Grenze International Journal of Engineering and Technology, June Issue

Various Wireless Power Transfer Systems used to Charge Electric Vehicles: A Review

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***Abstract*— Electric vehicles (EVs) require fast, cost-effective, and reliable charging systems to ensure optimal performance. Wireless charging systems address the inconvenience of plugging in devices by eliminating the need for physical connections. While traditional EVs rely on plug-in charging, modern EVs are increasingly adopting wireless or hybrid charging systems, which combine wired and wireless methods. The absence of wires and mechanical connectors in wireless charging systems makes them both environmentally friendly and user-friendly. This study explores essential techniques for wireless power transfer, focusing on three primary methods: capacitive power transfer method, inductive power transfer method, and magnetic wireless power transfer method. These approaches are analyzed and compared to highlight their respective advantages and applications. Additionally, the review delves into various wireless charging techniques, including systems based on vehicle positioning, and examines the components required for wireless power transfer across different topologies (SS, SP, PP, PS). By providing a detailed overview of these methods, the paper offers valuable insights into the advancements in EV charging technology.**

***Index Terms*—Charging system; Electric vehicles, Vehicle Charging, Wireless power Transfer, Comparison WPT Technologies.**

I. Introduction

Wireless power transfer uses electromagnetic fields to send electric energy to the load, without the need of wires or cables. Although wireless power transfer (WPT) has been planned since Tesla's time, the lack of supporting technology made it impractical at the time. A significant turning point in this field was reached in 2007 when scientists were able to wirelessly power a lightbulb from a source two meters distant [1]. Since then, remarkable progress has been achieved [2, 3], and WPT has gained recognition for its numerous advantages and potential [4, 5]. Traditional wired charging systems, also known as conductive charging systems, present several drawbacks. They require heavy charging cables and connectors, which must be manually connected to both the power source and the device being charged [6]. This process is neither convenient nor user-friendly [7]. Additionally, issues such as insulation breakdown or short circuits caused by high temperatures, ground friction, or wear and tear can lead to electric shocks [8]. To reduce charging times and associated risks, larger battery packs can be used. For instance, vehicles equipped with more batteries can travel longer distances on a single charge.

Grenze ID: 01.GIJET.11.2.179_20
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Alternatively, swapping out depleted batteries for pre-charged ones at charging stations has been proposed [9, 10]. However, this approach has limitations due to the heavy weight, high cost, and short lifespan of batteries. Carrying an excessive number of batteries is impractical, but advancements in energy storage technologies may address these challenges. WPT offers a promising alternative to address battery-related limitations [11]. Dynamic wireless power charging systems, for example, can reduce the initial costs and eliminate the need for large, heavy batteries [12]. Moreover, WPT eliminates the inconvenience of cables and connectors associated with manual plug-in systems, offering a more user-friendly and convenient solution [13, 14]. Due to its potential, WPT has become a subject of extensive research, with applications spanning electric vehicles (EVs), solar-powered satellites, medical devices, consumer electronics, underwater vehicles, and industrial facilities. Long-distance power transmission is also being studied using WPT, and grid-connected WPT systems have been evaluated [15]. The key advantages of WPT include its ease of use, safety, and adaptability, particularly in adverse weather conditions, as it minimizes the risk of electric shocks. Its mobility, position-free nature, and flexibility further enhance its appeal across various applications. Transportation remains the largest contributor to greenhouse gas emissions in the United States, primarily due to fossil fuel combustion in vehicles, trucks, ships, trains, and airplanes. Transitioning to low or zero-emission vehicles is critical for reducing these emissions and improving the sustainability of transportation networks. Electric vehicles (EVs), powered by widely available electric grids, are among the most promising alternatives for emission reduction. Governments worldwide are actively promoting EV adoption. By 2030, EVs are projected to account for 42%, 27%, and 48% of light-duty vehicle market shares in China, the US, and Europe, respectively. However, the increasing penetration of EVs presents challenges for electric power networks, including the need for transmission line upgrades, transformer overloading, and power quality issues. Many of these challenges are closely tied to the design and functionality of EV charging systems [34]. Wireless power transfer system mainly classified into three different categories. Here, receiving antennas are very closed to transmitting antenna. In this both the types of WPT, length of the antenna is electrically large λ, which is comparable with the size of the antenna. Here, EM field also varies with change in distance. The third type of WPT is Near-field Radiative WPT. This is divided into further two types. Electric field based WPT and Magnetic field based WPT are the types of the Near-field Radiative WPT. This review is organized into several sections. Section 1 provides a brief introduction to the study. In Section 2, methods for transmitting electricity using wireless media are examined. In Section 3, the paper's findings are examined and contrasted with Inductive Power Transfer, Capacitive Power Transfer, and Magnetic Power Transfer. Section 4 identifies existing research gaps, while Section 5 discusses the future scope of the study. Finally, Section 6 presents the conclusion of the review.

