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Innovative Compact Twin Whirly Bird-based Wind Turbine: A Sustainable Solution for EV Charging Infrastructure

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ABSTRACT

The global adoption of whirly bird vent roofs across various industries underscores their utility in harnessing wind energy for cooling purposes within warehouses and similar environments. The innovation proposed in the current study builds upon this established technology by integrating semi-perpetual motion principles into a compact twin whirly bird-inspired wind turbine design. This novel approach aims to enhance power generation efficiency, thereby offering a sustainable solution for energy production.

The compact twin whirly bird turbine concept represents a significant advancement, particularly in the context of powering electric vehicle (EV) chargers. As the demand for EVs continues to surge, concerns persist regarding the availability of charging infrastructure. By integrating the proposed innovative wind turbine technology into the EV charging ecosystem, we address this critical issue while simultaneously promoting the adoption of renewable energy sources.

The key to our proposal is the deployment of small-scale wind turbines in diverse public locations, thereby democratizing access to clean energy generation. Unlike conventional large- scale wind turbines, our whirly bird-inspired turbines boast versatility in installation, akin to streetlamps, facilitating widespread deployment across urban landscapes. While these turbines may yield comparatively modest power outputs relative to megawatt-scale counterparts, their strategic placement ensures a decentralized network capable of powering EV charging stations.

In summary, our research presents a compelling solution that bridges the gap between EV charging infrastructure availability and the utilization of renewable energy sources. By leveraging the inherent advantages of whirly bird-inspired wind turbines, we offer a practical pathway towards sustainable energy provision in public spaces, thereby facilitating the widespread adoption of electric vehicles.

Keywords: Compact twin whirlybird turbine, Semi-Perpetual motion, Electric Vehicle Charges, Charging Stations, Renewable Energy.

INTRODUCTION

The Electric Vehicle (EV) industry has grown by leaps and bounds over the past few decades and global reports claim that the escalating growth is only going to increase exponentially in the future [1]. EVs present a substantial solution to increase sustainability and has proven to have a positive impact in reducing pollution and depletion of air quality. However, they do carry certain limitations of limited

driving range and frequent need for battery charging [2]. These curbs put EVs at a disadvantage for longer range drives, especially due to the lack of proper and sufficient EV charging stations and infrastructure in most countries [3]. The critical need to address two intertwined challenges: the scarcity of electric vehicle (EV) charging stations and the imperative to transition towards sustainable energy sources, serves as the impetus behind the innovative concept proposed in this study. Currently, the inconvenience of locating charging stations before commencing a journey poses a significant hurdle to the widespread adoption of electric vehicles [4]. This predicament underscores the urgent necessity for the establishment of a robust and accessible network of charging infrastructure. Furthermore, the need to mitigate the environmental impact of transportation mandates a shift towards renewable energy sources [5]. The integration of renewable energy into transportation infrastructure not only reduces greenhouse gas emissions but also fosters energy independence and resilience [6]. Recognizing these requirements, the current study aims to propose concepts that would result in the revolution of the landscape of EV charging through the convergence of renewable energy technology and innovative design.

In response to these challenges, this paper presents a pioneering solution: the "Compact Twin Whirly Bird-Based Wind Turbine Integrated with EV Charger." This visionary concept combines the principles of wind energy generation with the practical requirements of EV charging infrastructure. By harnessing the power of wind through strategically positioned turbines [7], this concept seeks to provide a sustainable and decentralized energy source for charging electric vehicles. This approach capitalizes on the versatility of whirly birds, traditionally utilized for ventilation purposes in industrial settings [8], to serve as dual-purpose structures capable of both energy generation and functional utility. This transformational concept not only optimizes land use but also capitalizes on existing infrastructure to minimize environmental impact and maximize efficiency.

The proposed concept implies the development of a novel whirly bird design optimized for electricity generation. Drawing inspiration from principles of aerodynamics and mechanical engineering, the study delivers the model of a semi-perpetual motion system that maximizes energy output while ensuring stability and reliability. Through rigorous testing and iterative refinement, a breakthrough in wind turbine technology that promises to revolutionize the field of renewable energy can be successfully attained. Moreover, the proposed concept emphasizes the strategic deployment of charging infrastructure in key public locations, including educational institutions, IT parks, residential complexes, and commercial hubs. By integrating EV chargers with renewable energy generation facilities, this paper aims to present an approach to creating a symbiotic relationship between clean transportation and sustainable energy production.

