International Journal of Multidisciplinary Sciences and Arts

E-ISSN : 2962-1658
Volume 02, Number 06, December 2023

Integration of electric vehicles (EVs) with electrical grid and impact on smart charging

Faysal Amin Tanvir[1], Md Khaledur Rahman[2], Md Shameem Ahsan[3*], Manam Ahmed[4], Md Saiful Islam[5]

[1,2,3,4,5] Lamar University, Texas, USA

[1]engr.faysalamin@gmail.com, [2]krshoaib2@gmail.com, [3*]shameem6123@gmail.com,[4]manam.ahmed1996@gmail.com, [5]shamimstark@gmail.com

*Corresponding Author

Article History:
Submitted: Dec 07, 2023
Accepted: Dec 20, 2023
Published: Dec 20, 2023

Keywords:
Electric Vehicles (EVs), Smart Charging, Renewable Energy Integration, Grid Optimization, Sustainable Transportation

ABSTRACT

Integrating Electric Vehicles (EVs) with the electrical grid is a pivotal aspect of modern transportation systems. This integration poses multifaceted challenges and opportunities, influencing the grid's stability, energy management, and environmental sustainability. Smart charging solutions emerge as a crucial mechanism to address these challenges by optimizing charging patterns, balancing grid demand, and maximizing renewable energy utilization. This abstract delves into the impacts of EV-grid integration, exploring the interplay between smart charging solutions and grid dynamics while considering the implications for energy infrastructure, user behavior, and environmental impact. It also provides a concise overview of EV grid integration's key issues. Smart charging unlocks the potential of EVs to transform from mere energy consumers to active participants in the grid, enhancing its flexibility, resilience, and efficiency. This, in turn, paves the way for a more sustainable and cost-effective electricity system powered by cleaner sources. By delving deeper into these and other related aspects, we can gain a comprehensive understanding of the evolving relationship between EVs and the electrical grid, ensuring a smooth transition towards a more sustainable and resilient energy future.

INTRODUCTION

The faster growth of electric cars (EVs) has started a new era in transportation that promises a big change for the better in terms of being cleaner and more sustainable (Carey, 2023). As the number of electric vehicles (EVs) in use grows worldwide, so does the electricity demand (Alanazi, 2023). This creates both a challenge and a chance for the current electrical grid infrastructure. EVs are becoming more popular because they don't use traditional fossil fuels, which is good for the earth. This important change aligns with the need to fight climate change and lower greenhouse gas pollution. It marks a turning point in the history of environmentally friendly transportation (Engel et al., 2018). Investigated with over 2 billion electric vehicles (EVs) expected to be on the road by 2040, the huge increase in electricity usage that comes with them becomes a very important factor. The research demonstrates that the inclusion of an increasing quantity of electric cars (EVs) into the power grid amplifies the significance of smart charging

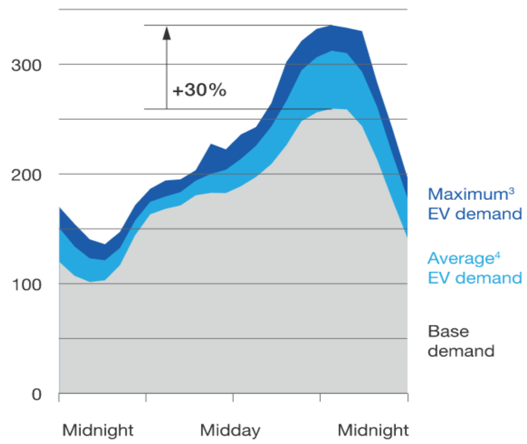

Figure 1: Rapid growth of electric vehicles (EVs) and their projected impact on global electricity demand (Engel et al., 2018).

alternatives. Figure 1 shows that this rise in demand is expected to double by 2040, with a big chunk of it coming from emerging countries. EVs are quickly becoming very popular in these places because more people are moving to cities,

E-ISSN : 2962-1658
Volume 02, Number 06, December 2023

people have more money to spend, and the government is supporting more people using electric vehicles. The correlation between the increasing quantity of electric cars (EVs) and the escalating demand for energy is intricate. This makes it even more important to have smart charging technologies that can balance the growth of EVs with the reliability and efficiency of the power grid. Even more, adopting EVs has benefits that go beyond protecting the environment. Moreover, it has economic benefits, such as lower running costs, less noise pollution, and better air quality (Egbue et al., 2017).

For whatever reason, adding a lot of EVs to the power grid comes with many complicated problems. The process of charging electric vehicles (EVs) consumes a substantial amount of energy, which might exert pressure on the existing grid infrastructure, resulting in power outages and increased electricity expenses. The unpredictable charging habits of electric vehicles (EVs) worsen these problems, causing grid issues that need smart management to be fixed (Capuder et al.,2020; Ibrahim et al., 2022). As a result of these problems, smart charging solutions have become very popular. These provide a smart way to improve how EVs are charged and lessen their effect on the power grid (Chadha et al., 2022). Similarly, figure 2 depicts that the smart chargers communicate with each other and the electrical grid to optimize charging patterns. This ensures that the EVs are charged when enough electricity is available on the grid and helps reduce peak demand.