II. Comprehensive Review of Methods

EV charging methods can broadly be categorized into wired and wireless systems [16]. Wired conductive charging comes in three different levels: Level 1, Level 2, and Level 3[17]. Similarly, wireless charging methods are primarily divided into Capacitive Power Transfer (CPT) and Inductive Power Transfer (IPT). Among these, IPT is considered a superior technique compared to CPT [18, 19, 20]. CPT systems use an electric field to transfer power. This method exhibits relatively low power losses when the electric field passes through electrically isolated metal barriers [21], making it a viable option for EV charging [22]. Capacitors, often made from inexpensive and lightweight materials like aluminum, are used in power transmission for CPT systems. These materials are lightweight, inexpensive, and effective conductors. However, in CPT systems, the car and the charging pad must be precisely aligned. This approach has the drawback of detuning due to positional misalignment [23].

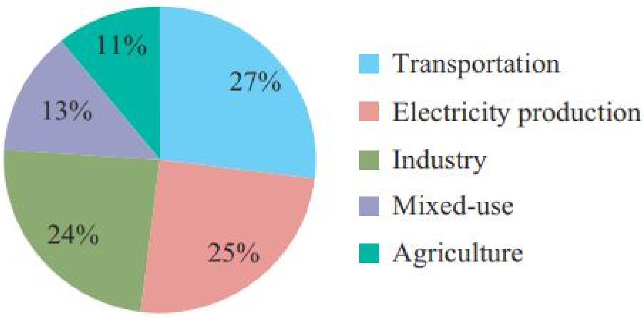

Fig.1 Total emissions in United States in 2020, [34]

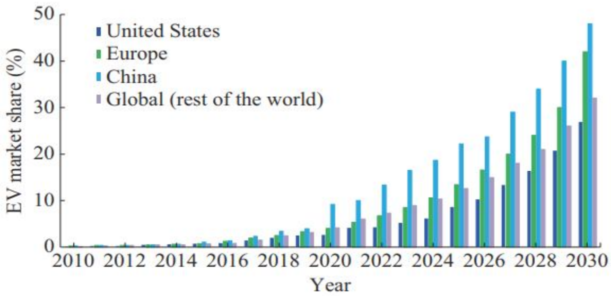

Fig. 2. Expected EV market share of light-duty vehicles, [34]

A. Capacitive Power Transfer Technique (CPT)

In a Capacitive Power Transfer (CPT) system, an electric field is used to transfer power, with minimal power losses occurring when the field passes through electrically isolated metal barriers [21]. This characteristic makes CPT a suitable option for EV charging [22]. The system relies on capacitors for power transmission, typically made from inexpensive, lightweight, and efficient materials like aluminum. Proper alignment between the vehicle and the charging pad is crucial in CPT systems, as positional misalignment can lead to detuning, which the system cannot prevent [23]. The structure of a CPT charging system is relatively simple, utilizing metal plates instead of coils. Two capacitive couplers, each made up of four metal plates, are used for power transfer. These plates can be positioned vertically or horizontally depending on the specific application. CPT technology is best suited for low-power, short-range applications [24], as the effective charging distance is generally limited to around 1 mm [25]. Beyond EV charging, CPT systems find applications in synchronous motor activation, robotic charging, and LED drivers [26]. The distance limitation in CPT systems stems from circuit topologies that rely on coupling capacitors. These topologies are classified into resonant and non-resonant types [27]. Pulse Width Modulation (PWM) is employed for conversion in non-resonant topologies, and a coupling capacitor serves as a power storage element to provide a constant power supply. Class E converters and series resonance converters are used in resonant topologies [28]. Resonance between an inductor and the coupling capacitor is achieved using a compensation circuit, which allows for higher resonant inductance and switching frequencies while reducing coupling capacitance [29]. However, the power capability of the converter limits the switching frequency, while the self-resonant frequency restricts inductance and efficiency. Additionally, resonant topologies are highly sensitive to parameter variations caused by misalignment, presenting another significant limitation. This is also called as electric coupling between transmitter plate and receiving plate.

