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A Survey On Wireless BRT Bus Charging

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Abstract— In order to facilitate power transfer between the electric vehicle (EV) and the grid while the vehicle is operating, this paper suggests a dynamic wireless charging system for EVs. The system makes use of an RFID-based method as well as inductive power transfer (IPT) based on theresonance principle. The design and analysis of the wireless charging system, including the hardware prototype's implementation, the computation of the self and mutual inductances, and the modeling and simulation of the power transfer efficiency, are presented in this paper. The advantages, disadvantages, and potential applications of wireless charging technology for EVs are also covered in thepaper. The suggested system is a workable, secure, and cleverway to charge EVs.

Key Words:

Design and analysis, RFID technology, Power transfer, A dynamic wireless charging system, EVs.

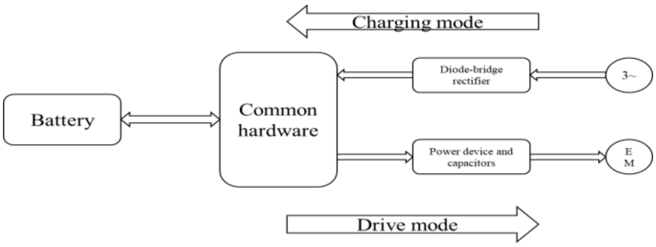
I.INTRODUCTION

In this comprehensive paper, a groundbreaking dynamic wireless charging system propose for electric vehicles(EVs) that leverages magnetic resonance coupling technology, eliminating the need for physical contact or bulky wires. The system is designed to transfer power from the grid to the EV while it is in motion, utilizing wireless power transfer (WPT) technology. Our approach includes a detailed examination of the circuit model, coil parameters, power transfer efficiency, and simulation results, providing a holistic view of the dynamicwireless charging system. Simultaneously, address the challenges inherent in designing efficient and safe WPT systems for EVs. This involves an exploration of critical aspects such as coil design, compensation topology, magnetic field distribution, and system stability. Introduction of a novel design methodology and conduct a thorough circuit analysis, employing a serial–serial (SS) compensation topology. The paper outlines a step-by-step procedure to determine optimal pad dimensions and electrical parameters for transferring a specific power level to the EV battery. In evaluating the overall merits and demerits of the dynamic wireless charging system, we also consider the potential environmental and societal benefits. The paper concludes by exploring the future scope of wireless charging technology for EVs, highlighting potential advancements and areas for further research. The comprehensive overview provided aims to understand the significance of proposed dynamic wireless charging system and resonant WPT design methodology in advancing the field and promoting sustainable EV charging solutions.

This paper section II demonstrates a literature review of various existing research work done by previous authors andsection III demonstrates the block diagram. Section IV demonstrates a conclusion of work proposed research. Section V demonstrates findings and discussion

II.LITERATURE REVIEW

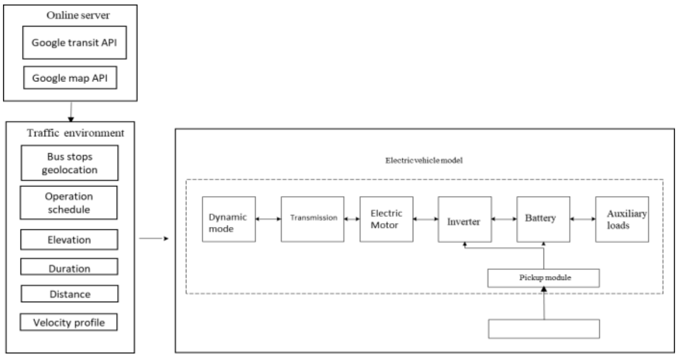
Authored by Ruilong Deng et al. [1] offers an extensive surveyon electric buses (EBs) focusing on vehicles powered primarily by electricity. The exploration covers crucial components integral to the design and operation of EBs, including energy storage systems, powertrains, interleaving elements, electric motors, and driving cycles. The paper delves into existing research topics related to EBs, providing a thorough review of literature. This includes insights into energy storage system sizing, power/energy management, range remedy methods, as well as charging design/scheduling. Additionally, the paper touches upon trial projects involving EBs, offering an overview of the main challenges faced in each area and the correspondingsolutions that have been proposed. Furthermore, the survey discusses open issues and future research opportunities in the sector of EBs.



Notable among these are suggestions for extending research practices from electric vehicles (EVs) to EBs, modeling EB charging demands, and exploring the broader impact of EBs onpower systems. The paper thus contributes to the identification of ongoing challenges and provides a roadmap for furtherinvestigation in the field of electric buses.