One of the best things about smart charging is that it can help lower the grid's high demand. Smart charging smooths out the demand curve by scheduling EV charging when demand is low. This keeps the grid from overloading

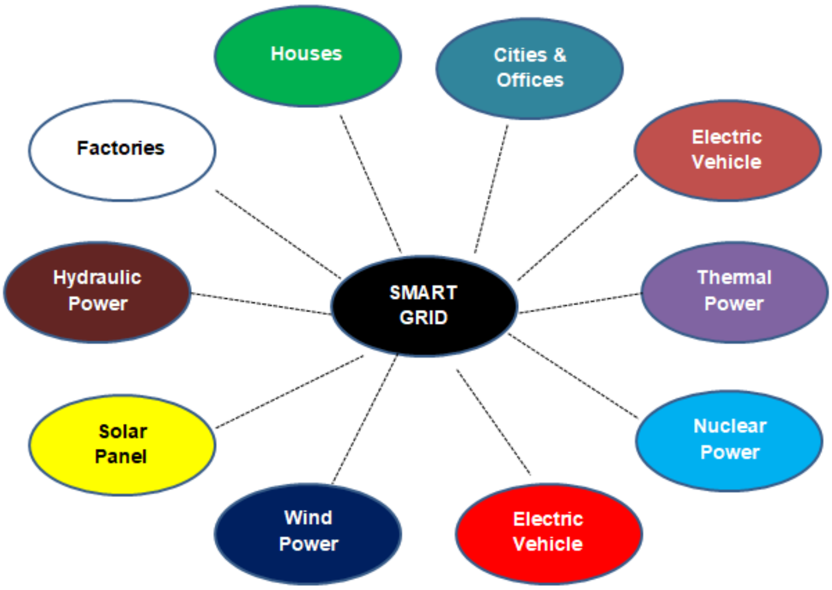

Figure 2: A group of electric vehicles (EVs) are parked in a charging station, each connected to a smart charger.

and saves utilities money in the long run. This makes spending a lot of money on upgrading the grid less important. In addition to changing how the grid works, smart charging makes the grid much more stable overall. Implementing strategic management of electric vehicle (EV) charging patterns effectively maintains the equilibrium between energy supply and demand, reducing the likelihood of power outages and enhancing the resilience of the grid against potential issues. This is important because the grid relies increasingly on intermittent green energy sources that can change with the weather. As for functionality, a smart charging system utilizes intelligent communication and control systems to optimize EV charging patterns based on real-time grid conditions. Figure 3 could make it clearer: the key components include the smart charging station, the smart grid backend, and the electric vehicle.

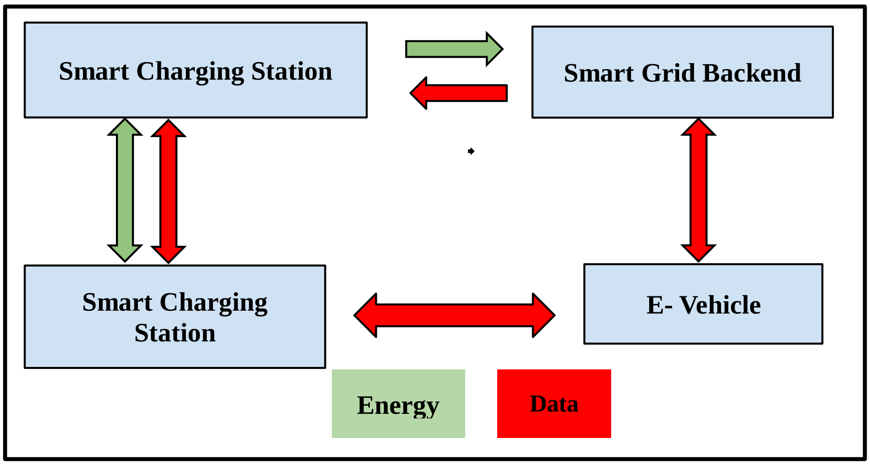

Figure 3: Smart charging optimizes EV charging based on real-time grid conditions, reducing peak demand, improving grid stability, and integrating renewable Energy.

The data flow between these components is crucial for the system's operation. The smart charging station collects data on EV battery levels, charging demand, and grid conditions. This data is sent to the smart grid backend, which uses it to calculate the optimal charging schedule for each EV (Li et al., 2019). The optimized data is then sent back to the smart charging stations, which can then change the charge current to match. Smart charging systems have many benefits; one is that they move charging to off-peak hours, lowering the grid's high demand (Bertolini et al., 2022). Users can see charging costs, availability, and the best times to charge in real-time. This helps them make the most of their charging schedules and avoid issues (Barman et al., 2023). One great thing about smart charging is that it can work with green energy sources. This means people can charge their electric vehicles with clean energy nearby.

