et al., (2024)	Spatial cross-side network effect of charging stations on electric vehicle aoption	Cross-side network effects and spatial econometrics	aksesibilitas ke infrastruktur SPKLU, harga kendaraan, harga bahan bakar, kebijakan pemerintah	SPKLU fast charging yang terletak strategis di jalan raya ataupun di perkotaan, SPKLU slow charging yang terletak di lokasi perhotelan	SPKLU fast charging 90-200 kW di perkotaan dan SPKLU dengan daya 19,2 kW di perhotelan	fokus hanya untuk tesla
14	Burra et al., (2024)	Impact of charging infrastructure on electric vehicle adoption : A synthetic population approach	Utilized discrete choice modeling and Bayesian network-generated synthetic populations	tingkat pendapatan, SPKLU fast charging, SPKLU pada lokasi kerja, karakteristik perumahan	SPKLU pada lokasi kerja memberikan kenyamanan untuk melakukan adopsi EV	SPKLU Fast charging	fokus di Maryland, Amerika Serikat
15	Luo et al., (2022)	Dynamic subsidies for synergistic development of charging infrastructure and electric vehicle adoption	Utilizes dynamic game theory and principal-agent models to address the interaction between EV adoption and charging infrastructure development	subsidi, ketersediaan SPKLU, inovasi otomotif dan manfaat ekonomi	aksesibilitas dan keandalan SPKLU dan integrasi dengan tempat tinggal serta kantor	SPKLU Fast charging	fokus kepada EV dan kebijakan infrastruktur di China

5 Discussion

1. Factors Influencing Electric Vehicle (EV) Adoption

Electric vehicle (EV) adoption is influenced by a variety of interrelated factors, both individual and macro. Some of the key factors that influence consumers' decision to switch to EVs include:

a. Price and Financial Incentives: While the initial cost of electric vehicles tends to be higher compared to fossil-fuelled vehicles, government incentives such as subsidies and tax reductions can increase the attractiveness of EVs to consumers. This is especially true in markets with policies that favour clean energy.

b. Charging Infrastructure: The availability of widespread and easily accessible charging stations is a key factor in increasing the convenience of electric vehicle use. The better this infrastructure is, the more willing consumers will be to switch to EVs.

c. Environmental Awareness: Awareness of climate change and air pollution is driving environmentally conscious consumers to switch to electric vehicles as a greener alternative.

d. Performance and Reliability: Developments in battery technology that increase the mileage and battery life of electric vehicles contribute greatly to EV adoption. Consumers increasingly believe that electric vehicles can fulfil their daily needs efficiently.

e. Social and Cultural Factors: Societal attitudes and social opinions also play a role in EV adoption. If EVs are perceived as a status symbol or a popular modern choice, this can accelerate their adoption among certain demographic groups.

f. Government Policies: Government policies that support the transition to electric vehicles, such as emission restrictions for fossil-fuelled vehicles or incentivising EVs, also factor heavily into adoption rates.

2. EVCS Infrastructure Design and Development

The development and design of SPKLU infrastructure plays a crucial role in driving the mass adoption of electric vehicles (EVs). Some important factors that influence the design and development of SPKLUs include:

a. Location and Accessibility: Strategic location selection, such as in city centres, along major transportation routes, and high-traffic public areas, is critical to ensure user convenience in accessing charging stations.

b. Charging Technology and Capacity: The adoption of fast-charging technologies and charging systems compatible with different types of electric vehicles is essential to meet the needs of various consumers. This will reduce waiting time and improve the operational efficiency of the SPKLU.

c. Scalability and Availability: Infrastructure should be designed to be easily expandable as the number of electric vehicles increases. Additional charging

capacity, as well as an increase in the number of stations spread across the region, will greatly support the sustainability of EV adoption.

d. Integration with Renewable Energy Systems: Integrating SPKLUs with renewable energy sources, such as solar panels or wind, can reduce the environmental impact of EV use and strengthen the impression of sustainability.

e. Government Regulations and Policies: Clear government policy support for SPKLU development, including incentives for infrastructure providers and setting technical standards, is essential to encourage investment and accelerate the development of charging networks.

f. Safety and Reliability: The design of SPKLU should consider safety aspects for users and technical reliability to keep the charging station functioning optimally in the long run.