BACKGROUND

The global transition towards sustainable transportation is increasing evidently, driven by concerns over environmental degradation and depletion of finite fossil fuel resources. Amid this shift, EVs have emerged as a promising alternative to conventional vehicles, offering reduced emissions and lower operational costs [9]. However, this rapid growth of EVs has presented the challenge of setting up robust functional charging stations at accessible locations for users. Several studies have been conducted highlighting the challenges caused due to the scarcity of EV charging stations [24] [25] [26] [27] [28]. In research conducted by Mastoi et.al., (2022 [10]), the authors discuss the impact of EVs on grid integration and propose standardized infrastructure and optimal placement of EV charging stations based on grid

impacts. In India, the adoption of EVs has spread far and wide especially in the bigger urban cities [11], leading the Ministry of Power in collaboration with the Government of India to present guidelines & standards regarding Charging Infrastructure for EVs in the year 2018 [12] which was later amended in 2023 [13]. In these reports, the need for more EV stations has been acknowledged and policies have been set in place to promote the installation of charging stations. The ammended report states that "1. *Private charging at residences/ offices shall be permitted. DISCOMs may facilitate the same. 2. Setting up of Public Charging Stations (PCS) shall be a de-licensed activity and any individual/entity is free to set up public charging stations, provided that, such stations meet the technical as well as performance standards and protocols laid down below as well as any further norms/standards/specifications laid down by Ministry of Power and Central Electricity Authority from time to time. 1 2.1 Any person seeking to set up a Public Charging Station may apply for connectivity, and he shall be provided connectivity on priority by the Distribution Company licensee to supply power in the area. Any Charging Station/ Chain of Charging Stations may also obtain electricity from any generation company through open access."*
In addition to the lack of charging stations one of the most pressing concerns include the fact that conventional EV charging methods, namely Level 1, Level 2, and DC fast charging, have limitations such as slow charging speeds, infrastructure constraints, and reliance on fossil fuels [14]. Numerous scholars have studied and researched on approaches that present more sustainable options for EV charging infrastructure. Vlad et.al., (2023 [15]) explored the notion of using photovoltaic system connected to the network for charging EVs and successfully conducted a large-scale experiment proving it to be a viable and profitable option for using renewable sources to charge EVs. Opting for renewable sources ensures economical and sustainable charging of EVs, however, there prevails a severe shortage of such infrastructure across the globe [16] [17] [18] [21] [22] [23]. Therefore, the present study focuses on proposing an approach that provides a plausible and robust solution to both the lack of charging stations and the shortage of renewable energy-based charging infrastructures for EVs.

METHODOLOGY

To address the limitations and challenges of existing EV charging infrastructure, it is mandated to explore innovative solutions that prioritize scalability, accessibility, and environmental sustainability. The proposed approach in the current study aims to revolutionize the charging stations by harnessing wind energy through a unique whirly bird-based turbine design. By leveraging wind power, which is abundantly available and environmentally friendly, we can create a decentralized network of EV charging stations that reduce reliance on non- renewable energy sources and promote greener transportation alternatives. The proposed whirly bird-based turbine offers several advantages over traditional wind turbines. Primarily, its compact design allows for easy installation in urban and densely populated areas, where space constraints often limit the feasibility of large-scale wind farms. Additionally, the blade design, inspired by existing whirlybird vents, is optimized for aerodynamic efficiency, enabling effective energy capture even in low wind conditions. Despite generating less power compared to megawatt-scale turbines, these turbines are well-suited for powering EV charging stations and other small-scale applications, making them a versatile and practical solution for renewable energy generation.

Components
include:

