International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

AI-Driven Optimization of V2G Systems for Electric School Buses

Pawan Kumar

Zum Services Inc, Redwood City, California, USA

Abstract
This paper explores the transformative potential of AI-driven optimization in Vehicle-to-Grid (V2G) systems, with a focus on electric school buses. V2G technology enables bidirectional energy flow, allowing electric vehicles to not only draw power from the grid but also discharge electricity back to it. This capability is particularly beneficial for electric school buses, which can serve as valuable energy storage assets during their idle periods. By integrating AI, these systems can enhance operational efficiency, reduce costs, and support environmental sustainability through optimized energy management. Despite these advantages, challenges such as technological complexities and infrastructure limitations persist. Addressing these challenges through targeted research and supportive policy frameworks is crucial for realizing the full potential of AI-driven V2G systems in advancing sustainable transportation and energy solutions.

Keywords: AI-driven optimization, Vehicle-to-Grid (V2G), Electric school buses, Machine learning, Neural networks, Energy management, Grid stability, Renewable energy integration, Peak shaving, Load leveling

1. Introduction

The integration of Vehicle-to-Grid (V2G) technology with electric school buses offers a transformative approach to both transportation and energy management. V2G systems enable bidirectional energy flow between electric vehicles (EVs) and the power grid, allowing these vehicles to not only draw power for charging but also discharge electricity back to the grid. This capability is particularly advantageous for electric school buses, which often remain idle for extended periods and can thus serve as valuable energy storage assets. By participating in V2G operations, electric school buses can provide critical services such as peak shaving, load leveling, and emergency power supply during outages, thereby enhancing community resilience and supporting grid stability.

Artificial intelligence (AI) plays a crucial role in optimizing V2G systems, amplifying their benefits. AI-driven algorithms can efficiently manage energy flows, predict demand patterns, and optimize charging schedules, leading to enhanced operational efficiency and reduced costs. Moreover, the integration of renewable energy sources into V2G systems, facilitated by AI, contributes to environmental sustainability by reducing greenhouse gas emissions and air pollution. Despite these advantages, the widespread adoption of AI-driven V2G systems faces several challenges, including technological complexities, infrastructure limitations, and the need for supportive policy frameworks.

Addressing these challenges through targeted research and development is crucial for realizing the full potential of V2G technology in electric school buses. Future efforts should focus on developing robust AI algorithms tailored to the unique operational schedules of school buses, exploring the socio-economic impacts of V2G systems in disadvantaged communities, and ensuring equitable access to the benefits of this technology. By overcoming these hurdles, AI-driven V2G systems can play a pivotal role in advancing sustainable transportation and energy solutions, contributing to a more resilient and sustainable energy future.

2. Literature Review

Overview of V2G Technology:

Vehicle-to-grid (V2G) technology enables bidirectional energy flow between electric vehicles (EVs) and the power grid, allowing EVs to not only charge but also discharge electricity back to the grid. This technology is particularly promising for electric school buses, which often remain idle for extended periods. By integrating V2G, these buses can provide valuable services such as peak shaving, load leveling, and emergency power supply during outages, thereby enhancing community resilience. Additionally, V2G-equipped school buses contribute to reducing greenhouse gas emissions and air pollution, promoting a cleaner environment. This dual functionality of transportation and energy storage optimizes grid stability and offers economic benefits by potentially lowering electricity costs and generating revenue through grid services.[1][2]

Energy storage solutions and advanced technologies such as Vehicle-to-Grid (V2G) systems offer significant benefits for grid stabilization, cost savings, and enhanced energy resilience. By integrating energy storage technologies like batteries, pumped hydro storage, and compressed air energy storage, grid operators can achieve peak shaving, load leveling, and frequency regulation, which collectively contribute to grid stabilization and reliability[3]. Additionally, these technologies can lead to substantial cost savings by optimizing energy use and reducing operational costs. For instance, energy-intensive companies have reported electricity cost savings of up to 72% by utilizing hybrid energy systems that incorporate storage solutions[4]. Enhanced energy resilience is another critical benefit, particularly for historically disadvantaged communities. V2G technology, for example, allows electric school buses to discharge stored energy back into the grid during peak demand periods and emergencies, thereby providing crucial support and promoting energy equity. These advancements not only bolster the stability and efficiency of the power grid but also ensure a more resilient and sustainable energy future.