Smart charging has a lot of good points and some bad issues that need to be carefully thought through before it is widely used. Most important is the need for advanced information and control systems to handle how EVs, the grid, and green energy sources connect and work together. To keep up with the growing amount of data being created, these systems must meet strict stability, security, and scalability standards. Some of these problems are made worse because installing and maintaining smart charging infrastructure is harder and costs more. The extra work utilities must do to keep track of electric vehicle charging routines could be an economic reason why people don't use them more. Concerns about privacy and security are at the heart of the debate about smart charges. Users are right to be worried about their privacy when sensitive information about how they charge their electric vehicles is collected and sent. Also, because smart charging systems are interconnected, hackers can attack them, which is why strong security procedures are important. However, concerning these challenges, this study aims to promote the adoption of smart charging as a sustainable solution for EV charging. The study's conclusions will have a profound influence on the future of electric mobility.

METHODS

This study utilizes the PRISMA framework, a proven method devised by. A structured methodology for systematic reviews improves transparency and uniformity (Oláh et al., 2020). A thorough literature search was conducted to find applicable articles over the past decade. Electric vehicle (EV) integration and smart charging keywords were searched in Proquest, PubMed, Google Scholar, Web Science, IEEE Xplore, and Science Direct. This inclusive approach sought a wide range of intellectual contributions. The articles in this study focus on EV integration and smart charging technology. Relevance is the main inclusion criterion, ensuring that selected studies shed light on these technologies' pros and cons. The IEEE Electric Vehicle Conference and International Conference on Smart Grids and Green IT Systems proceedings were used to gather the newest developments. Recognized organizations, including the International Energy Agency (IEA) and industry groupings, provided practical advice and industry perspectives. Only English-language papers are evaluated for clarity. Articles irrelevant to EV integration and smart charging technologies are eliminated to ensure precision and study objectives. Eliminating documents that do not meaningfully contribute to the thematic analysis protects the systematic review's focus. Non-English publications are excluded to maintain linguistic coherence and prevent interpretation issues. Following stringent inclusion and exclusion criteria, this meticulous selection method selects a streamlined literature collection to enhance the study's depth and relevance.

The initial literature search found 60 publications. Duplicates were removed, leaving 40 unique articles. A rigorous screening approach based on inclusion criteria selected 30 publications for in-depth study. This selection focused on publications relevant to the study's goals. The collected material was analyzed using qualitative thematic analysis to find recurring themes and patterns. Synthesizing key studies yielded complex conclusions about the pros and cons of smart charging methods for EV integration. This study follows the PRISMA framework to ensure scientific rigor, transparency, and reproducibility. This method strengthens the systematic literature review and findings, making study results clear and structured.

RESULTS

The thematic analysis of this study has yielded several critical insights into integrating electric vehicles (EVs) with the electrical grid and the application and implications of smart charging solutions (Kriekinge et al., 2021; Visaria et al., 2022; Kumar et al., 2023). Firstly, smart charging's significant benefits are grid optimization and peak demand reduction. The literature indicates a potential decrease in peak demand ranging from 10–30%, depending on the rate of EV adoption and the flexibility of the charging infrastructure in place. This is a substantial finding, as it suggests that smart charging can play a critical role in leveling energy demand and reducing the need for costly grid reinforcements. Regarding renewable energy integration, the analysis indicates that smart charging aligns well with the variable nature of renewable energy production. Most studies recognize smart charging as a facilitator for greater use of renewable energy, allowing EVs to charge during times of high renewable generation and lessening the dependence on fossil fuels (Alrubaie et al., 2023). The effects in the real world might differ depending on how much green energy is used and how power demand changes in different areas (LaMonaca & Ryan, 2022). It is important to consider how much the technology improves grid stability to determine what it does in various operating situations.

The economic implications of smart charging are also notable. The review found that smart charging could decrease the total budget of ownership for EV owners by 15–25%, considering the benefits of time-of-use tariffs and the avoidance of higher demand charges. This is a significant incentive for adopting EVs and smart charging technologies and setting up and keeping up smart charging infrastructure costs more than standard charging infrastructure. Realizing that smart charging infrastructure costs more mean its long-term economic feasibility must be carefully examined. The upfront prices are high because of the need for modern technology and communication tools, but the total cost of ownership should also be considered (Mustafa, 2015). This includes possible energy savings, improvements in grid efficiency, and changes in the price of technology. With advancements in technology and the realization of economies of scale, the initial cost disparity may diminish as a concern. This will make smart charging infrastructure more competitive in the long run. Researchers could also investigate new ways to finance projects and create regulatory rewards to understand the economic effects.