B. Inductive Power Transfer Technique (IPT)

A typical Inductive Power Transfer (IPT) system consists of two main components: the primary side, which transmits electricity, and the secondary side, which receives it. In an IPT-based EV charging system, the primary side can be installed either above or below the road, while the secondary side is attached to the moving vehicle [30, 31]. Power is transferred from the primary to the secondary side, with the power source determined by the application's requirements.

For low-power devices, small batteries can suffice, while power-intensive applications may require single-phase or three-phase systems [31]. An inverter is employed to convert low-frequency electricity into high-frequency power for transmission [32]. Power is transferred between the primary and secondary coils through a mutual inductive connection. Using a small gap between the coils, the IPT system enables wireless power transfer, eliminating the need for physical contact between the EV and the charging unit. This makes IPT one of the most efficient techniques for EV wireless charging [33]. The operation of an IPT system is like that of a transformer, where electricity is transferred between the transmitting primary coil and the receiving secondary coil via electromagnetic induction [34]. To enhance power transfer efficiency, IPT systems often utilize resonance [35]. With no physical connection required, IPT offers a highly convenient charging solution [36], suitable for both stationary and dynamic (on-the-move) EV charging [37].

Magnetic structural design plays a crucial role in IPT systems, as the shapes and sizes of materials used for magnetic structures directly influence coupling efficiency and magnetic flux leakage [38, 39]. Magnetic coupling significantly affects power transmission capabilities, and any imperfections in coupling can lead to leakage flux. Magnetic flux that is not useful in power transfer is referred to as leakage flux.

As per the International Commission on Non-Ionizing Radiation Protection, human health is at risk when the leakage magnetic flux density surpasses 27 micro-Tesla [40].

Here, in inductive wireless power transfer, we do not use any resonance. Transmitter and receiver do not externally compensate by any capacitors.

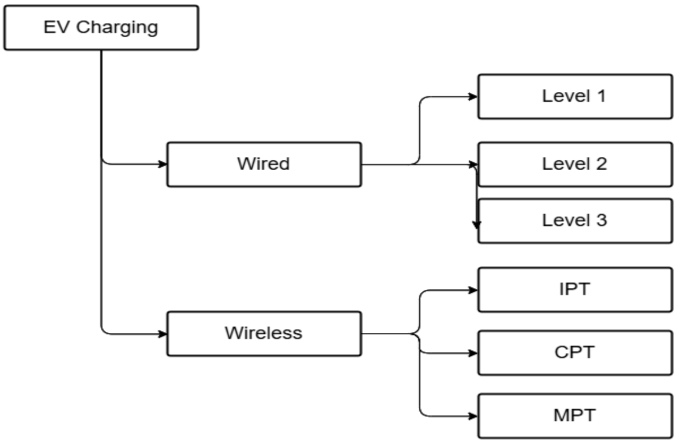

Fig. 3 There are two ways to charge an EV: wired and wireless

TABLE I: COMMERCIALLY AVAILABLE IPT E-VEHICLES, [35]