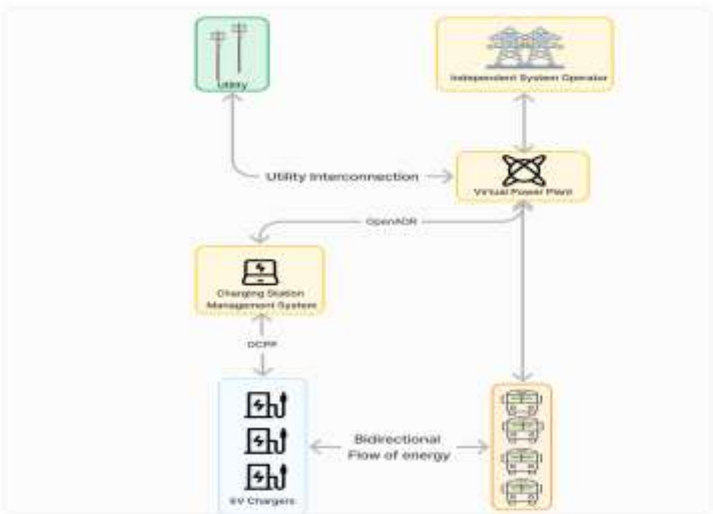

Figure 01. Vehicle-to-Grid System for Electric School Buses

Challenges in V2G Systems: Vehicle-to-Grid(V2G) systems face several challenges that can hinder their widespread adoption and effectiveness. Some key challenges are:

Technical Challenges

Battery Degradation: Frequent charging and discharging cycles can accelerate battery wear, reducing the lifespan of EV batteries[8]. Every battery has a limited number of charge-discharge cycles it can undergo before its capacity significantly diminishes. V2G activities increase the number of these cycles, potentially reducing the battery's useful life. Over time and with repeated cycling, the battery's ability to hold a charger diminishes. This is known as capacity fade, which can affect the range and performance of the EV. Charging and discharging generate heat, which can exacerbate degradation if not properly managed. Effective thermal management systems are crucial to mitigate this issue. Operating the battery at extreme states of charge (either very high or very low) can accelerate degradation. V2G systems need to carefully manage SOC to minimize stress on the battery.

Interoperability: There is a lack of standardized protocols and systems, which complicates the integration of diverse EV models and grid systems[9]. Different manufacturers produce EVS with varying specifications, communications protocols, and charging technologies. This diversity can create compatibility issues when connecting EVs to V2G systems. There are multiple charging standards globally, such as CHAdeMO, CCS, and Tesla's proprietary system. These different standards can hinder the implementation of a universal V2G system. Grid infrastructure and management systems vary widely between regions and countries, further complicating the integration of V2G technology on a broad scale. To overcome these interoperability challenges, industry stakeholders are working towards adopting ISO 15118-20 standards for vehicle-to-grid communication. This common framework facilitates interoperability across different EV models and grid systems[10].