As shown in Figure 1, the components of the whirly bird-based wind turbine

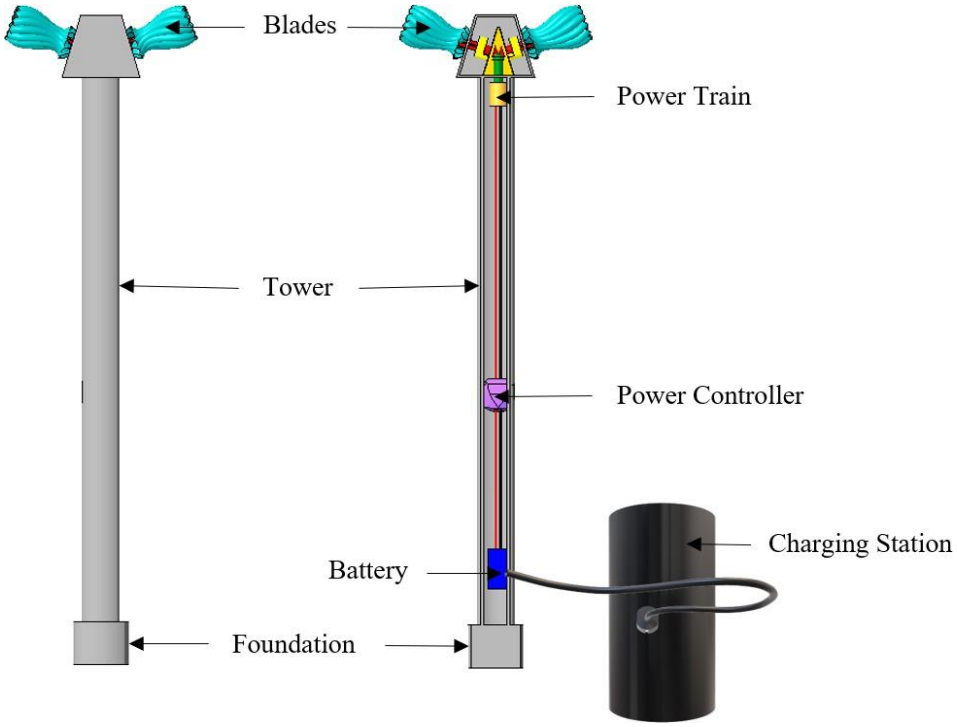

Figure 1: Compact Twin Whirly Bird Wind Turbine (Left- Overview_ Right- Section View)

1. **Foundation:** The foundation provides stability and support for the turbine, ensuring it can withstand wind forces and vibrations.
2. **Tower:** The tower supports the turbine blades at an optimal height for wind capture, maximizing energy production.
3. **Blades:** Inspired by whirly bird vents, the blades are designed to maximize aerodynamic performance and energy capture efficiency.
4. **Powertrain:** The powertrain system transmits rotational energy from the turbine blades to the generator, converting mechanical energy into electrical power.
5. **Generator:** The generator converts the rotational energy from the turbine into electrical power, which can be used to charge electric vehicles.
6. **Power Controller:** The power controller regulates voltage and power output, ensuring consistent and safe charging operations.
7. **Battery Packs:** Battery packs store excess energy generated by the turbine for use during periods of low wind or high demand.
8. **Charging System:** The charging system distributes power from the turbine to EV charging stations, allowing electric vehicles to recharge their batteries.

Blades

The blade design is a critical component of the turbine, as it directly impacts energy capture efficiency and overall performance. Inspired by existing whirly bird vents as shown in Figure 3, the blade design is optimized for aerodynamic performance as shown in Figure 2, with a focus on maximizing lift and minimizing drag. Manufacturing methods for the blades mirror those used for traditional whirly bird vents, with galvanized sheets selected as the blade material for their durability and cost-effectiveness.

Figure 3: Existing Design of Whirly Bird Vent

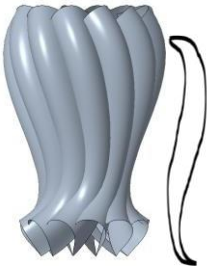

Figure 2: Proposed Design of Whirly Brid-based Wind Turbine

Power-Train System

The powertrain system is responsible for transmitting rotational energy from the turbine blades to the generator. It consists of three bevel gears, with two serving as input shafts connected to the turbine blades and one connected to the generator as the output shaft. Additionally, semi-perpetual magnets are integrated into the drive shaft to enhance rotational speed and efficiency. These magnets align with opposite poles, further boosting rotation when driven by wind, resulting in increased power output. Figure 4 shows the sectional view of the proposed power train for the whirly bird-based wind turbine.