A Survey on Wireless BRT Bus Charging

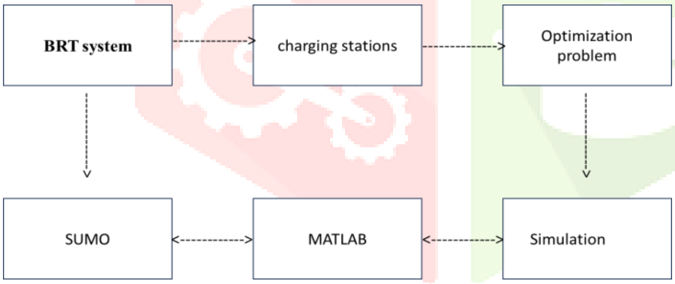
Lee et al. [2] propose a model and an algorithm for the optimaldesign of a wireless charging electric bus system based on



reinforcement learning. The authors use a Markov decision process to model the system, which consists of environment, state, action, reward, and policy. The environment is built usingreal-time traffic data from Google APIs, and the system dynamics include the electric vehicle model, the transmission, the electric motor, the inverter, the battery, and the wireless charging module.

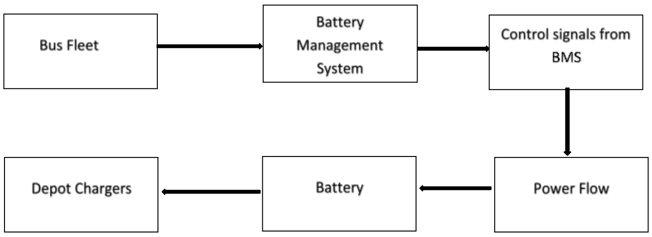
The authors apply Q-learning to find the optimal values of battery capacity, pickup capacity, and power cable installation number, which minimize the total cost and ensure a stable operation.

Semaria Ruiz et al. [3] presented a novel scheduling strategy for charging and dispatching electric heterogeneous Bus Rapid Transit (BRT) fleets equipped with batteries. The strategy is formulated as a model-based convex optimization problem, which takes into account a horizon corresponding to an entire day and incorporates proper selection matrices for restricting the operation and charging status of each BRT.



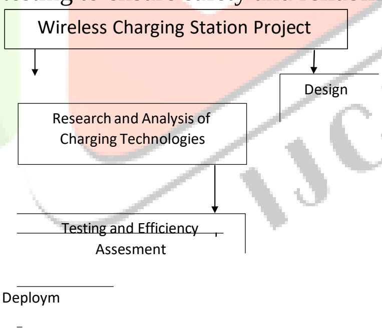
The approach is economic, since it considers the energy price variation during the day. The scheduling strategy is tested witha fleet of BRTs, considering two vehicle classes which differ intheir dimensions and capacities. Using the Simulation of UrbanMobility (SUMO) package, a simplified rule-based algorithm gives which type of BRT is needed in order to satisfy a given demand of passengers. Simulation results show the effectiveness of the scheduling method and its capacity to compute an economic optimal solution

In this paper penned by Andrés et al. [4] a novel planning method is proposed specifically tailored for partially grid- connected Bus Rapid Transit (BRT) systems employing battery electric buses (BEB) and in-motion charging (IMC) technology. The primary objective of the method is to minimizeboth the battery size and the medium voltage network requirements, all the while ensuring the technical and reliability conditions essential for the system's optimal functioning. The



applicability of this method is demonstrated through its implementation on a BRT route in Medellin, Colombia, leveraging real operational data from electric buses operating inthe region. The findings of the study underscore the method's efficacy in identifying cost-effective solutions for the partial electrification of a BRT line utilizing IMC. Notably, the proposed method demonstrates a capacity to reduce the batterysize and the overhead line length, showcasing its potential benefits in optimizing the infrastructure and resources associated with electrified transit systems. The paper further engages in a comprehensive discussion on the advantages and challenges posed by IMC when compared to alternative charging strategies for BEBs, including depot charging and opportunity charging. Through its contributions, this paper sheds light on a promising approach to enhance the efficiency and sustainability of Bus Rapid Transit systems through innovative planning methodologies.