Infrastructure: The current infrastructure, including bidirectional chargers and grid connections, is often insufficient to support large-scale V2G operations[11]. The availability of bidirectional chargers, which are essential for V2G operations, is limited. These chargers are necessary to allow electric vehicles (EVs) to both draw energy from and supply energy back to the grid. The development and deployment of these chargers are still in the early stages, and widespread implementation is needed to support large-scale V2G systems[12][13]. Existing grid infrastructure may not handle the additional load and complexity introduced by V2G systems. The integration of V2G requires robust grid connections that can manage bidirectional energy flow, which many current systems are not equipped to handle[14][15]. The increased demand for electricity during peak hours, coupled with the additional load from EV charging, can lead to grid congestion. This congestion can cause inefficiencies, voltage fluctuations, and even power supply disruptions, which are critical issues for the reliability of V2G services. While V2G systems can support the integration of renewable energy sources, the current infrastructure may not fully utilize this potential. Effective energy flow management and optimization between EVs and renewable sources are needed to maximize benefits[16]. Addressing these infrastructure challenges involves investing in advanced charging technologies, upgrading grid systems, and implementing strategic energy management practices such as peak shaving and load leveling to optimize power consumption and distribution.

Economic Challenges:

Business Models: There is a lack of clear and viable business models to make V2G economically attractive for stakeholders, including vehicle owners, grid operators, and energy companies[9] [11]. There is a need for business models that ensure economic viability for all stakeholders involved in V2G systems. For instance, a study evaluating V2G for autonomous electric ride-hailing fleets found that while V2G offers flexibility, it only leads to marginal profit increases compared to smart charging. This suggests additional incentives are necessary to encourage V2G adoption[16]. The lack of incentives for stakeholders, including vehicle owners and grid operators, is a critical issue. Without clear financial benefits or supportive policies, stakeholders may be reluctant to invest in V2G infrastructure and technology[11]. The design of tariffs plays a crucial role in influencing the charging behavior of electric vehicle(EV) owners. For instance, time-of-use pricing tariffs can encourage EV owners to charge their vehicles during off-peak hours, thereby reducing grid strain and voltage variations[17]. However, if tariffs are not designed to reflect the true costs and benefits of V2G participation, they may not provide adequate incentives for EV owners to engage in V2G activities.

Social and Behavioral Challenges: User participation in Vehicle-to-Grid (V2G) programs faces several social and behavioral challenges. The willingness of electric vehicle (EV) owners to engage in V2G activities is often uncertain due to concerns about battery life, privacy, and security. EV owners often hesitate to participate in V2G programs due to worries about battery degradation. Frequent charging and discharging cycles can reduce battery lifespan, and without adequate compensation for this degradation, EV owners may be reluctant to participate[19][20]. The exchange of data between EVs, charging stations, and grid operators in V2G systems raises privacy and security concerns. EV owners may be concerned about the security of their personal data and the potential for unauthorized access[21][22]. Understanding and integrating user preferences into V2G systems is essential. Models that consider user participation and preferences, such as optimal charger scheduling and strategic bidding, can enhance profitability and user satisfaction[19]. The availability of V2G-capable infrastructure, such as bidirectional chargers, and the accessibility of charging stations can influence use participation. Ensuring that EV owners have easy access to V2G services is critical for widespread adoption[23][24].

AI in V2G Optimization: The application of artificial intelligence (AI) techniques, such as machine learning and metaheuristic algorithms, can significantly enhance the optimization of Vehicle-to-Grid (V2G) operations. Here are some insights from the literature on how AI can improve grid stability, cost efficiency, and user satisfaction.

Grid Stability: AI-driven algorithms are instrumental in optimizing the bidirectional energy flow between electric vehicles(EVs) and the grid, which is crucial for maintaining grid stability. By accurately predicting energy demand and supply, AI helps balance the load on the grid, reducing the risk of instability and outages. For example, a study highlights the use of AI methods to tackle optimization challenges in V2G systems, leading to improved grid stability through better management of energy flows[7][25]. AI techniques, particularly machine learning algorithms, can be used to predict electricity demand and supply accurately. This capability helps in balancing the load on the grid, thereby reducing the risk of instability and outages. For instance, machine learning models can forecast potential grid issues, allowing for proactive measures to maintain stability [26]. AI methods are applied to optimize energy flows in V2G systems, improving grid stability through better management. This includes using AI to develop efficient scheduling and control strategies that ensure reliable energy distribution and minimize grid stress[27]. AI enables the implementation of advanced control approaches, such as rolling prediction decision frameworks and smart energy metering, which contribute to enhanced grid stability. These techniques allow for dynamic adjustments to energy glows based on real-time data, ensuring that the grid remains stable even with fluctuating energy demands[27]. AI can facilitate the integration of renewable energy sources into the grid by predicting and managing their variable outputs. This integration is crucial for maintaining stability as renewables become a larger part of the energy mix [26]. Overall, AI-driven optimization in V2G systems offers significant potential to improve grid stability by accurately predicting and managing energy flows, optimizing control strategies, and integrating renewable energy sources effectively.