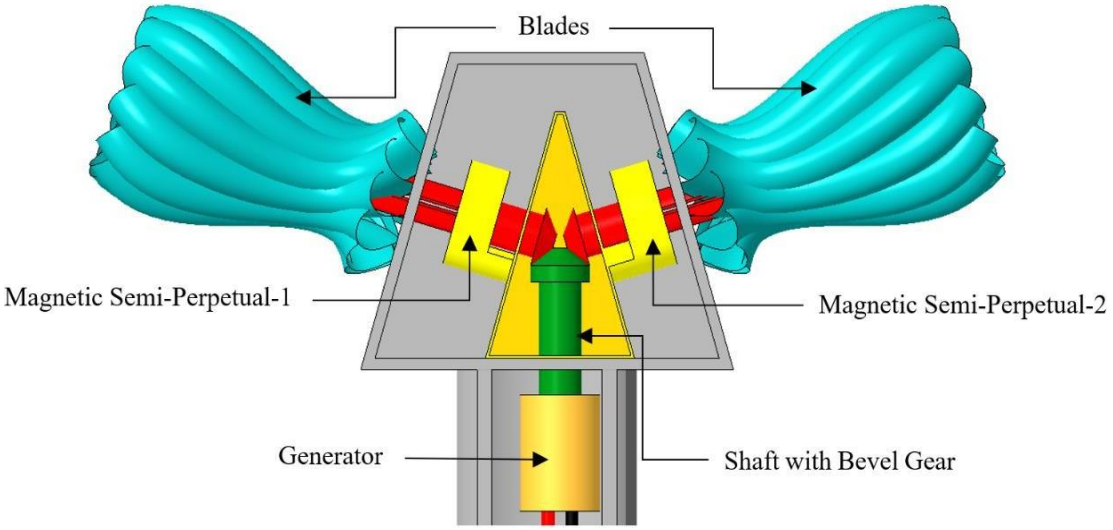

Figure 4: Section View of the Power Train System

Magnetic Semi-Perpetual System

The magnetic semi-perpetual system plays a crucial role in amplifying shaft speed and enhancing power generation [19] [20]. As the turbine blades rotate due to wind, the magnetic pole alignment within the semi-perpetual system (as shown in Figure 5) facilitates additional shaft acceleration, resulting in higher-than-expected power output. This innovative system maximizes energy capture efficiency and ensures optimal performance of the turbine under varying wind conditions.

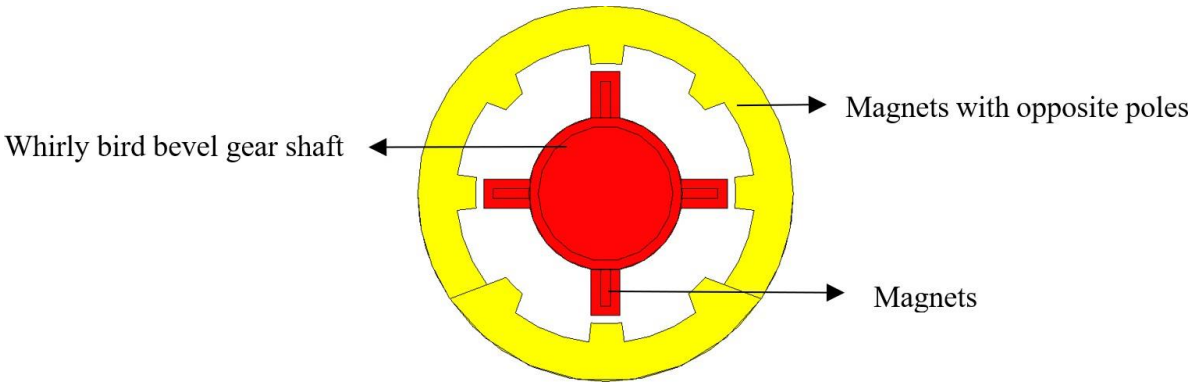

Figure 5: Semi-Perpetual Magnetic System

Power Distribution and Storage System

The power distribution and storage system manage the generated power and ensure efficient operation of the charging infrastructure. In the generator phase, electrical power is generated by the turbine and regulated by the power controller to maintain optimal voltage levels. The power is then distributed to the battery system, where excess energy is stored for use during periods of low wind or high demand. The charging system adapts to customer requirements, providing flexible charging options for various EV types and charging preferences.

Chargeable Vehicles

The proposed whirly bird-based turbine charging system is compatible with a wide range of electric vehicles, including four-wheelers, two-wheelers, and three-wheelers. This versatility ensures that a diverse range of EV owners can benefit from clean and sustainable charging infrastructure powered by renewable energy.

General Specifications

- **Expected Charger Capacity:** 48V 10kW.
- **Battery Type:** Lithium ferro phosphate.
- **Blade Material:** Galvanized sheets.
- **Tower Height (including blade top-tip):** 5 meters.
- **Approximate Overall Cost (including 48V 10kW charger cost):** ₹3,50,000.