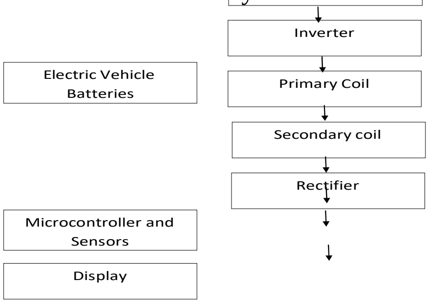
The current paper provides a summary of a project focused on the design and development of a wireless charging station for electric vehicles utilizing inductive power transfer technology.Spearheaded by Prof. Nazahat Balur et al. [5], the project encompasses comprehensive research and analysis of various wireless charging technologies. The primary goal is to create aprototype station, subjecting it to rigorous testing to ensure safety and reliability.

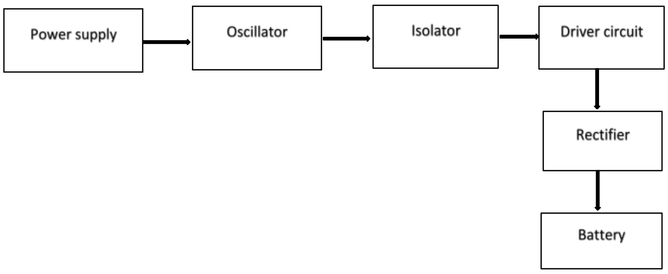


The webpage highlights the paper's content, which includes a detailed methodology, presentation of results, and discussions surrounding the project's outcomes. It serves as an overview ofthe efforts undertaken by the mentioned authors to contribute tothe advancements in wireless charging technology for electric vehicles.

This paper, authored by Sohan Sagulle et al. [6], focuses on the development of a wireless charging system for electric vehicles utilizing wireless power transfer (WPT) technology. The authors detailed the design and simulation of a resonant WPT system, incorporating primary and secondary coils, power electronics converters, and compensation circuits. Additionally, they employed infrared sensors and microcontrollers to automate the charging process, enhancing the system's efficiency and user-friendliness.

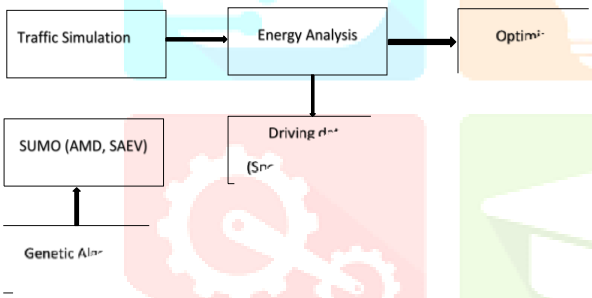
Jophy Johny et al. [8] That enables power transfer between thevehicle and the grid while the vehicle is running. The paper discusses the wireless power transfer (WPT) technology basedon inductive power transfer (IPT) and magnetic resonancecoupling (MRC), and the design and simulation of a WPT system with series-series (SS) compensation topology.





Through rigorous testing, the authors evaluated the system's performance under various conditions, including different speeds and distances between the coils. Their conclusion emphasized the critical role of resonance and coil separation indetermining the system's overall efficiency. This work contributes valuable insights into the practical implementation and optimization of wireless charging systems for electric vehicles, shedding light on factors crucial to their effective andreliable operation.

In a collaborative effort, Ahmed A. S. Mohamed et al. [7] introduce a comprehensive design methodology and optimization tool tailored for wireless charging infrastructure

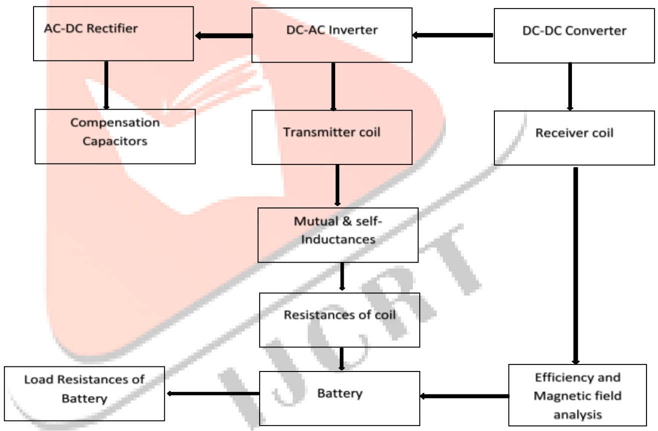


catering to shared automated electric vehicles (SAEVs) within automated mobility districts (AMDs).