3. Location and Optimisation of EVCS

The siting and network optimisation of Electric Vehicle Charging Stations (EVCS) is one of the critical factors in supporting the widespread adoption of electric vehicles. Based on the literature review, some of the key aspects to consider in EVCS site selection and optimisation are:

a. Strategic Location Considerations: The selection of an optimal location for EVCS should consider factors such as proximity to centres of economic activity (e.g. shopping malls, office buildings), accessibility from major roads, as well as proximity to densely populated settlements. A convenient location will make it easier for users to access the charging station and encourage the use of electric vehicles.

b. Population Density and Traffic Density: To optimise the distribution of charging stations, it is necessary to consider the population density and traffic volume in a region. Locations with high vehicle density or areas that are rapidly growing in the use of electric vehicles need to be equipped with more SPKLUs to meet the increasing charging demand.

c. Infrastructure Availability and Integration: EVCS locations should consider the presence of other supporting infrastructure such as parking, security, and integration with the renewable energy grid. The presence of supporting infrastructure will increase the convenience and reliability of EVCS usage.

d. Optimisation Algorithms for EVCS Networks: The use of information technology-based optimisation methods and algorithms (such as mathematical programming algorithms, artificial intelligence, and big data analysis) can help plan and distribute EVCS locations more efficiently. This

includes user demand modelling, station capacity analysis, and charging times and costs.

e. Economic and Sustainability Analysis: The financial and economic sustainability of an EVCS network largely depends on choosing the right locations. A more strategic location allows the station to attract more users, thus increasing the profitability and sustainability of the project. In addition, integration with renewable energy sources is also an important factor in ensuring long-term sustainability.

f. Role of Policy and Regulation: Government policies related to emission restrictions, infrastructure development incentives, and zoning regulations also influence EVCS location and development decisions. Policies that support the development of EVCS will encourage the growth of a more extensive and efficient charging network.

4. Technology Innovation and Sustainability in EV Charging

Technology innovation and sustainability in electric vehicle (EV) charging are key factors in accelerating EV adoption and ensuring that charging infrastructure remains efficient and environmentally friendly. Some of the key findings that can be summarised from the study on technology and sustainability in EV charging include:

a. Innovation in Charging Technology: Evolving charging technologies, including DC fast charging and wireless charging, can reduce long charging times, improve user convenience, and accelerate electric vehicle adoption. Research is also leading to the development of smart charging systems that can optimise energy use based on supply and demand, and reduce the load on the power grid.

b. Renewable Energy Integration: One of the key aspects of EV charging sustainability is the use of renewable energy such as solar and wind power in the charging process. Integrating renewable energy sources into EV charging stations (SPKLUs) not only reduces the carbon footprint of EV operations, but also supports the transition to a cleaner and greener energy system.

c. Smart Grid Based Charging System: The integration of SPKLU with smart grid technology enables more efficient power management and distribution. Smart grids can match charging to the capacity of the existing power grid, as well as minimise energy waste and ensure optimal energy use. This is critical to creating an economically and ecologically sustainable charging system.

d. Energy Management and Storage: The use of energy storage technologies, such as large batteries or renewable energy storage systems, can help address fluctuations in energy supply and improve the stability of electricity supply for vehicle charging. This energy storage also enables EVCS to charge at cheaper and environmentally friendly times, when renewable energy production is at its peak.

e. Reduced Emissions and Environmental Impact: While electric vehicles are considered more environmentally friendly than fossil-fuelled vehicles, the sustainability of the charging infrastructure must also be considered. The use of green materials in the construction of SPKLUs, as well as the processing and disposal of charging technology components, can help reduce the environmental impact of the entire EV charging infrastructure lifecycle.

f. Role of Policy and Funding: Government policies that support innovation in EV charging technologies, such as incentives for the development of green technologies and EV infrastructure, are essential to encourage the development of more environmentally friendly and efficient technologies. Funding and investment in research and development of new technologies will accelerate the technological breakthroughs needed to advance the sustainability of EV charging.