CONCLUSION

In conclusion, the innovative concept of the "Compact Twin Whirly Bird-Based Wind Turbine Integrated with EV Charger" contributes significantly to mitigating the challenges of EV charging infrastructure and renewable energy integration. By leveraging wind energy and adopting innovative infrastructure, this concept offers a practical and sustainable solution for charging electric vehicles. The proposed approach profits from on the versatility of whirly bird- inspired turbines, enabling easy installation in urban areas and facilitating widespread deployment across diverse public locations. Despite generating relatively modest power outputs compared to larger wind turbines, these compact turbines serve as an efficient and decentralized energy source for EV charging stations. The integration of renewable energy generation with EV charging infrastructure, not only promotes the adoption of clean transportation but also contributes to reducing greenhouse gas emissions and mitigating environmental impact.

In summary, this innovative concept represents a paradigm shift in the intersection of transportation and renewable energy. By leveraging innovative design principles and cutting- edge technology, the whirly bird-based turbine charging system offers an efficient and robust solution for powering EVs. With its compact footprint, aerodynamic blade design, and integrated power management system, this approach represents a significant advancement in establishing more accessible stations and renewable energy integration with EV charging infrastructure, paving the way for a cleaner and greener future for the automobile industry.

REFERENCES

1. EVreporter. (2024). In *EVreporter.com*. EVreporter Intelligence, Research, Outreach. https://evreporter.com/wp-content/uploads/2024/02/EVreporter-Feb-2024-magazine.pdf
2. Chung, B. D., Park, S., & Kwon, C. (2018). Equitable distribution of recharging stations for electric vehicles. *Socio-Economic Planning Sciences*, *63*, 1–11. https://doi.org/10.1016/j.seps.2017.06.002Mastoi, M. S., Zhuang, S., Munir, H. M., Haris, M., Hassan, M., Usman, M., Bukhari,
3. S. S. H., & Ro, J. (2022). An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends. *Energy Reports*, *8*, 11504– 11529. https://doi.org/10.1016/j.egyr.2022.09.011
4. Zeng, A., & Yan, X. (2022). The location problem of EV charging stations: research trends, critical gaps, and a future agenda. *Aries Systems Corporation*. https://www.researchgate.net/publication/363698105_The_location_problem_of_EV_ charging_stations_research_trends_critical_gaps_and_a_future_agenda
5. Feng, S., & Magee, C. L. (2020). Technological development of key domains in electric vehicles: Improvement rates, technology trajectories and key assignees. *Applied Energy*, *260*, 114264. https://doi.org/10.1016/j.apenergy.2019.114264
6. *Design of EV charging station using renewable energy sources*. (2023, June 16).
7. IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/10200546
8. Torasa, C., & Sermsri, N. (2015). The application of roof ventilator for electricity generation. *Procedia - Social and Behavioral Sciences*, *197*, 1690–1696. https://doi.org/10.1016/j.sbspro.2015.07.221