The proposed tool integrates critical parameters including traffic data, a vehicle energy consumption model, and a wireless charger power model to assess key design considerations such as battery capacity, charger placement, power level, and track length. Through the formulation and resolution of a multi- objective optimization problem, the authors aim to minimize infrastructure costs while maximizing the benefits of wireless charging, encompassing factors like charge-sustaining operation and battery size reduction. The study's findings showcase the effectiveness of the optimal design solution,revealing a substantial reduction in battery capacity and the potential for infinite driving range with strategically positioned wireless chargers. The authors further provide a comparative analysis, pitting wireless charging technology against alternative charging options like stationary wireless charging and DC fast charging. This comparison underscores the advantages of wireless charging in terms of cost-effectiveness, convenience, and overall performance, offering valuable insights for the integration of efficient charging infrastructure in the realm of shared automated electric vehicles operating in automated mobility districts.

The paper also presents a payment method for wireless charging of EVs based on RFID tags and a simple laboratory setup and hardware implementation of the WPT system. The paper claims that the proposed system can provide safe, efficient, and intelligent charging for EVs and overcome the limitations of conventional plug-in charging methods.

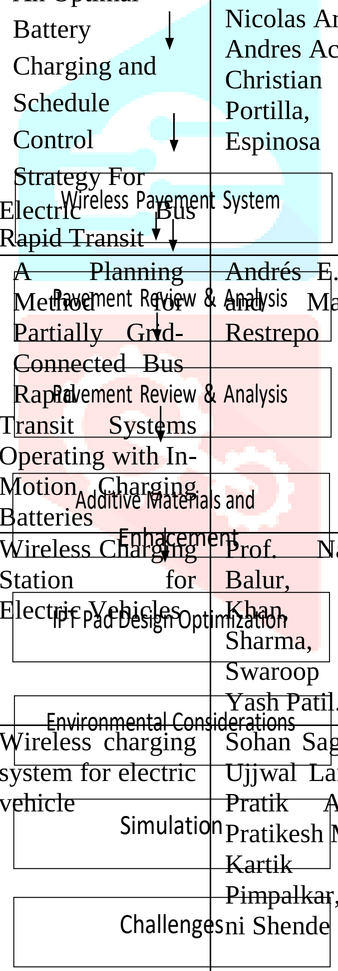
Authored by Tasnime Bouanou et al. [9], system dedicated to electric vehicle (EV) charging. The proposed system is based



on a serial–serial compensation topology, aiming to optimize efficiency and stability in the charging process.

Leveraging finite element analysis (FEA) software, the authorsdelve into the intricate task of optimizing pad dimensions and electrical parameters, achieving a power transfer capability of 3.7 kW at a frequency of 85 kHz. In addition to the optimizationefforts, the paper extensively explores the magnetic field distribution and losses within the charging pad, considering materials such as ferrite and aluminum. A thorough circuit analysis is conducted to unravel the nuances of the WPT system, shedding light on the bifurcation phenomenon's impacton efficiency and stability. The authors claim that their proposed design methodology attains a commendable efficiency of up to 90.02%, effectively circumventing the bifurcation problem. Conclusively, the paper emphasizes the critical role of pad design in the overall effectiveness of EV charging operations. The authors also point to the significance of future work in addressing safety concerns related to human exposure to the magnetic field, there by offering a comprehensive perspective on the proposed WPT system's design and its implications for the advancement of efficient andsafe EV charging technologies.

Sr NO	Paper Name	Author Name	Methodology/Algorithms / Techniques/
1	A Survey on Electric Buses — Energy Storage, Power Management, and Charging Scheduling	Ruilong Deng, Member, IEEE, Yuan Liu, Student Member, IEEE, Wenzhuo Chen, and Hao Liang, Member, IEEE	The paper surveys electric buses, addressing energy storage, power management, and charging. Stepscover components, research topics, and future opportunities
2	Optimal Design of Wireless Charging Electric Bus System Based on Reinforcement Learning	Hyukjoon Lee, Dongjin Ji and Dong-Ho Cho	Authors propose a wireless charging electric bus system using a Markov decision process and Q-learning algorithm.
3	An Optimal Battery Charging and Schedule Control Strategy For Electric Bus Rapid Transit	Semaria Ruiz, Nicolas Arroyo, Andres Acosta, Christian Portilla, Jairo Espinosa	Authors propose a model-based optimization for electric BRT scheduling, using a branch and cut algorithm for efficiency
4	A Planning Method for Partially Grid-Connected Bus Rapid Transit Systems Operating with In-Motion Charging Batteries	Andrés E. Díez and Mauricio Restrepo	Paper proposes optimization-based planning for in-motion charging in BRT. Uses Python, minimizes costs, considers constraints
5	Wireless Charging Station for Electric Vehicles	Prof. Nazahat Balur, Faraz Khan, Jyoti Sharma, Swaroop Patil, Yash Patil.	The paper proposes a wireless EV charging station with inductive power transfer, optimizing efficiency and safety
6	Wireless charging system for electric vehicle	Sohan Sagulle, Ujjwal Landge, Pratik Arjune, Pratikesh Mude, Kartik Pimpalkar, Yamini Shende	AC to DC with rectifier, DC to high-frequency AC with inverter, transmit via magnetic coupling, rectify at secondary coil, charge EV batteries.
7	System Designand Optimization of In-Route Wireless Charging Infrastructure for Shared Automated Electric Vehicles	ahmed a. s. mohamed, (senior member, ieee),andrew meintz,and lei zh	Authors develop WPTSim tool, optimizing wireless charging for SAEVs in AMDs using genetic algorithm and comparing with other technologies