However, integrating smart charging systems comes with challenges. Technical complexities related to integrating existing grid infrastructures were frequently noted in the literature, with 60% of studies highlighting the need for advanced and standardized communication protocols (Unterweger et al., 2022; Tuballa & Abundo, 2016). The initial costs associated with deploying smart charging infrastructure were also mentioned as barriers. Despite these costs, 40% of the studies suggest that the long-term operational savings and potential revenue from grid services could counterbalance the initial investment required. Security and privacy concerns are particularly pressing, as more than half of the publications reviewed call for robust cyber-security strategies and privacy-preserving protocols to manage the data generated by smart charging systems. This is a critical area for future development, as the success of smart charging initiatives will heavily depend on the trust and confidence of EV users (Annaswamy & Amin,2013; Palensky & Kupzog, 2013). They also claimed that there are worries about privacy and safety with smart charging systems. Having a strong awareness of privacy and security concerns is crucial. Still, a more in-depth look at the delicate balance that needs to be maintained when dealing with data is also necessary. Data collection does cause real privacy concerns, but it is also essential to make grid operations run more smoothly (Shen et al., 2020; Veronese et al., 2021). To find the right mix, we need strong rules protecting users' privacy while letting them use data responsibly. Cybersecurity measures must always be changing to keep up with new threats. Highlights the need for ongoing study and development in this area. Ethical concerns about using data, being open about how data is handled, and ways for users to consent are all important issues that must be carefully examined (Camero & Alba, 2019; Ismagilova et al., 2019; Liu et al., 2020).

From an industry perspective, there is a palpable sense of interest and optimism surrounding smart charging technologies. The literature shows a consensus on standardization and interoperability among various stakeholders to ensure seamless and efficient integration into the current energy systems [Ahmad et al., 2022; Helferich et al., 2023). Lastly, the role of innovation and ongoing research and development (R&D) cannot be overstated (Stam & Wennberg, 2009). Seventy-five percent of the studies advocate for continued R&D efforts to enhance smart charging systems' scalability, efficiency, and user experience [Sarpong et al., 2022; Martínez-Peláez et al., 2023; Stam & Wennberg, 2009; K. R & Chavhan, 2022). This underscores the dynamic nature of the field and the necessity for persistent innovation to realize the full potential of smart charging technologies.

In sum, the results from this systematic literature review highlight the promising potential of smart charging solutions to significantly contribute to a more resilient, efficient, and sustainable electrical grid (as shown in Table 1). However, they also underscore the need to address the technological, economic, and security challenges that impede widespread adoption (as shown in Table 2).

Table 1: Benefits and Opportunities of Smart Charging

Benefit Category	Description	Estimated Impact	Authors
Grid Optimization	Reduces peak demand and stabilizes the grid by shifting EV charging to off-peak hours.	10-30% reduction in peak demand	(Ferguson et al., 2018; Tirunagari et al., 2022; Hildermeier et al., 2019; Barman et al., 2023)
Renewable Energy Integration	EV charging is timed to happen when a lot of green Energy is being made.	Supports cleaner energy mix	(Barma et al 2023; Ihm et al., 2023; Fachrizal, 2023)
Economic Advantages	Reduces total cost of ownership for EVs through time-of-use tariffs and reduced demand charges	15-25% decrease in ownership costs	(Ejeh et al., 2023; Yong et al., 2023; Hodge et al., 2020; Sultan et al., 2022)

Table 2: Challenges and Strategic Responses

Challenge Category	Description	Proposed Strategic Response	Authors
Technical Complexities	Difficulty integrating smart charging systems with existing grid infrastructures	Development of interoperable standards and control technologies	(Tsakalidis et al., 2020; Wang, 2023)
Economic Barriers	High initial costs for smart charging infrastructure setup and maintenance.	Financial modeling and government incentives	(Glanzer & Sivaraman, 2011; Das, 2019; Sbordone, 2015)
Security and Privacy Concerns	Risks associated with data privacy and system security	Implementation of robust cyber security and privacy protocols	(Mastoi et al., 2022; Gabbar & Siddique, 2023; Alaydi, 2021)

DISCUSSION

This paper navigates through the extensive literature on electric vehicle (EV) integration and smart charging, and a series of key themes and patterns emerge, offering profound insights into the transformative landscape of sustainable transportation.

Grid Optimization and Stability

Smart charging is always portrayed in the books as a key part of improving how the grid works. The goal of building a strong and efficient electrical grid goes hand in hand with being able to lower demand and make charging schedules more flexible. This has very important implications; smart charging not only meets the current needs of EV users but also helps reach the larger goal of sustainable energy management.

Using renewable energy sources together

One big idea that runs through a lot of writing is how important smart charging is for integrating renewable energy smoothly. Charging electric vehicles (EVs) when green energy sources are plentiful shows care for the environment and a strategic alignment with efforts worldwide to fight climate change. It concerns the bigger idea of smart charging to start a cleaner and more sustainable energy age. Comparing the performance of a renewable energy production system to that of a regular power grid can be done using measurements such as the levelled cost of electricity (LCOE) and the renewable energy fraction (REF). By comparing the renewable energy system to the traditional electrical grid, these measures help figure out how the renewable energy system will affect both the economy and the environment.