Cost Efficiency: AI can optimize charging and discharging schedules to minimize costs for EV owners and grid operators. Machine learning models can predict electricity prices and demand patterns, enabling more efficient energy trading and reducing operational costs. The integration of agile optimization concepts further enhances the flexibility and responsiveness of V2G systems, contributing to cost savings[7][28]. AI algorithms based on real-time data and forecasts can determine the most cost-effective times to charge and discharge EVs. By aligning these activities with periods of low electricity prices or high demand, AI can help minimize energy costs for EV owners and maximize revenue from selling energy back to the grid. Machine learning models are adept at predicting electricity prices and demand patterns. These predictions allow grid operators and EV owners to make informed decisions about when to buy or sell electricity, leading to more efficient energy trading and reduced operational costs. The concept of agile optimization concepts in V2G systems enhances their flexibility and responsiveness. Agile optimization allows quick adjustments to charging and discharging schedules in response to changing grid conditions or market prices, ensuring operations remain cost-effective. AI can facilitate strategies such as peak shaving and load shifting, which help flatten demand peaks and reduce the need for expensive peaking power plants. By managing the timing of energy use, AI contributes to overall cost reductions for grid operators. AI-driven energy management systems can coordinate multiple EVs and other distributed energy resources to optimize energy use. This coordination leads to more efficient grid operations and cost savings through improved resource allocation. By leveraging these capabilities, AI enhances the cost efficiency of V2G systems, providing economic benefits to both EV owners and grid operators while supporting the broader integration of renewable energy sources.

User Satisfaction: AI enhances user satisfaction by incorporating user preferences into V2G operations. Intelligent frameworks can manage and allocate energy based on user needs, optimizing both cost and time. A study on V2V energy sharing demonstrates how a user satisfaction model can ensure realistic and satisfying matchings for EV owners, thereby increasing their willingness to participate in V2G programs[23]. AI frameworks can manage and allocate energy based on individual user needs and preferences, optimizing both cost and time. This personalized approach ensures that users receive energy services that align with their specific requirements, enhancing overall satisfaction. Studies, such as those on Vehicle-to-Vehicle (V2V) energy sharing, have demonstrated the use of intelligent frameworks to manage energy allocation between EVs. These frameworks employ algorithms like the Gale-Shapley stable matching to ensure realistic and satisfying matchings for EV owners, thereby increasing their willingness to participate in V2G programs[29]. AI models can incorporate user preferences into the optimization process, ensuring that energy management decisions reflect the priorities and constraints of the users. This approach not only optimizes energy use but also aligns with user expectations, leading to higher satisfaction levels. By using explainable AI (XAI) methodologies, AI systems can improve transparency and trust in decision-making processes. This transparency helps users understand how their preferences are being considered, which can enhance their satisfaction with the system[30]. Overall, AI-driven systems that consider user preferences and provide transparent, personalized services can significantly improve user satisfaction in V2G operations. This user-centric approach is crucial for encouraging broader participation and acceptance of V2G technologies.