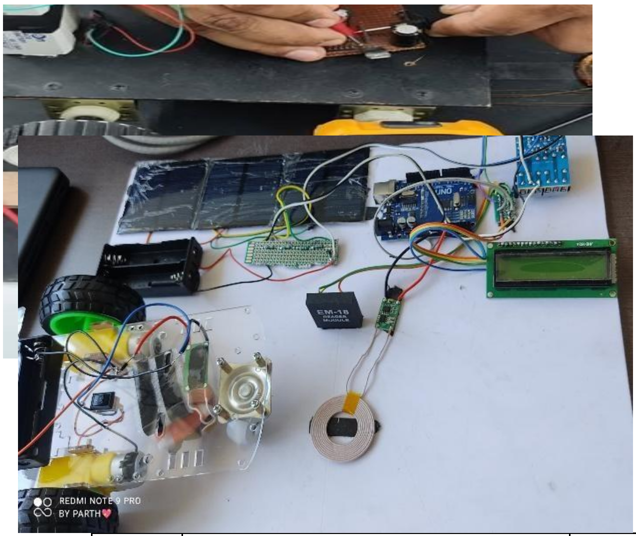


In this paper authored by Adarsh Kumar et al. [10] The authors employ a forward-thinking strategy by integrating Industry 4.0standards with a discrete event-based simulation model. This model takes into account a multitude of crucial factors including battery consumption, passenger demand, traffic conditions, charging stations, and the performance of the Internet of Things (IoT) network. The optimization aspect of the approach is facilitated through a simulated-annealing method, focusing on enhancing objective functions related to the electric bus system. The paper systematically evaluates theresults of the proposed approach across various scenarios and metrics, offering a comprehensive understanding of its efficacy. Beyond design optimization, the authors delve into the communication and computational costs associated withimplementing this approach, providing a comparative analysis with existing methods. The paper asserts that the proposed approach has the potential to substantially reduce error rates, energy consumption, and hardware requirements within the electric bus system. Additionally, the authors contend that the adoption of this approach could contribute to an improved quality of life and a more environmentally sustainable urban environment within the smart city context.

In this paper Bozhi et al. [11] the wireless pavement system (WPS) based on the inductive power transfer (IPT) technologyfor electric vehicles (EVs). The paper explores the effects of IPT pad embedment on pavement performance and power transfer efficiency, as well as the methods to enhance pavement properties using various additives and materials.

The paper also discusses the challenges and opportunities of IPT technology for sustainable and efficient EV charging infrastructure, such as cost, standardization, environmental impact, and integration with smart grids.

explores futureprospects for wireless charging technology in EVs, highlightingareas for further research and advancement.



System output

In essence, the study contributes valuable insights into the design and optimization of wireless charging systems for EVs,emphasizing the importance of resonance and coil separationfor overall efficiency. By addressing key challenges andproposing innovative solutions, the paper lays the groundworkfor promoting sustainable EV charging solutions and advancingthe field of wireless charging technology.