Manufacturer	Model	Launch Year	Distance (km)	Battery Capacity (kAH)	Charging Time (0–80%) (h)		
					Level 1	Level 2	DCFC
Honda	Fit ("Honda fit EV., ", 2014)	2014	132	20	15	3	-
Ford	Focus ("Ford focus, ", 2016)	2016	161	23	20	3.5	0.5
Tesla	Model 3 ("Tesla model 3, ", 2018)	2017	354	50	-	12	52/60
Mitsubishi	i-MiEV ("i-MiEV, ", 2017)	2017	180	16	22	6	0.5
Volkswagen	e-Golf ("Volkswagen e-Golf, ", 2017)	2017	201	36	-	6	1
Renault	Zoe ("Renault zoe, ", 2017)	2017	400	41	16	4.5	2.67
	Twizy ("Renault twizy, ", 2017)	2017	100	6.1	-	3	-
Toyota	Prius Prime ("Toyota prius prime, ", 2018)	2018	40	9	5.5	2.1	-
Nissan	Leaf ("Nissan LEAF, ", 2018)	2018	243	40	35	7.5	0.5
Chevrolet	Volt ("Chevrolet volt, ", 2018)	2018	85	18	13	4.5	0.33
	Clarity ("Honda clarity electric, ", 2018)	2018	75	26	12	2.5	-
Tesla	Model X ("Tesla model X, ", 2018)	2018	465	100	8.9	9.5	1.33
Kia	Kia (" Kia Soul EV Specifications, ", 2017, 2018)	2018	177	30	24	5	0.75
	E-Up ("Volkswagen e-Up, ", 2018)	2018	159	20	-	9	0.5
BMW	i3 ("BMW i3, ", 2018)	2018	183	33	15	5	0.5
	i3s ("BMW i3s, ", 2019)	2019	153	0.12	-	7	-
Chevrolet	Bolt ("CHEVROLET BOLT EV, ", 2019)	2019	383	60	-	9.3	1.33
Tesla	Model S ("Tesla Model S, ", 2021)	2021	200	100	-	-	0.25
Chevrolet	Spark ("Chevrolet spark Bolt EV, ", 2022)	2022	259	18	-	7	0.75

C. Magnetic Power Transfer technique (MPT)

Magnetic Gear Wireless Power Transfer (MGWPT) differs from capacitive and inductive power transfer methods [41]. This technique, also referred to as Resonance Magnetic Weak Coupling WPT, was theoretically developed by the Massachusetts Institute of Technology in 2005 and experimentally validated in 2007. The method transfers electrical energy through electromagnetic resonance between transmitter and receiver coils, with a coil and capacitor functioning as a resonator [42].

By aligning the resonance frequencies of the two coils with a high-quality factor, significant electrical energy can be efficiently transferred. The transmitter and receiver coils are only weakly magnetically coupled, offering flexibility in the placement of the receiving coil relative to the transmitter coil. This flexibility makes it an appealing option for wireless power transfer.

Applied technical insights regarding this method are detailed in various studies, including [43]. Despite its advantages, there is a lack of research addressing the efficiency of magnetic coupling structures across different technological pathways for EV wireless charging systems, both indoors and outdoors [44]. In Magnetic Resonant wireless power transfer, external capacitor connected to compensate the reactive component or inductive reactive component [46]. So, transmitter coil net impedance reduces and maximum amount of current flow through transmitter coil. So, enhancement of flux towards receiving coil will increase. Significant advantages of magnetic field WPT is less harmful to the human beings compared to electric field base.

Because, Electric field polarized the human body because our body made up of 70% of water, so more the electric field our body can be polarized easily, where in magnetic field cannot polarized our body, because our body is non- magnetic material effects are very minimal and transfer distance between transmitter and receiver coil, distance can be enhanced [45]. Where, in capacitive WPT it is significantly small distance. A pressing challenge is the interoperability of magnetic coupling mechanisms across various technical approaches.

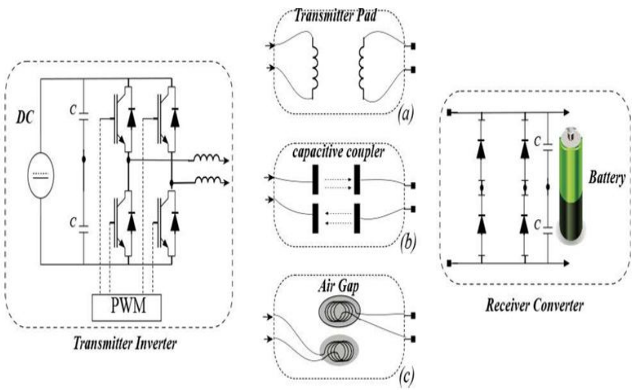

Fig. 4. a) IPT (b) CPT (c) MPT [48].