AI-Driven Optimization Techniques

AI-driven optimization techniques, particularly machine learning, and deep learning, play a significant role in enhancing the efficiency of Vehicle-to-Grid (V2G) systems, especially for electric school buses. Here's how these techniques can be applied:

Machine Learning and Deep Learning:

Data Pattern Analysis: Machine learning models can analyze complex data patterns related to energy consumption, driving behavior, and environmental conditions. For instance, a study on electric city buses used machine learning to predict energy demand with high accuracy, enabling more efficient operations [31].

Energy Demand Prediction: Deep learning models can predict the energy consumption for electric buses based on various trip parameters, such as route, schedule, and travel time. This allows for accurate forecasting of energy needs, which is crucial for optimizing charging schedules[32].

Optimizing Charging Schedules: By predicting electricity prices and demand patterns, machine learning can optimize charging and discharging schedules to minimize costs and enhance grid stability. This is particularly important for managing the energy needs of electric school buses, which have specific operational schedules[33].

Agile Optimization:

Real-time Adjustments: Agile optimization methods allow V2G systems to make real-time adjustments based on current grid conditions and user preferences. This flexibility is crucial for responding to unexpected changes in energy demand or supply, ensuring efficient energy management [34].

Integration with Renewable Energy: Agile optimization can facilitate the integration of renewable energy sources by dynamically adjusting charging schedules to align with renewable energy availability. This approach helps in reducing reliance on non-renewable energy and supports sustainable operations[34].

Responsive Energy Management: Agile optimization enhances the responsiveness of V2G systems by enabling quick adaptations to changes in grid conditions or user needs. This responsiveness is vital for maintaining user satisfaction and ensuring a reliable energy supply[35].

Overall, the application of AI techniques, including machine learning and deep learning, along with agile optimization methods, significantly improves the flexibility, efficiency, and user satisfaction of V2G systems for electric school buses. These technologies enable more accurate predictions, efficient energy management, and seamless integration with renewable energy sources.

Discussion

Benefits of AI-Driven V2G Systems:

Enhanced Operational Efficiency AI algorithms can optimize the charging and discharging schedules of electric school buses to align with grid demands and electricity prices. This optimization ensures that energy is used and stored at the most efficient times, improving overall system efficiency.

Reduced Operational Costs By predicting energy demand and supply patterns, AI helps minimize electricity costs for both vehicle owners and grid operators. Participation in energy markets and leveraging time-of-use pricing allow for charging when electricity is cheapest and discharging when it is most valuable.

Environmental Benefits AI-driven V2G systems support the integration of renewable energy sources by managing energy flows more effectively. This reduces reliance on fossil fuels, leading to lower emissions and a smaller carbon footprint for transportation systems.

Challenges and Future Directions

Technological Complexities: Implementing AI-driven Vehicle-to-Grid (V2G) systems involves several technological complexities that present significant challenges.

Advanced Algorithms and Data management AI-driven V2G systems require the development of advanced algorithms capable of optimizing energy flows and predicting demand patterns. These algorithms need to be robust and scalable to handle the complexities of real-time data processing and decision-making. Robust data management systems are essential to process and analyze large volumes of data generated by V2G operations. This includes managing data from various sources such as EVs, grid operators, and weather forecasts to ensure accurate predictions and optimizations [36].

Infrastructure Requirement The successful implementation of V2G systems requires a suitable infrastructure, including bidirectional charging stations and enhanced grid connectivity. The current lack of such infrastructure poses a significant barrier to scalability and widespread adoption. Investments in infrastructure development are necessary to support the integration of AI technologies with V2G systems, ensuring reliable and efficient operations [36].

Technological Maturation: Significant collaboration and funding are needed to mature the technologies required for AI-driven V2G systems. This includes advancing AI algorithms, enhancing data processing capabilities, and developing reliable hardware solutions.

Future Research Directions:

Development of Robust AI Algorithms: Future research should focus on developing AI algorithms specifically tailored for V2G systems in school buses. These algorithms need to optimize energy management by considering the unique operational schedules and constraints of school buses, such as fixed routes, specific time windows, and varying energy needs throughout the day.