System Architecture

IV. FINDINGS AND DISCUSSIONS

8	Dynamic Wireless Chargingof Electrical Vehicle	Jophy Johny, Delbin k Biju, Aveens Verghese, Justin Joyson	Paper proposes dynamic wireless chargin for EVs using IPT and MRC optimizing system design and payment method.
9	Design Methodology and Circuit Analysis of Wireless Power Transfer Systems Applied to Electric Vehicles Wireless Chargers	Tasnime Bouanou, Hassan El Fadil, Abdellah Lassioui, Issam Bentalhik, Mohamed Koundi and Sidina El Jeilani	Authors propose a 3.7 kW, 85 kHz WPT system for EVs, optimizing design with FEA and circuit analysis, validating agai standards.
10	A Novel Simulated-Annealing Based Electric Bus System Design, Simulation, and Analysis for Dehradun Smart City	Adarsh Kumar, P. Srikanth, Anand Nayyar, (Senior Member, Ieee), Gaurav Sharma, Rajalakshmi Krishnamurthi (Senior Member, Ieee), Mamoun Alazab, (Senior Member, Ieee)	The paper proposes a simulation-optimization approach for Dehradun's electric bus system, integrating Industry 4.0 standards, addressing challenges, and validating with real-world data.
11	A Review of Wireless Pavement System Based on the Inductive Power Transfer in Electric Vehicles	Bozhi, Mahmoud Mohamed, Vahid Najafi Moghaddam Gilani, Ayesha Amjad, Mohammed Sh. Majid, Khalid Yahya and Mohamed Salem	The paper investigates IPT pad impact on pavement damage and analyzes wireless system effects on layers. It reviews studie and discusses challenges, providing recommendations for future research.

Electric buses (EBs) are examined in the literature study, which covers parts, energy storage, drivetrains, and charging techniques. The papers include planning techniques for partially grid- connected BRT systems with in-motion charging, innovative scheduling tactics for electric bus fleets, and models for the best wireless charging electric bus systems. Design techniques for wireless charging infrastructure for shared automated electric vehicles (SAEVs) in automated mobility districts are being presented through collaborative initiatives. Another concept employs inductive power transmission to construct a wireless charging station for electric vehicles. Other contributions include combining primary and secondary coils, power converters, and automation using sensors and microcontrollers, as well as creating a wireless charging system for electric vehicles (EVs) using Wireless Power Transfer (WPT) technology. In order to achieve 3.7 kW of power transfer, a thorough WPT design characteristics, and power transfer efficiency. Utilizing Industry 4.0 guidelines and taking into account variables like battery life and passenger volume, the method uses simulated annealing to optimize. The findings point to possible decreases in hardware needs, energy usage, and mistake rates, all of which might support smart and environmentally friendly transportation systems. To sum up, the improvements that have been described together havea positive impact on the development of intelligent and sustainabletransportation solutions. These solutions include electric bus systems, wireless charging infrastructure, and dynamic wireless charging. The paper introduces an innovative dynamic wireless charging system for Electric Vehicles (EVs) utilizing Inductive Power Transfer (IPT) and Radio-Frequency Identification (RFID)technology. This technology eliminates physical touch by transferring power to EVs while they are moving and is powered by the resonance principle.

IV.RESULT AND DISCUSSION

The paper presents a novel approach to dynamic wireless charging for electric vehicles (EVs) using magnetic resonance coupling technology. The proposed system eliminates the need for physical contact or bulky wires, allowing power transfer from the grid to the EV while in motion. Through detailed circuit analysis and simulation, the study addresses challenges in designing efficient and safe wireless power transfer (WPT) systems for EVs, focusing on coil design, compensation topology, magnetic field distribution, and system stability.

Furthermore, the paper offers a step-by-step procedure for determining optimal pad dimensions and electrical parameters to transfer specific power levels to EV batteries. It evaluates the system's merits and demerits, considering potential environmental and societal benefits. Notably, it

V. CONCLUSION

In conclusion, the evaluated articles enhance the development of sustainable transportation options, charging infrastructure, and electric vehicle (EV) technology. A dedication to tackling issues in the sector is evident in the investigation of wireless charging systems, optimization techniques, and creative designs for EV charging stations. Dynamic wireless charging systems, simulation-optimization methods for electric bus systems, and thorough examinations of wireless pavement systems are among the noteworthy achievements. By improving EV charging's effectiveness, security, and intelligence, these initiatives want to improve transportation and make it more intelligent and environmentally friendly. Together, the articles grasp how critical it is to include state-of-the-art technology, such magnetic resonance coupling (MRC), inductive power transfer (IPT), and Industry 4.0 standards, to provide practical and astute responses to the changing demands of electric mobility. Future developments in sustainable transportation are paved with the research paths examined in these articles, which include improvements in wireless charging, electric bus system optimization, and the possibilities of wireless pavement technology.

VI. REFERENCES

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