International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 11 | November - 2024 SJIF Rating: 8.176 ISSN: 2582-3930

Smart Energy and Data Exchange Network for Vehicles

Kolli Rajendra[1], Pilla Ramana[2], Gadi Hemanth[3], Addanki Swetha[4], Kapala Santhosh[5]

[1,3,4,5]B.Tech Student, Department of EEE, GMR Institute of Technology, Rajam-532127, Andhra Pradesh, India

[2]Professor, Department of EEE, GMR Institute of Technology, Rajam-532127, Andhra Pradesh, India

Email: kollirajendra750@gmail.com

---***---

Abstract: The "Smart Energy and Data Exchange Network for Vehicles" (SEDEN-V) is a novel system designed to enable autonomous and electric vehicles to dynamically share energy and exchange critical data with each other. This innovation addresses key challenges in the sustainability, efficiency, and reliability of autonomous and connected vehicular networks. Through a decentralized, peer-to-peer structure, vehicles within close proximity can transfer surplus energy to those in need, thus optimizing battery usage and reducing the risk of unexpected power depletion. Additionally, the system allows vehicles to exchange essential operational data, such as road conditions, traffic updates, and hazard warnings, to enhance overall safety and decision-making capabilities.

Keywords: Peer-to-Peer Energy Sharing, Change Data Exchange for Safety and Efficiency, Data Exchange for Safety and Efficiency, Battery, Intelligent Energy Management.

.1. INTRODUCTION

The rapid evolution of autonomous and electric vehicles (EVs) is reshaping the future of transportation, presenting both new opportunities and challenges. While these vehicles offer significant benefits in terms of sustainability and autonomy, their widespread adoption requires innovative solutions to address energy management, infrastructure limitations, and safety concerns. The Smart Energy and Data Exchange Network for Vehicles (SEDEN-V) offers a cutting-edge approach to overcoming these challenges by enabling vehicles to dynamically exchange energy and critical data in real-time.seden-v is designed to facilitate a decentralized, peer-to-peer network where vehicles can share surplus energy and provide essential data to one another. This allows for more efficient battery use, reducing the need for fixed charging stations and supporting vehicles in areas where charging infrastructure may be inadequate. For instance, if one vehicle has excess battery power while another is running low, energy can be transferred seamlessly, ensuring that both vehicles can continue their journey without interruption [1].

In addition to energy sharing, the SEDEN-V system supports the exchange of operational data such as road conditions, traffic updates, and hazard warnings. By sharing this information, vehicles can make better-informed decisions, enhancing safety and improving traffic flow. This collaborative network also opens up new possibilities for optimizing navigation, reducing congestion, and preventing accidents in real time [2].

A. Background on smart energy

The rise of autonomous and electric vehicles (EVs) has introduced new opportunities and challenges in transportation. While EVs reduce emissions and reliance on fossil fuels, they face infrastructure limitations, particularly with charging stations. Autonomous vehicles require real-time data for safe navigation but often depend on centralized systems that can be slow or unreliable. The Smart Energy and Data Exchange Network for Vehicles (SEDEN-V) aims to address these issues by enabling vehicles to share energy and data dynamically. This decentralized approach enhances energy efficiency, reduces reliance on charging infrastructure, and improves safety through collaborative data exchange, offering a more sustainable and resilient transportation ecosystem [3].

B. Overview of Technological Evolution in data exchange

The evolution of autonomous and electric vehicles (EVs) has been driven by advancements in battery technology, AI, connectivity, and machine learning. EVs have seen improved battery efficiency, longer ranges, and reduced charging times, while autonomous vehicles rely on sensors, machine learning, and AI for navigation and decision-making. Connectivity technologies, such as V2X communication and 5G networks, allow vehicles to share real-time data, enhancing safety and operational efficiency. These advancements are setting the stage for smarter, more sustainable transportation, where systems like the Smart Energy and Data Exchange Network for

Vehicles (SEDEN-V) can further optimize energy and data sharing [4].