Socio-Economic Impacts: Research should explore the socio-economic impacts of V2G systems, particularly in disadvantaged communities. This includes examining how V2G technology can contribute to energy equity, provide economic benefits, and improve resilience during power outages. Ensuring equitable access to the benefits of V2G technology is crucial for its widespread adoption and success.

Battery Health and Sustainability: Investigating the long-term effects of V2G participation on battery health is essential. Research should focus on understanding how frequent charging and discharging cycles impact battery life and performance. Developing strategies to mitigate any negative impacts on battery health will be crucial for the sustainable implementation of V2G systems.

Integration with Renewable Energy: Future research could explore how AI-driven V2G systems can be integrated with renewable energy sources to enhance sustainability. This includes optimizing the use of solar or wind energy in conjunction with V2G operations to reduce reliance on non-renewable energy sources.

Scalability and Infrastructure: Research should address the scalability of AI-driven V2G systems and the necessary infrastructure improvements. This includes developing scalable AI solutions that can be deployed across different regions and grid systems, as well as investing in the necessary infrastructure, such as bidirectional chargers and enhanced grid connectivity.

By focusing on these areas, future research can help overcome current challenges and maximize the potential benefits of AI-driven V2G systems in school buses.

Conclusion

This paper has explored the transformative potential of AI-driven optimization in Vehicle-to-Grid (V2G) systems, particularly for electric school buses. Key findings highlight that AI technologies, such as machine learning and deep learning, can significantly enhance the operational efficiency of V2G systems by optimizing charging and discharging schedules. These optimizations lead to reduced operational costs and environmental benefits, such as lower emissions and better integration of renewable energy sources. The implementation of AI-driven V2G systems in school buses presents an opportunity to improve energy efficiency, cost savings, and user satisfaction while also supporting grid stability.

The broader implications of AI-driven V2G systems extend to sustainable transportation and energy management. By enabling more efficient energy use and supporting the integration of renewable energy sources, these systems contribute to a reduction in carbon emissions and reliance on fossil fuels. Furthermore, the deployment of V2G technology in school buses can enhance community resilience, particularly in disadvantaged areas, by providing backup power during outages.

For successful implementation, supportive policy frameworks are essential. Policies should focus on developing standardized protocols, providing economic incentives, and ensuring equitable access to V2G benefits. Additionally, investments in infrastructure and research into robust AI algorithms tailored for specific applications, such as school buses, are crucial. By addressing these areas, AI-driven V2G systems can play a pivotal role in advancing sustainable transportation and energy solutions.

References

3. M. A. Rahman, "The Impact of Renewable Energy Integration on Grid Stability," The American Journal of Engineering and Technology, vol. 6, no. 4, pp. 45-56, Apr. 2024.
4. T. Ercan, M. Noori, Y. Zhao, and O. Tatari, "On the Front Lines of a Sustainable Transportation Fleet: Applications of Vehicle-to-Grid Technology for Transit and School Buses," Energies, vol. 9, no. 4, pp. 1-19, Mar. 2016.
5. Oladiran Kayode Olajiga, Emmanuel Chigozie Ani, Tosin Michael Olatunde, & Zamathula Queen Sikhakane. (2024). ASSESSING THE POTENTIAL OF ENERGY STORAGE SOLUTIONS FOR GRID EFFICIENCY: A REVIEW. Engineering Science & Technology Journal, 5(3), 1112-1124. https://doi.org/10.51594/estj.v5i3.974
6. Benalcazar, P., Malec, M., Kaszyński, P., Kamiński, J., & Saługa, P. W. (2024). Electricity Cost Savings in Energy-Intensive Companies: Optimization Framework and Case Study. Energies, 17(6), 1307. https://doi.org/10.3390/en17061307
7. G. S. Rupa, R. S. S. Nuvvula, P. P. Kumar, A. Ali and B. Khan, "Machine Learning-Based Optimization Techniques for Renewable Energy Systems," 2024 12th International Conference on Smart Grid (icSmartGrid), Setubal, Portugal, 2024, pp. 389-394, doi: 10.1109/icSmartGrid61824.2024.10578295.
8. J. Dong, A. Yassine, A. Armitage, and M. S. Hossain, "Multi-Agent Reinforcement Learning for Intelligent V2G Integration in Future Transportation Systems," in IEEE Transactions on Intelligent