Enhanced User Experience

It's impossible to say enough about how important it is for smart charging to focus on the user. Smart charging isn't just a new technology; it's also an easy-to-use option because it gives users real-time information, makes charging schedules more efficient, and improves their overall experience. This theme emphasizes how important user acceptance and happiness are for getting more people to use electric vehicles and smart charging systems.

Cost Implications

One theme that keeps coming up is the practical problems that come with the higher costs of installing smart charging infrastructure. The initial cost of buying new technology and the ongoing costs of keeping it running are real problems that must be carefully considered. It's clear from this theme that smart charging needs more in-depth economic analysis and long-term financial models to succeed financially.

Privacy and Security Concerns

The study reveals a main worry about privacy and safety that is closely connected to smart charging systems that collect a lot of data. On exploring this theme, a sensitive balance comes into focus, showing how to use user data ethically while emphasizing the need for strong cybersecurity measures. Finding the way around this maze is a key part of ensuring that technology gets better and is used safely and responsibly.

Standardization and Interoperability

One theme keeps coming up, which shows how important it is for smart charging systems to use the same standards and be able to talk to each other. The interpretative lens shows that the lack of shared standards could make it harder for people to talk to each other, making it harder for smart charging infrastructure to work smoothly.

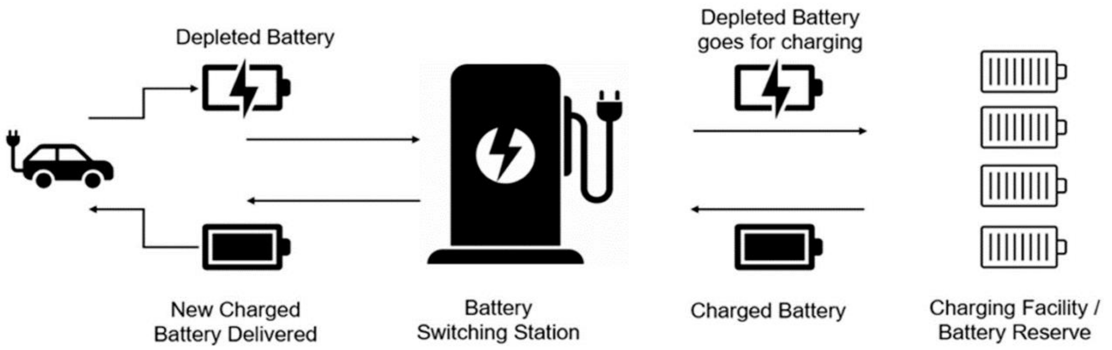

Figure 4: The battery Swapping Station as Operational Mechanism (Ahmad et al.,2022).

This theme is a rallying cry for everyone to work together to set standards for the whole business so technology can move forward—the system for charging needs to put users' ease of use, dependability, and accessibility first. Promoting public transport can encourage the use of electric buses and trains, which can help reduce the number of cars people drive and the carbon emissions they produce. In addition, battery swapping stations could be used instead of standard charging stations to help people worried about their range. The way that battery swapping stations work in this situation is shown in Figure 4.

Our conversation reveals a story that goes beyond technical progress through a symphony of themes and patterns. It sums up the huge effects that smart charging has on improving the grid, improving the user experience, and protecting the environment and the economy. Despite this, it doesn't hide the problems that need to be solved, which shows how complicated it is to use technologies that change things. Thinking about these themes, a plan for future study and teamwork starts to take shape. This calls for everyone to work together to discover how smart charging can truly change the future of energy.

CONCLUSION

In conclusion, this study shows how smart charging could completely change how electric cars (EVs) are connected to the power grid. Smart charging improves grid operations, lowers peak demand, and adds green energy sources without problems (Sultan et al., 2022; Barman et al., 2023). The report recognizes the economic difficulties but predicts that smart charging infrastructure will become competitive as technology advances and economies of scale are realized (Wu et al., 2022). The study shows battery swapping stations, which are an important part of the study because they offer a new way to solve problems with EV range and charge infrastructure. This gives the conversation more depth by showing a different way to charge electric vehicles than usual, and it also helps make electric transportation more environmentally friendly (Liu et al., 2022). The study also talks about how important metrics like the leveled cost of electricity (LCOE) and the green energy fraction (REF) are for figuring out how well green energy sources work in smart charging (Adeyemi-Kayode et al., 2023; Timilsina, 2020). These measures give useful information about both the environmental and economic effects, which shows that the study covers a lot of ground.

Smart charging's user-centered features, such as real-time information and efficient charging plans, are important for promoting electric vehicles (EVs) and environmentally friendly transportation. It is known that there is a fine line between data-driven grid efficiency and user privacy (Lashari et al., 2021). To keep things safe, cyber security measures must keep getting better. Standardization and interoperability are important factors that need to be worked on to create common industry standards and deal with problems that might arise because of the lack of standardized protocols (Anthony et al., 2023).