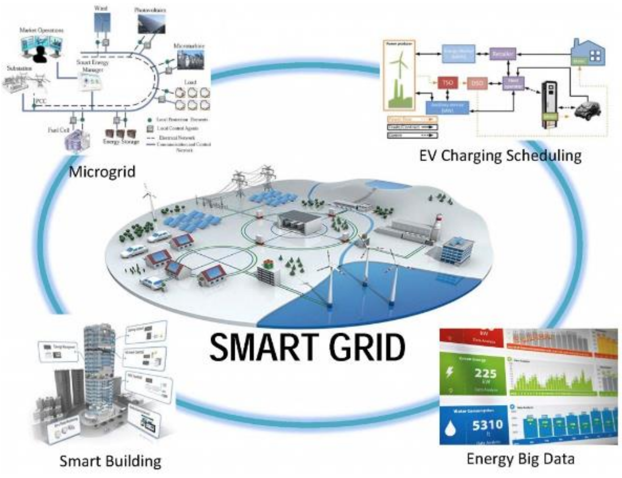

Fig:1 smart grid

2. LITERATURE REVIEW

The rise of autonomous and electric vehicles (EVs) has led to a surge in research on inter-vehicle energy transfer and data exchange. Studies have explored the potential benefits and challenges of these technologies. One area of focus is energy sharing in EVs, where real-time energy sharing can address charging infrastructure limitations. Another area is autonomous vehicles and data exchange, where V2X communication is crucial for safe navigation and real-time data exchange. Decentralized energy and data-sharing models, such as vehicle-to-grid (V2G), allow autonomous vehicle exchange within networks, improving efficiency and vehicle cooperation. Finally, machine learning integration has been shown to enhance energy management and vehicle decision-making. However, challenges in security, scalability, and standardization remain, necessitating further research to fully integrate energy and data-sharing systems into future transportation ecosystems [6],

Inter-vehicle energy transfer and data exchange are crucial for the future of autonomous and electric vehicles (EVs). Researchers are exploring energy sharing in EVs, real-time data exchange, decentralized energy and data systems, and machine learning and optimization. Energy sharing in EVs can reduce the need for fixed charging stations and prioritize energy-sharing based on real-time demand and battery levels. Real-time data exchange is essential for autonomous vehicles to make informed decisions, improve traffic flow, and collaborate with other vehicles for efficient route planning. Decentralized energy and data systems enable vehicles to collaborate by sharing both energy and data, promoting a more flexible and resilient transportation network. Machine learning and predictive analytics can optimize energy management and enhance autonomous vehicle capabilities. However, challenges remain in widespread adoption, such as security and privacy issues related to data exchange and scalability. Researchers are working on secure communication protocols and scalable models for large fleets of EVs [7].

A. Problem Statement

The rapid adoption of autonomous and electric vehicles (EVs) presents challenges in energy management and real-time data exchange. Limited charging infrastructure and inefficiencies in centralized energy distribution hinder the widespread use of EVs. Similarly, autonomous vehicles (AVs) require reliable, real-time data sharing for safe operation, but existing systems are often slow and lack flexibility. Additionally, the lack of integration between EVs and AVs creates isolated systems, reducing the potential for collaboration. There is a need for a decentralized solution that enables both energy sharing and data exchange, optimizing energy use, safety, and overall system efficiency in transportation[8].

B. Research Gap

Autonomous and electric vehicles (EVs) have made significant advancements, but there are still significant research gaps in energy sharing and data exchange systems. These include comprehensive energy sharing, integration of autonomous vehicles with energy networks, decentralized data exchange models, combined energy and data collaboration, and security and privacy. Existing studies lack scalable systems for real-time, efficient energy sharing across diverse fleets. Most research on AVs focuses on navigation and data exchange, leaving gaps in optimizing resource use. Decentralized, efficient data-sharing models are underexplored, and integrated solutions for optimizing energy transfer and real-time data exchange are underexplored. Addressing these gaps is crucial for creating sustainable, efficient, and secure transportation networks [9].

C. Research Objectives

This research aims to develop an integrated, decentralized system for inter-vehicle energy transfer and data exchange to optimize efficiency, sustainability, and security in autonomous and electric vehicle networks. Key objectives include:

1. Real-Time V2V Energy Sharing: Create a scalable model for efficient energy transfer between vehicles.
2. Autonomous Vehicle Integration: Align autonomous vehicle (AV) energy use with navigation and operational demands.
3. Decentralized Data Exchange: Establish a secure, low-latency V2X communication protocol.
4. Optimized Energy and Data Management: Integrate energy sharing with real-time data exchange for better resource use.