TABLE II. MISALIGNMENT PERFORMANCE COMPARISON FOR VARIOUS POWER TRANSFER METHODS, [35]

Feature	IPT	CPT	MPT
Vertical Misalignment	Conventional coils: Moderate sensitive Modified or multiple coils: Least sensitive	• two plates: Moderately sensitive • four plates: Slightly sensitive	Highly sensitive, because the transmitter and receiver beam angle is highly important. However, the receptor beam power loss increase due to a mismatch transmitter antenna angle.
Horizontal Misalignment	Conventional coil: 40–60% tolerance Modified or multiple coils: Least sensitive	• Two plates: Slightly sensitive • Four plates: Slightly sensitive • Six plates: quite sensitive	

To address this, two key issues must be tackled:

- Coil Compatibility: Ensuring compatibility between coils used in different technical pathways.
- Resonant Compensation Networks: Harmonizing the resonant compensation network topologies across these technical routes [59].

Resolving these issues is critical for advancing the efficiency and universality of wireless EV charging systems.

The four IPT topologies are categorised and described according to the way the capacitor is linked to the coil. As described, these four structures [58] are (a) series-series (b) parallel-parallel. (c) series-parallel (d) parallel-series Compensation techniques that focus on many reactive components are referred to as multi-resonant compensation. Conversely, insufficient compensation leads to a higher reactive current. Higher reactive currents result in more conduction losses and semiconductor losses, particularly on the inverter side [47].

Compensation Challenges and Solutions-Parasitic capacitance alone cannot sufficiently resonate or compensate the system due to network design limitations. Additional reactive parts, like capacitors or inductors, are added to rectify this by modifying the operational resonant frequency. A single capacitor added in series or parallel can provide basic compensation, commonly referred to as mono-resonant topology. On the other side, for better performance multi-resonant compensation employs multiple reactive elements.

Problems with Inadequate Compensation: Insufficient compensation raises reactive current, which can result in increased conduction and semiconductor losses, particularly on the inverter side. Major objectives of pricing include:

- Lowering reactive power.
- Enabling soft switching operation.
- Preventing bifurcation.
- Improving alignment tolerance.
- Achieving high efficiency, compactness, and cost-effectiveness.

Compensation Topologies

Whereas a parallel-compensated transmitter coil needs an extra inductor to transform the inverter into a current source inverter, a series-compensated transmitter coil can be attached straight to a voltage source inverter. The goal of secondary compensatory schemes is to lower the coil's VA rating. For example:

- Series secondary compensation enables the transmitter coil's constant current output to act as a voltage source.
- Parallel secondary compensation generates a current source.

Zero Phase Angle (ZPA) Criterion

The ZPA requirement, which requires that voltage and current be in phase, must be met in order to reduce the system's VA rating. By modifying the primary capacitor under particular coupling.

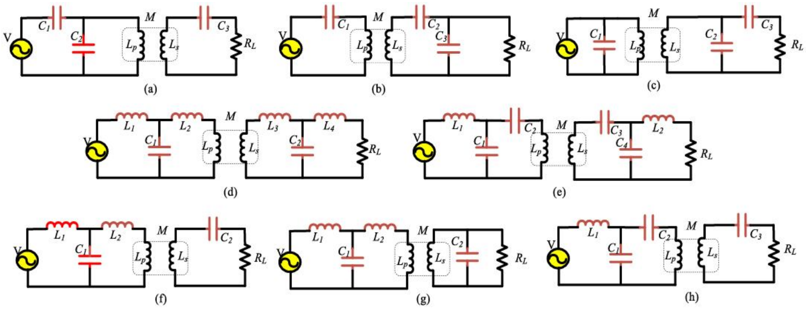

Fig. 5 Various compensation topologies, including a) SP-S b) S-SP c) P-PS d) LCL-LCL e) LCC-LCC f) LCL-S g) LCL-P h) LCC-S, [49]