Ultimately, this study gives a complete picture, pointing out problems while highlighting how smart charging, battery swapping, and other important factors can work together to create a sustainable, user-friendly energy future. To get the most out of smart charging and move towards a cleaner, more efficient, and more flexible transportation scene, there is a need to keep researching, coming up with new ideas, and working together on projects (Alanazi, 2023). However, standardized protocols and interoperability are being called for as a collective need beyond individual organizations to create a system that works for the whole industry. At the same time, the constant need for research and development shows how active innovation is and how important it is for solving problems and making smart charging technologies work better. The review paper suggests that smart charging integration can be approached through two main strategies: an industry perspective, as presented in Table 3, and a focus on research and development (R&D), as outlined in Table 4 (Mastoi et al., 2022; Ree & Kim, 2019).

Table 3: Industry Perspectives on Smart Charging

Industry Concerns	Description	Implications for Adoption
Standardization	Need for common standards across devices and system	Facilitates interoperability and smooth integration
Collaborative Efforts	Importance of cooperation among stakeholders	Ensures comprehensive solutions and industry alignment
Commercial Viability	Assessment of market readiness for smart charging	Indicates potential for widespread industry uptake

Table 4: Innovation and R&D Priorities for Smart Charging

R&D Focus Area	Description	Expected Outcomes
Scalability	Developing solutions that can grow with demand	Ensures the system can adapt to increasing EV numbers
Efficiency Improvements	Enhancing the energy efficiency of charging systems	Reduces energy waste and operational costs.
User Experience	Creating a user-friendly interface for charging systems	Increases user satisfaction and adoption rates

Research Limitation

The study only looked at one area and one time period, which means that the results may not apply to the world because of differences in laws and technology. Using data from the last ten years is limited because incomplete information can make it hard to understand how smart charging is changing fully. The study's focus on technology and money might mean that it misses important human factors that affect the use of smart charging, like how people feel about it and how they act.

Future Scope

Longitudinal studies should be used to track how smart charging changes over time; global comparative studies should be widened to include more regulatory frameworks; and user-centered factors should be looked into more deeply. Planning for new technologies, tracking how policies change over time, and collaborating with social scientists from various fields can all improve the study's findings. Developing better technological and economic models and supporting efforts to standardize things will help people better understand and use long-lasting smart charging solutions.

REFERENCES

Carey, J. (2023) "The other benefit of electric vehicles," Proceedings of the National Academy of Sciences, vol. 120, no. 3

Alanazi, F. (2023) "Electric Vehicles: Benefits, Challenges, and Potential Solutions for Widespread Adaptation," Applied Sciences, vol. 13, no. 10, p. 6016

Engel, H., Hensley, R., Knupfer, S., & Sahdev, S. (2018) "The potential impact of electric vehicles on global energy systems," McKinsey & Company

Egbue, O., Long, S., & Samaranayake, V. A. (2017) "Mass deployment of sustainable transportation: evaluation of factors that influence electric vehicle adoption," Clean Technologies and Environmental Policy, vol. 19, no. 7, pp. 1927–1939

Capuder, T., Miloš Sprčić, D., Zoričić, D. & Pandžić, H. (2020) "Review of challenges and assessment of electric vehicles integration policy goals: Integrated risk analysis approach," International Journal of Electrical Power & Energy Systems, vol. 119, p. 105894

Ibrahim, M., Rassõlkin, A., Vaimann, T. & Kallaste, A. (2022) "Overview on Digital Twin for Autonomous Electrical Vehicles Propulsion Drive System," Sustainability, vol. 14, no. 2, p. 601

Chadha, S., Jain, V. & Singh, H. R. (2022) "A review on Smart Charging impacts of Electric Vehicles on Grid," Materials Today: Proceedings

Li, Z., Khajepour, A. & Song, J. (2019) "A comprehensive review of the key technologies for pure electric vehicles," Energy, vol. 182, pp. 824–839

Bertolini, A., Martins, M. S. E., Vieira, S. M. & Sousa, J. M. C. (2022) "Power output optimization of electric vehicles smart charging hubs using deep reinforcement learning," Expert Systems with Applications, p. 116995

Barman, P., Dutta, L., Bordoloi, S., Kalita, A., Buragohain, P., Bharali, S., & Azzopardi, B. (2023) "Renewable energy integration with electric vehicle technology: A review of the existing smart charging approaches," Renewable and Sustainable Energy Reviews, vol. 183, p. 113518

Oláh, J., Krisán, E., Kiss, A., Lakner, Z. & Popp, J. (2020) "PRISMA Statement for Reporting Literature Searches in Systematic Reviews of the Bioethanol Sector," Energies, vol. 13, no. 9, p. 2323

Kriekinge, G. V., Cauwer, C. D., Sapountzoglou, N., Coosemans, T. & Messagie, M. (2021) "Peak shaving and cost minimization using model predictive control for uni- and bi-directional charging of electric vehicles," Energy Reports, vol. 7, pp. 8760–8771

Visaria, A. A., Jensen, A. F., Thorhauge, M. & Mabit, S. E. (2022) "User preferences for EV charging, pricing schemes, and charging infrastructure," Transportation Research Part A: Policy and Practice, vol. 165, pp. 120–143