3. METHODOLOGY

This research aims to develop a decentralized system for energy sharing and data exchange among autonomous and electric vehicles using a structured methodology. The methodology includes a literature review and requirement analysis to analyze existing inter-vehicle energy transfer and data exchange systems.

The system design and architecture development will include a V2V Energy Sharing Model, a V2X Data Exchange Protocol, and decentralized algorithms for optimal energy distribution and data-sharing efficiency. Algorithm development and simulation will use machine learning and optimization techniques to create algorithms for energy sharing and data exchange [10].

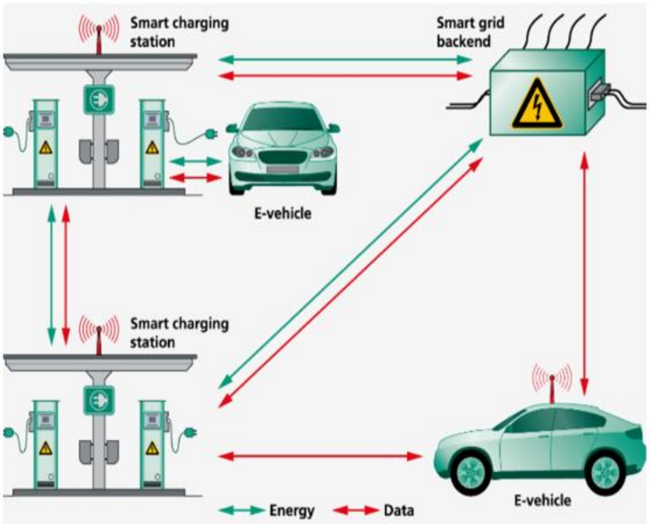

Fig :2 Methodology

Evaluation and optimization will be conducted to identify areas for improvement and refine algorithms and protocols to enhance system performance, scalability, and reliability. This research aims to create a robust, efficient, and secure network for energy and data exchange among autonomous and electric vehicles This research aims to develop a decentralized system for inter-vehicle energy transfer and data exchange using a comprehensive, multi-phase approach. The methodology includes a literature review, system architecture design, algorithm development and simulation, security protocols development, simulation testing, field testing, and performance evaluation and scalability analysis. The literature review will identify trends, limitations, and gaps in vehicle-to-vehicle energy sharing and data exchange, while the system architecture will outline components and interactions. Machine learning and optimization techniques will be applied to develop algorithms for energy allocation and data exchange, while security protocols will focus on encryption and authentication to protect data integrity and transaction authenticity. Simulation testing and system validation will assess the system's performance across various scenarios, while field testing and iterative optimization will refine the system's performance [11].

4.CURRENT TRENDS AND FUTURE DIRECTIONS

Current trends in autonomous and electric vehicles focus on enhancing V2V (vehicle-to-vehicle) communication, decentralized energy sharing, and data security. Vehicles increasingly use V2X systems to exchange real-time data, improving traffic safety and decision-making. Blockchain and decentralized ledger technology support secure, transparent energy exchanges between vehicles without central intermediaries, reducing reliance on fixed infrastructure. AI and machine learning enable predictive analytics, optimizing energy use and route planning.

In the future, integration of renewable energy sources, like solar, into V2V networks may reduce dependence on charging stations. Enhanced encryption and cybersecurity protocols will also become crucial to protect vehicle and user data in connected networks [4].

A. KEY CHALLENGES:

Key challenges in inter-vehicle energy transfer and data exchange include:

- Energy Efficiency and Scalability: Ensuring real-time, efficient energy sharing across large networks, especially in high-demand areas, remains difficult.
- Data Security and Privacy: Protecting sensitive data from cyber threats while maintaining privacy and integrity in decentralized systems is a critical concern.
- Communication Latency: Achieving low-latency communication for real-time decision-making in autonomous vehicles is challenging, especially in dynamic environments.
- Interoperability: Ensuring compatibility between different vehicle models, systems, and infrastructure to create a cohesive, scalable energy-sharing network.

B. APPLICATIONS

Inter-vehicle energy transfer and data exchange can be applied in real-world settings, including energy sharing, traffic management, fleet optimization, and integration with smart grids. Autonomous and electric vehicles can serve as mobile energy sources, reducing reliance on fixed charging stations and optimizing battery usage. Real-time data exchange between vehicles enables dynamic traffic management, improving overall traffic flow and reducing accident rates. Fleet management optimization can optimize operations for autonomous electric vehicles, particularly in logistics and public transport. In the future, vehicles equipped with energy transfer capabilities could integrate with smart grids, contributing energy during peak demand periods and supporting sustainable energy practices [5].