5. General Limitations and Recommendations for Further Research

While this research provides important insights into the development and sustainability of electric vehicle charging infrastructure (EVCS), some limitations found in this study are as follows:

a. Data Limitations: One of the main limitations in this study is the lack of empirical data regarding the actual usage and performance of electric vehicle charging stations in various geographic and demographic locations. The study may have focused on simulated scenarios or data from limited regions, which does not fully illustrate the variation in market conditions and user behaviour of electric vehicles.

b. Limitations in Technology Analysis: While there is discussion of technological innovations in charging, in-depth analyses of new emerging technologies, such as wireless charging and blockchain-based charging technologies, may be limited. In addition, technical challenges related to the implementation and interoperability of various charging technologies are also not comprehensively discussed.

c. Economic Factors and Financial Sustainability: This study focuses more on the technical and environmental aspects of EVCS, while economic factors, including long-term development and operational costs, as well as the

financial sustainability of the SPKLU business model, have received less attention. This is important for a better understanding of the economic challenges faced by infrastructure providers and end-users.

d. Limitations in Generalisability: This research may be based on specific contexts, such as country-specific conditions or specific types of electric vehicles. Therefore, the findings and recommendations may not be fully applicable to countries or regions with different social, economic or regulatory conditions.

e. Policy and Regulatory Aspects: While the role of government policies in the development of EVCS is mentioned, in-depth analyses of the influence of public policies at local, regional and international levels on EVCS investment and development decisions have not been sufficiently detailed. The study may have under-explored how different regulations affect the pace of infrastructure adoption and development.

A review of journals on Public Electric Vehicle Charging Stations (EVCS) shows the advantages of a comprehensive approach, especially in incorporating technical, social, economic and policy factors to increase electric vehicle (EV) adoption. For example, Patel et al. (2024) and Kumar & Alok (2020) highlight the importance of charging infrastructure in overcoming barriers such as "range anxiety" and increasing user confidence. Other studies, such as Burra et al. (2024), use synthetic population-based data to evaluate the impact of charging infrastructure on EV adoption at the micro-geographic level, providing relevant insights for local policies.

Some studies provide an in-depth focus on charging locations and technologies, such as Mastoi et al. (2022) and Metais et al. (2021), which emphasize the importance of strategic location of EVCSs to maximize services while minimizing costs. In Indonesia, Yulistio & Satino (2024) highlighted the relevance of regulation and funding challenges in EVCS development. However, while these studies provide valuable insights, many fall short of highlighting global standards of charging technology and consumer-specific preferences, especially in the context of developing countries.

Other shortcomings include the reliance on stated preferences surveys that may not reflect real user behavior, as noted in Burra et al. (2024). There is also limited research relevant to consumer preferences for EVCS technical design. In addition, studies often focus on the experiences of developed countries, leaving gaps in the context of developing regions that have unique challenges in regulation, funding and market acceptance.

As a recommendation, future research needs to focus on the design of EVCS specifications that consider consumer preferences and location-specific needs.

This approach not only increases technical relevance, but also provides a strong basis for policy development that supports businesses in providing efficient and user-friendly infrastructure. The combination of empirical data, consumer preferences, and local regulations will help build a sustainable and inclusive electric vehicle ecosystem.

Each of the journals discussed makes an important contribution to understanding electric vehicle adoption and EVCS development. However, there are some limitations that need to be considered, such as:

Limited geographic coverage of many studies, which reduces the generality of the results.

Insufficient focus on social and psychological factors that can strongly influence consumer decisions.

Limitations of the methodologies used in some journals, which emphasise quantitative or technical analysis without relating it to consumer experiences or the broader socio-economic context.

However, the main strength of these journals is that they provide in-depth understanding and empirical data that is very useful for infrastructure developers and policy makers interested in supporting electric vehicle adoption through the development of effective EVCSs.

6 Conclusion

The development of EVCSs in Indonesia must prioritize user preferences, strategic deployment, and sustainable designs to promote EV adoption. Rest areas and shopping malls are key locations for high-impact infrastructure deployment. Future research should explore advanced technological solutions and collaborative frameworks to overcome deployment challenges and optimize infrastructure utility.