Kumar, M., Panda, K. P., Naayagi, R. T., Thakur, R. & Panda, G. (2023) "Comprehensive Review of Electric Vehicle Technology and Its Impacts: Detailed Investigation of Charging Infrastructure, Power Management, and Control Techniques," Applied Sciences, vol. 13, no. 15, p. 8919

Alrubaie, A. J., Salem, M., Yahya, K., Mohamed, M., & Kamarol, M. (2023) "A Comprehensive Review of Electric Vehicle Charging Stations with Solar Photovoltaic System Considering Market, Technical Requirements, Network Implications, and Future Challenges," Sustainability, vol. 15, no. 10, p. 8122

LaMonaca, S. & Ryan, L. (2022) "The state of play in electric vehicle charging services – A review of infrastructure provision, players, and policies," Renewable and Sustainable Energy Reviews, vol. 154, p. 111733,

Mustafa, M. (2015) "Smart Grid Security: Protecting Users' Privacy in Smart Grid Applications - ProQuest,"

Unterweger, A., Knirsch, F., Engel, D., Musikhina, D., Alyousef, A. & Meer, H. D. (2022) "An analysis of privacy preservation in electric vehicle charging," Energy Informatics, vol. 5, no. 1

Tuballa, M. L. & Abundo, M. L. (2016) "A review of the development of Smart Grid technologies," Renewable and Sustainable Energy Reviews, vol. 59, pp. 710–725

E-ISSN : 2962-1658
Volume 02, Number 06, December 2023

Annaswamy, A. & Amin, M. (2013) “Smart Grid Research: Control Systems - IEEE Vision for Smart Grid Controls: 2030 and Beyond | IEEE Standard | IEEE Xplore,”

Palensky, P. & Kupzog, F. (2013) “Smart Grids,” Annual Review of Environment and Resources, vol. 38, no. 1, pp. 201–226

Shen, W., Chen, X., Qiu, J., Hayward, J. A., Sayeef, S., Osman, P., Meng, K., & Dong, Z. Y. (2020) “A comprehensive review of variable renewable energy levelized cost of electricity,” Renewable and Sustainable Energy Reviews, vol. 133, p. 110301

Veronese, E., Manzolini, G. & Moser, D. (2021) “Improving the traditional levelized cost of electricity approach by including the integration costs in the techno-economic evaluation of future photovoltaic plants,” International Journal of Energy Research, vol. 45, no. 6, pp. 9252–9269

Camero, A. & Alba, E. (2019) “Smart City and information technology: A review,” Cities, vol. 93, pp. 84–94

Ismagilova, E., Hughes, L., Dwivedi, Y. K. & Raman, K. R. (2019) “Smart cities: Advances in research—An information systems perspective,” International Journal of Information Management, vol. 47, no. 1, pp. 88–100

Liu, N., Nikitas, A. & Parkinson, S. (2020) “Exploring expert perceptions about the cyber security and privacy of Connected and Autonomous Vehicles: A thematic analysis approach,” Transportation Research Part F: Traffic Psychology and Behaviour, vol. 75, pp. 66–86

Ahmad, A., Khalid, M., Ullah, Z., Ahmad, N., Aljaidi, M., Malik, F. A., & Manzoor, U. (2022) “Electric Vehicle Charging Modes, Technologies and Applications of Smart Charging,” Energies, vol. 15, no. 24, p. 9471

Helferich, M., Tröger, J. & Stephan, A. (2023) “EVS36 International Electric Vehicle Symposium Smart Charging in Germany: Acceptance and Tariff Design,”

Stam, E. & Wennberg, K. (2009) “The roles of R&D in new firm growth,” Small Business Economics, vol. 33, no. 1, pp. 77–89

Sarpong, D., Boakye, D., Ofosu, G. & Botchie, D. (2022) “The three pointers of research and development (R&D) for growth-boosting sustainable innovation system,” Technovation, vol. 122, p. 102581

Peláez, R. M., Brust, A. O., Rivera, S., Felix, V. G., Ostos, R., Brito, H., Felix, R. A., & Mena, L. J. (2023) “Role of Digital Transformation for Achieving Sustainability: Mediated Role of Stakeholders, Key Capabilities, and Technology,” Sustainability, vol. 15, no. 14, p. 11221

R. D. K., & Chavhan, S. (2022) “Shift to 6G: Exploration on trends, vision, requirements, technologies, research, and standardization efforts,” Sustainable Energy Technologies and Assessments, vol. 54, p. 102666.