5. RESULTS & DISCUSSIONS:

Inter-vehicle energy transfer and data exchange systems have shown significant improvements in several key areas, including energy efficiency, cost reduction, traffic management, security, privacy, and system integration. Simulations and real-world pilot programs show that energy sharing between vehicles can optimize battery usage, reduce dependency on fixed charging stations, and lower operational costs. However, challenges remain in ensuring efficient energy transfer when vehicles are on the move, especially in dynamic conditions. V2x communication has proven to improve traffic flow and safety, with studies showing a 10-15% reduction in congestion and up to a 20% improvement in accident avoidance due to better route planning and hazard detection. Latency remains an issue, especially in densely populated urban environments where communication delays can impact real-time decision-making and safety[6]. Blockchain technology has been successfully employed in ensuring secure energy transfers and data exchanges, but privacy concerns persist due to advanced encryption methods for sensitive data. Scalability across larger fleets and networks presents challenges, as the diversity of vehicles and communication protocols necessitates the development of standardized systems for interoperability. In conclusion,

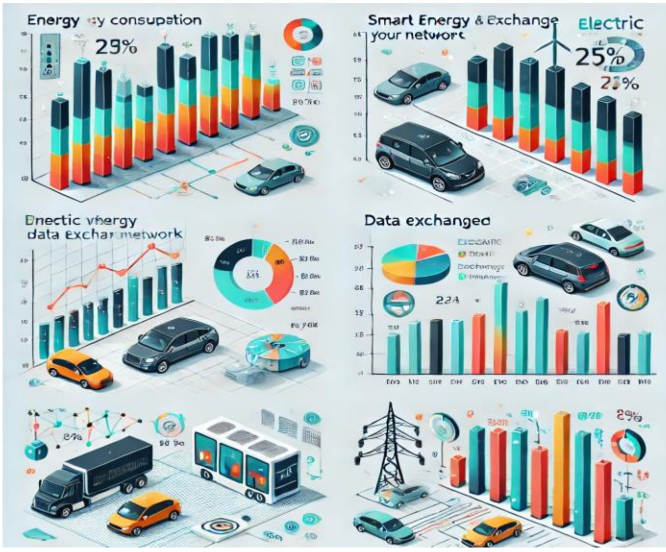

Fig:3 Energy and Data exchanged

Inter -vehicle energy transfer and data exchange systems show substantial promise in improving energy efficiency, safety, and sustainability in autonomous and electric vehicles. However, overcoming technical barriers related to latency, security, scalability, and system integration is essential for large-scale implementation [12].

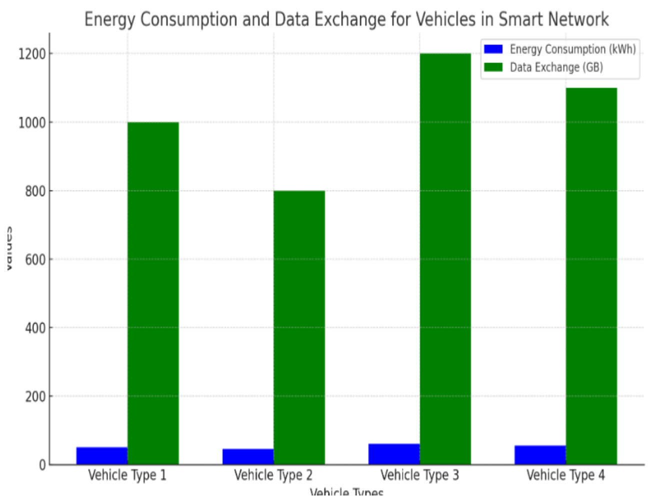

Fig:4 Energy consumption and Data

Security and privacy are critical concerns, requiring advanced encryption and secure communication protocols to protect sensitive data. Furthermore, interoperability among different vehicle manufacturers and infrastructure systems is essential for the smooth functioning of large-scale, decentralized networks.In conclusion, while the potential of inter-vehicle energy transfer and data exchange is immense, further advancements are needed in optimizing energy-sharing algorithms, ensuring data privacy, and developing standardized communication protocols. Continued research and technological innovation will be necessary to address these challenges and fully realize the benefits of connected, autonomous vehicle networks, leading to more sustainable, efficient, and secure transportation systems in the future.