The objectives of this study are as follows:
1. To find out what factors influence the interest of electric vehicle users to charge at EVCS in rest areas and shopping centers (malls).
2. To find out the right combination of factors that are of interest to electric vehicle users to build Public Electric Vehicle Charging Stations (EVCS) in rest areas and shopping centers (malls).
3. To develop managerial implications for PT PLN (Persero) UID East Java in building EVCS in rest areas and shopping centers (malls).

Acknowledgement

The authors would like to thank Fakultas Teknologi Industri, Institut Teknologi Bandung for supporting this study.

References

[1] Patel, M., Singh, R., Arora, P., & Mahapatra, D. EV adoption in India: Barriers and policy solutions from manufacturers' and consumers' perspectives. *Energy for Sustainable Development,* 2024, *83*, 101583.

[2] Kumar, R. R., & Alok, K. Adoption of electric vehicle: A literature review and prospects for sustainability. *Journal of Cleaner Production, 2020, 253*, 119911.

[3] Yulistio, M. R., & Satino. Legal Transplantation and Funding for Public Electric Vehicle Charging Stations in Achieving Zero Emissions. *Jurnal Legalitas dan Perubahan Hukum, 2024, 4*(6), 2287-2292.

[4] Sylvia Y. He, Shuli Luo, & Ka Kit Sun. Factors affecting electric vehicle adoption intention: The impact of objective, perceived, and prospective charger accessibility. *Journal of Transport and Land Use, 2022, 15*(1), 779–801.

[5] Apurva Pamidimukkala, Sharareh Kermanshachi, Jay Michael Rosenberger, & Greg Hladik. Evaluation of barriers to electric vehicle adoption: A study of technological, environmental, financial, and infrastructure factors. *Transportation Research Interdisciplinary Perspectives, 2023, 22*, 100962.

[6] Sarah LaMonaca & Lisa Ryan. The state of play in electric vehicle charging services – A review of infrastructure provision, players, and policies. *Renewable and Sustainable Energy Reviews, 2022, 154*, 111733.

[7] Muhammad Shahid Mastoi, Shenxian Zhuang, Hafiz Mudassir Munir, et al. An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends. *Energy Reports, 2022, 8*, 11504–11529.

[8] Marc-Olivier Metais, Jouini, O., Perez, Y., Berrada, J., & Suomalainen, E. Too much or not enough? Planning electric vehicle charging infrastructure: A review of modeling options. *Renewable and Sustainable Energy Reviews, 2021.*

[9] Feng Liu, Xingjun Huang, & Longxiao Li. The impact of green consumers on electric vehicle charging station diffusion based on complex network evolutionary game. *Energy & Environment, 2023.*

[10] Haryadi, Fajar Nurrohman, et al. Investigating the impact of key factors on electric/electric-vehicle charging station adoption in Indonesia. *International Journal of Energy Economics and Policy, 2023, 13*(3), 434–442.

[11] Globisch, J., Plötz, P., Dütschke, E., & Wietschel, M. Consumer preferences for public charging infrastructure for electric vehicles. *Transport Policy, 2019, 81*, 54–63.
[12] Qian, L., Huang, Y., Tyfield, D., & Soopramanien, D. Dynamic consumer preferences for electric vehicles in China: A longitudinal approach. *Transport Research Part A: Policy & Practice, 2023.*
[13] Qian, L., Zhang, C., Chen, Y., & Xiao, Z. Spatial cross-side network effect of charging stations on electric vehicle adoption. *Transport Research Part D: Transport and Environment, 2024, 136*, 104400.
[14] Burra, L. T., Al-Khasawneh, M. B., & Cirillo, C. Impact of charging infrastructure on electric vehicle adoption: A synthetic population approach. *Travel Behaviour and Society, 2024, 37*, 100834.
[15] Luo, Q., Yin, Y., Chen, P., & Zhan, Z. Dynamic subsidies for synergistic development of charging infrastructure and electric vehicle adoption. *Transport Policy, 2022, 129*, 117–136.