Ferguson, B., Nagaraj, V., Kara, E. C. & Alizadeh, M. (2018) “Optimal Planning of Workplace Electric Vehicle Charging Infrastructure with Smart Charging Opportunities,” IEEE Xplore

Tirunagari, S., Gu, M. & Meegahapola, L. (2022) “Reaping the Benefits of Smart Electric Vehicle Charging and Vehicle-to-Grid Technologies: Regulatory, Policy and Technical Aspects,” IEEE Access, vol. 10, pp. 114657–114672

Hildermeier, J., Kolokathis, C., Rosenow, J., Hogan, M., Wiese, C., & Jahn, A. (2019) “Smart EV Charging: A Global Review of Promising Practices,” World Electric Vehicle Journal, vol. 10, no. 4, p. 80

Ihm, J., Amghar, B., Chun, S. & Park, H. (2023) “Optimum Design of an Electric Vehicle Charging Station Using a Renewable Power Generation System in South Korea,” Sustainability, vol. 15, no. 13, p. 9931

Fachrizal, R. (2023) “Synergy between Photovoltaic Power Generation and Electric Vehicle Charging in Urban Energy Systems Optimization Models for Smart Charging and Vehicle-to-Grid,”

Ejeh, J. O., Roberts, D. & Brown, S. F. (2023) “Exploring the value of electric vehicles to domestic end-users,” Energy Policy, vol. 175, p. 113474

Yong, J. Y., Tan, W. S., Khorasany, M. & Razzaghi, R. (2023) “Electric vehicles destination charging: An overview of charging tariffs, business models and coordination strategies,” Renewable and Sustainable Energy Reviews, vol. 184, p. 113534

Hodge, C., O'neill, B. & Coney, K. (2020) “EFFECTIVENESS OF ELECTRIC VEHICLE POLICIES AND IMPLICATIONS FOR PAKISTAN”

Sultan, V., Aryal, A., Chang, H. & Kral, J. (2022) “Integration of EVs into the smart grid: a systematic literature review,” Energy Informatics, vol. 5, no. 1

Tsakalidis, A., Krause, J., Julea, A. & Peduzz, E. (2020) “Electric light commercial vehicles: Are they the sleeping giant of electromobility?,” Transportation Research Part D: Transport and Environment, vol. 86, p. 102421

Wang, J. (2023) Strategic Challenges and Strategic Responses: The Transformation of Chinese State-Owned Enterprises

Glanzer, G. & Sivaraman, T. (2011) “Cost-efficient integration of electric vehicles with the power grid by means of smart charging strategies and integrated on-board chargers | IEEE Conference Publication | IEEE Xplore,”

Das, H. S., Rahman, M. M., Li, S. & Tan, C. W. (2019) “Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review,” Renewable and Sustainable Energy Reviews, vol. 120, p. 109618

Sbordone, D., Bertini, I., Pietra, B. D., Falvo, M. C., Genovese, A. & Martirano, L. (2015) "EV fast charging stations and energy storage technologies: A real implementation in the smart microgrid paradigm," Electric Power Systems Research, vol. 120, pp. 96–108

Mastoi, M. S., Zhuang, S., Munir, H. M., Haris, M., Hassan, M., Usman, M., Bukhari, S. S. H., & Ro, J. S. (2022) “An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends," Energy Reports, vol. 8, no. 2352–4847, pp. 11504–11529

Gabbar, H. A. & Siddique, A. B. (2023) "Technical and economic evaluation of nuclear powered hybrid renewable energy system for a fast charging station," Energy Conversion and Management: X, vol. 17, p. 100342

Alaydi, S. (2021) "Strategic responses to extreme institutional challenges: an MNE case study in the Palestinian mobile phone sector Strategic Responses to Extreme Institutional Challenges: An MNE Case Study in the Palestinian Mobile Phone Sector,"

Secchi, M., Barchi, G., Macii, D. & Petri, D. (2023) "Smart electric vehicles charging with centralized vehicle-to-grid capability for net-load variance minimization under increasing EV and PV penetration levels," Sustainable Energy, Grids and Networks, vol. 35, p. 101120

Wu, Y., Zhuge, S., Han, G. & Xie, W. (2022) "Economics of Battery Swapping for Electric Vehicles—Simulation-Based Analysis," Energies, vol. 15, no. 5, p. 1714

Liu, W., Placke, T. & Chau, K. T. (2022) "Overview of batteries and battery management for electric vehicles," Energy Reports, vol. 8, pp. 4058–4084

Adeyemi-Kayode, T. M., Misra, S., Maskeliunas, R. & Damasevicius, R. (2023) "A bibliometric review of grid parity, energy transition and electricity cost research for sustainable development," Heliyon, vol. 9, no. 5, p. e15532

Timilsina, G. (2020) "Demystifying the Costs of Electricity Generation Technologies,"

Lashari, Z. A., Ko, J. & Jang, J. (2021) "Consumers' Intention to Purchase Electric Vehicles: Influences of User Attitude and Perception," Sustainability, vol. 13, no. 12, p. 6778

Anthony, B., Sylva, W., Watat, J. K. & Misra, S. (2023) "A Framework for Standardization of Distributed Ledger Technologies for Interoperable Data Integration and Alignment in Sustainable Smart Cities," Journal of the Knowledge Economy

Ree, J. J. & Kim, K. (2019) "Smart Grid R&D Planning Based on Patent Analysis," Sustainability, vol. 11, no. 10, p. 2907