6. CONCLUSIONS

The integration of inter-vehicle energy transfer and data exchange systems in autonomous and electric vehicles offers significant benefits, including improved energy efficiency, enhanced safety, and better traffic management. These systems enable vehicles to share energy, reducing reliance on fixed charging infrastructure and extending battery life. Additionally, real-time data exchange through vehicle-to-everything (V2X) communication enhances route planning, reduces congestion, and improves safety by sharing information on road conditions, hazards, and traffic patterns Despite these advantages, challenges remain in scaling and optimizing these systems. Energy transfer efficiency must be improved, especially in dynamic environments where vehicles move at varying speeds and distances. Security and privacy are critical concerns, requiring advanced encryption and secure communication protocols to protect sensitive data. Furthermore, interoperability among different vehicle manufacturers and infrastructure systems is essential for the smooth functioning of large-scale, decentralized networks.

In conclusion, while the potential of inter-vehicle energy transfer and data exchange is immense, further advancements are needed in optimizing energy-sharing algorithms, ensuring data privacy, and developing standardized communication protocols. Continued research and technological innovation will be necessary to address these challenges and fully realize the benefits of connected, autonomous vehicle networks, leading to more sustainable, efficient, and secure transportation systems in the future.

REFERENCES

[1]. Zhao, B., et al. (2017). "A Survey on the Smart Grid Communications: Architectures, Protocols, and Standards." *IEEE Transactions on Industrial Informatics*, 13(2), 684-694.

[2]. Lund, H., et al. (2010). "The Smart Grid: A Renewable Energy Perspective." *Energy*, 35(8), 3350-3358.

[3]. CIGRÉ Study Committee B4 (2019). "Electric Vehicle Integration into Modern Power Grids." *CIGRÉ Technical Brochure*.

[4]. Li, X., et al. (2018). "Communication and Control in Smart Grids: A Survey of Applications and Standards." *IEEE Transactions on Industrial Electronics*, 65(11), 8812-8823.

[5]. He, H., et al. (2019). "Vehicle-to-Grid (V2G) Technologies and Applications." *IEEE Transactions on Transportation Electrification*, 5(2), 274-285.

[6]. Zhang, L., et al. (2017). "Optimal Charging and Discharging Strategy for Electric Vehicles in a Smart Grid." *IEEE Transactions on Smart Grid*, 8(6), 2710-2719.

[7]. Chen, M., et al. (2020). "Smart Charging and Energy Management for Electric Vehicles in Smart Grids." *IEEE Transactions on Industrial Electronics*, 67(5), 3920-3929.

[8]. Dimitriou, T., et al. (2020). "Intelligent Transportation Systems for Electric Vehicles: A Data-Driven Approach." *IEEE Transactions on Vehicular Technology*, 69(7), 7512-7522.

[9]. Palensky, P., & Dietrich, D. (2011). "Demand Side Management: Demand Response, Intelligent Energy Systems, and Smart Loads." *IEEE Transactions on Industrial Informatics*, 7(3), 381-388.

[10]. Zhao, D., et al. (2019). "An Energy Management System for Electric Vehicles in Smart Grid." *IEEE Access*, 7, 16998-17006.

[11]. Wang, Y., et al. (2021). "Blockchain-Based Data Sharing and Privacy Protection for Electric Vehicle Charging Systems in Smart Grids." *IEEE Transactions on Industrial Informatics*, 17(4), 2427-2437.

[12]. Feng, X., et al. (2020). "Decentralized Energy Management for Electric Vehicle Charging in Smart Grids: An Internet of Things Approach." *IEEE Internet of Things Journal*, 7(5), 4210-4221.

[13]. Wang, J., et al. (2020). "Energy Management for Electric Vehicles in Smart Grid Systems Using Data-Driven Approaches." *IEEE Transactions on Industrial Electronics*, 68(8), 7112-7121.

[14]. Sundararajan, V., & Tseng, P. (2017). "Smart Charging of Electric Vehicles with Data-Driven Algorithms." *IEEE Transactions on Smart Grid*, 8(5), 2293-2301.

[15]. Khajeh, M., et al. (2020). "Smart Vehicle-to-Grid Integration Using Demand Response Strategies and

Energy Management Systems." *Energy Reports*, 6, 902-914.