9. Insulation, R. (2022, August 26). Wind turbine roof ventilators. *Roof Insulation*. https://roofinsulations.co.za/wind-turbine-roof-ventilators/
10. IVC Association & IndusLaw. (2022). *ELECTRIFYING INDIAN MOBILITY*. Ernst & Young LLP.
11. Mastoi, M. S., Zhuang, S., Munir, H. M., Haris, M., Hassan, M., Usman, M., Bukhari, S. S. H., & Ro, J. (2022). An in-depth analysis of electric vehicle charging station infrastructure, policy implications, and future trends. *Energy Reports*, *8*, 11504–11529. https://doi.org/10.1016/j.egyr.2022.09.011
12. IVC Association & IndusLaw. (2022). *ELECTRIFYING INDIAN MOBILITY*. Ernst & Young LLP.
13. Ministry of Power. (2018). Charging Infrastructure for Electric Vehicles (EV)- The Revised Consolidated Guidelines & Standards. In *Government of India* (No.12/2/2018-EV (Comp No. 24434)).
14. Ministry of Power & Central Electricity Authority. (2023). ELECTRIC VEHICLES UTILIZATION FOR VEHICLE-TO-GRID (V2G) SERVICES. In *File No.CEA-GO-*
15. *12-22/1/2023-GM Division*. https://cea.nic.in/wp-content/uploads/gm_and_npc/2023/11/V2G_Report.pdf
16. Barman, P., Dutta, L., Bordoloi, S., Kalita, A., Buragohain, P., Bharali, S., & Azzopardi, B. (2023). Renewable energy integration with electric vehicle technology:
17. A review of the existing smart charging approaches. *Renewable & Sustainable Energy Reviews*, *183*, 113518. https://doi.org/10.1016/j.rser.2023.113518
18. Vlad, C., Bancila, M. A., Munteanu, T., & Murariu, G. (2013). Using renewable energy sources for electric vehicles charging. *Conference Paper*. https://doi.org/10.1109/iseee.2013.6674349
19. CHARGE YOUR ELECTRIC VEHICLE SUSTAINABLY WITH GREEN POWER. (2018). In *ENERGY STAR* [Report].
20. https://www.energystar.gov/sites/default/files/asset/document/Charging%20EVs%20with%20Green%20Power.pdf
21. Alkawsi, G., Baashar, Y., U, D. A., Alkahtani, A. A., & Tiong, S. K. (2021). Review of Renewable Energy-Based Charging Infrastructure for Electric Vehicles. *Applied Sciences*, *11*(9), 3847. https://doi.org/10.3390/app11093847
22. Alrubaie, A. J., Salem, M., Yahya, K., Mohamed, M., & Jamil, M. K. M. (2023). A Comprehensive Review of Electric Vehicle Charging Stations with Solar Photovoltaic System Considering Market, Technical Requirements, Network Implications, and Future Challenges. *Sustainability*, *15*(10), 8122. https://doi.org/10.3390/su15108122
23. Abu, R. & Ekasakti University. (2018). Gravitational Power Plants using the Semi- Perpetual Motion Concept. In *International Journal of Science and Research (IJSR)*. https://www.ijsr.net/archive/v7i11/ART20193194.pdf
24. Hidayat, M. N., Chairandy, S. P., & Ronilaya, F. (2021). A review on how a Perpetual Motion Machine generates electrical power. *IOP Conference Series: Materials Science and Engineering*, *1098*(4), 042063. https://doi.org/10.1088/1757- 899x/1098/4/042063
25. Brown, A., Cappellucci, J., White, E., Heinrich, A., Cost, E., National Renewable Energy Laboratory, & ICF Inc. (2023). *Electric Vehicle Charging Infrastructure*

26. *Trends from the Alternative Fueling Station Locator: First Quarter 2023* (Technical Report NREL/TP-5400-86446). National Renewable Energy Laboratory. https://afdc.energy.gov/files/u/publication/electric_vehicle_charging_infrastructure_trends_first_quarter_2023.pdf
27. Wood, E., Raghavan, S., Rames, C., Eichman, J., Melaina, M., & National Renewable Energy Laboratory. (2017). Regional charging Infrastructure for Plug-In Electric Vehicles: A Case study of Massachusetts. In *Technical Report*. National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy17osti/67436.pdf
28. *Alternative Fuels Data Center: electric vehicle charging stations*. (n.d.). https://afdc.energy.gov/fuels/electricity_stations.html
29. Kumar, P., & Dash, K. (2013b). Potential Need for Electric Vehicles, Charging Station Infrastructure and its Challenges for the Indian Market. In Research India Publications, *Advance in Electronic and Electric Engineering* (Vol. 3, Issue 4, pp. 471–476). Research India Publications.
30. Alanazi, F. (2023). Electric vehicles: Benefits, challenges, and potential solutions for widespread adaptation. *Applied Sciences*, *13*(10), 6016. https://doi.org/10.3390/app13106016
31. Ullah, I., Liu, K., Layeb, S. B., Severino, A., & Jamal, A. (2023). Optimal deployment of electric vehicles' Fast-Charging stations. *Journal of Advanced Transportation*, *2023*, 1–14. https://doi.org/10.1155/2023/6103796
32. BACANCY. (2023). EV charging infrastructure in India: Research paper. In *www.bacancysystems.com*. https://www.bacancytechnology.com/blog/wp-content/uploads/2023/01/ev-charging-infrastructure.pdf
33. Tirupati, M. K. & Tata Elxsi. (2022). An overview on electric vehicle charging infrastructure. In *An Overview on EV Charging Infrastructure*.
34. https://www.tataelxsi.com/storage/insights/March2022/x2duYkPYy74huw0gN7eQ.pdf