Transportation Systems, vol. 24, no. 12, pp. 15974-15983, Dec. 2023, doi: 10.1109/TITS.2023.3284756.
9. Escoto, Marc, Antoni Guerrero, Elnaz Ghorbani, and Angel A. Juan. 2024. "Optimization Challenges in Vehicle-to-Grid (V2G) Systems and Artificial Intelligence Solving Methods" Applied Sciences 14, no. 12: 5211. https://doi.org/10.3390/app14125211
10. Chen, G., & Zhang, Z. (2024). Control Strategies, Economic Benefits, and Challenges of Vehicle-to-Grid Applications: Recent Trends Research. World Electric Vehicle Journal.
11. Rodríguez, C.S., Vidal, C., Díaz, M., Contreras, E., Guggisberg, G., & Rivas, I. (2021). An Overview of Challenges and Benefits Associated with the Development of Vehicle to-Grid Technology. 2021 IEEE CHILEAN Conference on Electrical, Electronics Engineering, Information and Communication Technologies (CHILECON), 1-6.
12. https://www.iso.org/standard/77845.html
13. Mojumder, M.R., Ahmed Antara, F., Hasanuzzaman, M., Alamri, B., & Alsharef, M. (2022). Electric Vehicle-to-Grid (V2G) Technologies: Impact on the Power Grid and Battery. Sustainability.
14. Mejia-Ruiz, G.E., Paternina, M.R., Rodríguez, J., Zamora, A., Bolivar-Ortiz, G., & Toledo-Santos, C. (2021). A Bidirectional Isolated Charger for Electric Vehicles in V2G Systems with the Capacity to Provide Ancillary Services. 2020 52nd North American Power Symposium (NAPS), 1-6.
15. Semsar, S., Soong, T., & Lehn, P.W. (2020). On-board single-phase Integrated Electric Vehicle Charger With V2G Functionality. IEEE Transactions on Power Electronics, 35, 12072-12084.
16. Mkhize, S., & Dorrell, D.G. (2019). Practical Limitations of Vehicle to Grid (V2G) Infrastructure. 2019 IEEE International Conference on Industrial Technology (ICIT), 1616-1621.
17. Kirmani, S., Akhtar, I., & Rehman, M.U. (2023). Electric Vehicle Infrastructure Management with Maximum Utilization of Renewable Energy: A Review. 2023 IEEE 3rd International Conference on Sustainable Energy and Future Electric Transportation (SEFET), 1-8.
18. Punt, L. (2023). Evaluating the Financial Viability of Vehicle-to-Grid for Autonomous Electric Ride-Hailing Fleets. 2023 IEEE PES Innovative Smart Grid Technologies - Asia (ISGT Asia), 1-5.
19. Jung, D., & Sundström, C. (2023). Analysis of Tariffs and the Impact on Voltage Variations in Low-Voltage Grids with Smart Charging and Renewable Energy. Energies.
20. Adnan, N., Nordin, S.M., & Althawadi, O.M. (2018). Barriers Towards Widespread Adoption of V2G Technology in Smart Grid Environment: From Laboratories to Commercialization.
21. Khezri, R., Steen, D., & Tuan, L.A. (2023). Optimal EV Charge Scheduling Considering FCR Participation and Battery Degradation. 2023 IEEE International Conference on Energy Technologies for Future Grids (ETFG), 1-6.
22. Mehrnia, S., Song, H., Al Khafaf, N., Jalili, M., McGrath, B., & Meegahapola, L.G. (2023). Multi-Objective Electric Vehicle Charge Scheduling Using Incentive-Based Compensation Mechanism to Increase Vehicle-to-Grid Participation. IECON 2023- 49th Annual Conference of the IEEE Industrial Electronics Society, 1-6.
23. Yazdandoust, M., & Golkar, M.A. (2020). Participation of Aggregated Electric Vehicles in Demand Response Programs.
24. Giordano, F., Diaz-Londono, C., & Gruosso, G. (2023). Comprehensive Aggregator Methodology for EVs in V2G Operations and Electricity Markets. IEEE Open Journal of Vehicular Technology, 4, 809-819.