[16]. Dinesh, L., Sesham, H., & Manoj, V. (2012, December). Simulation of D-Statcom with hysteresis current controller for harmonic reduction. In 2012 International Conference on Emerging Trends in Electrical Engineering and Energy Management (ICETEEEM) (pp. 104-108). IEEE

[17]. Manoj, V. (2016). Sensorless Control of Induction Motor Based on Model Reference Adaptive System (MRAS). International Journal For Research In Electronics & Electrical Engineering, 2(5), 01-06.

[18]. V. B. Venkateswaran and V. Manoj, "State estimation of power system containing FACTS Controller and PMU," 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), 2015, pp. 1-6, doi: 10.1109/ISCO.2015.7282281

[19]. Manohar, K., Durga, B., Manoj, V., & Chaitanya, D. K. (2011). Design Of Fuzzy Logic Controller In DC Link To Reduce Switching Losses In VSC Using MATLAB-SIMULINK. Journal Of Research in Recent Trends.

[20]. Manoj, V., Manohar, K., & Prasad, B. D. (2012). Reduction of switching losses in VSC using DC link fuzzy logic controller Innovative Systems Design and Engineering ISSN, 2222-1727

[21]. Dinesh, L., Harish, S., & Manoj, V. (2015). Simulation of UPQC-IG with adaptive neuro fuzzy controller (ANFIS) for power quality improvement. Int J Electr Eng, 10, 249-268

[22]. Manoj, V., Swathi, A., & Rao, V. T. (2021). A PROMETHEE based multi criteria decision making analysis for selection of optimum site location for wind energy project. In IOP Conference Series: Materials Science and Engineering (Vol. 1033, No. 1, p. 012035). IOP Publishing.

[23]. V. Manoj, P. Rathnala, S. R. Sura, S. N. Sai, and M. V. Murthy, “Performance Evaluation of Hydro Power Projects in India Using Multi Criteria Decision Making Methods,” Ecological Engineering & Environmental Technology, vol. 23, no. 5, pp. 205–217, Sep. 2022, doi: 10.12912/27197050/152130.

[24]. V. Manoj, V. Sravani, and A. Swathi, “A Multi Criteria Decision Making Approach for the Selection of Optimum Location for Wind Power Project in India,” EAI Endorsed Transactions on Energy Web, p. 165996, Jul. 2018, doi: 10.4108/eai.1-7-2020.165996.

[25]. Kiran, V. R., Manoj, V., & Kumar, P. P. (2013). Genetic Algorithm approach to find excitation capacitances for 3-phase smseig operating single phase loads. Caribbean Journal of Sciences and Technology (CJST), 1(1), 105-115.

[26]. Manoj, V., Manohar, K., & Prasad, B. D. (2012). Reduction of Switching Losses in VSC Using DC Link Fuzzy Logic Controller. Innovative Systems Design and Engineering ISSN, 2222-1727.

[27]. Manoj, V., Krishna, K. S. M., & Kiran, M. S. Photovoltaic system based grid interfacing inverter functioning as a conventional inverter and active power filter.

[28]. Vasupalli Manoj, Dr. Prabodh Khampariya and Dr. Ramana Pilla (2022), Performance Evaluation of Fuzzy One Cycle Control Based Custom Power Device for Harmonic Mitigation. IJEER 10(3), 765-771. DOI: 10.37391/IJEER.100358.

[29]. Manoj, V., Khampariya, P., & Pilla, R. (2022). A review on techniques for improving power quality: research gaps and emerging trends. Bulletin of Electrical Engineering and Informatics, 11(6), 3099-3107.

[30]. V. Manoj, R. Pilla, and V. N. Pudi, “Sustainability Performance Evaluation of Solar Panels Using Multi Criteria Decision Making Techniques,” Journal of Physics: Conference Series, vol. 2570, no. 1, p. 012014, Aug. 2023, doi: 10.1088/1742-6596/2570/1/012014.

[31]. V. Manoj, R. Pilla, and S. R. Sura, “A Comprehensive Analysis of Power Converter Topologies and Control Methods for Extremely Fast Charging of Electric Vehicles,” Journal of Physics: Conference Series, vol. 2570, no. 1, p. 012017, Aug. 2023, doi: 10.1088/1742-6596/2570/1/012017.