25. Al-obaidi, A.A., & Farag, H.E. (2024). Optimal Design of V2G Incentives and V2G-Capable Electric Vehicles Parking Lots Considering Cost-Benefit Financial Analysis and User Participation. IEEE Transactions on Sustainable Energy, 15, 454-465.
26. Cheikh-Mohamad, S., Celik, B., Sechilariu, M., & Locment, F. (2023). PV-Powered Charging Station with Energy Cost Optimization via V2G Services. Applied Sciences.
27. Escoto, M., Guerrero, A., Ghorbani, E., & Juan, A.A. (2024). Optimization Challenges in Vehicle-to-Grid (V2G) Systems and Artificial Intelligence Solving Methods. Applied Sciences.
28. Yerrolla., C., & Ramesh, D. (2023). Electrical Grid Stability Prediction using Machine Learning Algorithms. 2023 4th International Conference on Electronics and Sustainable Communication Systems (ICESC), 1048-1057.
29. Umair, M., Hidayat, N.M., Nik Ali, N.H., Abdullah, E., Bin Johari, A.R., & Hakomori, T. (2023). The effect of vehicle-to-grid integration on power grid stability: A review. IOP Conference Series: Earth and Environmental Science, 1281.
30. Bassiliades, N., & Chalkiadakis, G. (2018). Artificial Intelligence Techniques for the Smart Grid. Advances in Building Energy Research, 12, 1 - 2.
31. Shurrab, M., Singh, S., Otrok, H., Mizouni, R., Khadkikar, V., & Zeineldin, H.H. (2022). A Stable Matching Game for V2V Energy Sharing–A User Satisfaction Framework. IEEE Transactions on Intelligent Transportation Systems, 23, 7601-7613.
32. Panagoulias, D.P., Sarmas, E., Marinakis, V., Virvou, M.K., Tsihrintzis, G.A., & Doukas, H.C. (2023). Intelligent Decision Support for Energy Management: A Methodology for Tailored Explainability of Artificial Intelligence Analytics. Electronics.
33. Sennefelder, R.M., Martín-Clemente, R., González-Carvajal, R., & Trifonov, D. (2023). Data-Driven Energy Economy Prediction for Electric City Buses Using Machine Learning. IEEE Access, 11, 97057-97071.
34. Pamuła, T., & Pamula, D. (2022). Prediction of Electric Buses Energy Consumption from Trip Parameters Using Deep Learning. Energies.
35. Deb, S., & Gao, X. (2022). Prediction of Charging Demand of Electric City Buses of Helsinki, Finland by Random Forest. Energies.
36. Abdelwahed, A., Berg, P.L., Brandt, T.L., Ketter, W., & Mulder, J. (2021). A Boost for Urban Sustainability: Optimizing Electric Transit Bus Networks in Rotterdam. INFORMS J. Appl. Anal., 51, 391-407.
37. Bukit, F.R., Zulkarnain, H., & Kusuma, C.P. (2024). Optimizing electric vehicle charging station placement integrates distributed generations and network reconfiguration. International Journal of Electrical and Computer Engineering (IJECE).
38. Prakash, P. (2024). Recent technological advancements, V2G systems, and their implications for increased adoption and scalability using Artificial Intelligence. International Journal of Multidisciplinary Research and Growth Evaluation.