Together, these actions aim to improve the effectiveness, dependability, and performance of EV wireless charging systems. Let, Lp represent for the primary side coil's leakage inductance. And Ls will be represented for that of the secondary side. Also, let CS represent for the capacitance of the receiving side compensation capacitor and CP for the transmitting side compensation capacitor. LM refers for the magnetising inductance. In the SS topology, the resonant frequency [50] that satisfies the zero-phase angle (ZPA) criterion is as follows:

$$f_r = \frac{1}{2\pi\sqrt{L_1 C_p}} = \frac{1}{2\pi\sqrt{L_2 C_s}} \quad \text{------------------------------------(1)}$$

where,

$$L_1 = L_m + L_p, \quad \text{------------------------------------(2)}$$

is the transmitting coil's self-inductance. It is provided for the receiving coil by,

$$L_2 = L_m + L_s, \quad \text{--------------------------------------(3)}$$

the CC operation is feasible after reaching the ZPA condition. (1) presents two resonant frequencies at which the output voltage (also known as CV operation) functions independently of the load. The operating frequency must be high in the CV mode. The resonant tank will function in the inductive zone due to the high frequency. Therefore, ZVS requirements for primary switch operation can be satisfied [51,52].

$$f_{cv} = \frac{1}{2\pi\sqrt{L_p C_p}} = \frac{1}{2\pi\sqrt{L_s C_s}}. \quad \text{--------------------------------------(4)}$$

Depending of the load, it functions as a voltage source [53]. On the other hand, its input impedance turns inductive when it functions as a cc source. As a result, this topology is unable to meet the ZPA criterion while in the CC mode [54]. The PS topology can only function in the CV mode; it is unable to implement the CC mode, even with the SS and SP topologies. Nevertheless, the CV mode is not supported by the CC mode, which is used in the PP topology [55]. A unique feature of wireless power transfer systems is their ability to charge several loads at once from a single transmitter. Notable features of the multi-receiver WPT system include its high degrees of freedom, safety, and convenience. However, analysing many receivers presents many challenges. The system's total size and cost are decreased via optimisation that considers load characteristics, power consumption, coil placement, and coil relationships. Nevertheless, the system experiences cross-coupling as a result. Each receiver coil interacts with other coils due to this cross-coupling effect, which decreases the system's many independent outputs. Because the system's input impedance is not entirely resistive, the cross-coupling effect, which leads to in power loss, reduces the system's capacity to transfer power. To increase output independence and system efficiency, steps are taken to remove this cross-coupling effect. The ideal compensation reactance is computed to counteract the cross-coupling effect in the multi-receiver. It is quite difficult to calculate the compensating reactance dynamically changing during the operation. With the control of the input's frequency, it is possible to eliminate the resonant frequency cross-coupling effect of coils. A possible technique is to remove the cross-coupling effect from the circuit using an adaptive tuning capacitor without changing the measurement parameters [60]. Series- series compensation topology is widely used, because frequency response is independent of mutual coupling between transmitter and receiver coil, as well as changes in load variation. In other compensation topologies, compensation topologies depend on the variation of load resistance and mutual coupling. Hybrid compensation is used to achieve constant voltage irrespective to change of load. When coil misalignment issue is managed by LCL/LCC compensation, a transmitter-side DC-DC converter is typically utilised [56]. The inverter typically maintains a constant frequency, demonstrating that a DC-DC converter may carry out control action. The primary side DC converter is managed to control the transmitter-side voltage in order to meet the charger level requirement. Therefore, when the inverter's losses decrease, the wireless power transfer system's efficiency rises. The battery will overcharge if the controller does not set the proper value for the inverter input. This is because the excess power will be sent to the receiver [57].

TABLE III: ADVANTAGES AND DISADVANTAGES OF DIFFERENT COMPENSATION TECHNIQUES

Parameters	**LCL**	**SP/S**	**S/SP**	**LCC and its variants**
Advantages	1. Provides high efficiency 2. Maintains high efficiency 3. Lower losses 4. VA rating reduced	1. For high misalignment, there is high constant output 2. Greater position tolerance than SS topology	1. Gain value independent on coupling coefficient 2. Circulating losses are less	1. Misalignment Tolerance 2. Operation possible, at time ZCA and ZPA 3. Current stress on the inverter reduced and compensate a reactive power on the secondary side. 4. It is independent on coupling coefficient
Disadvantage	Both imaginary and real part of the load include in primary side transfer impedance	Increasing reactive power under decreasing coupling conditions	No data	Complex tuning
Size and Cost	High	Less	Less	Less cost ad size

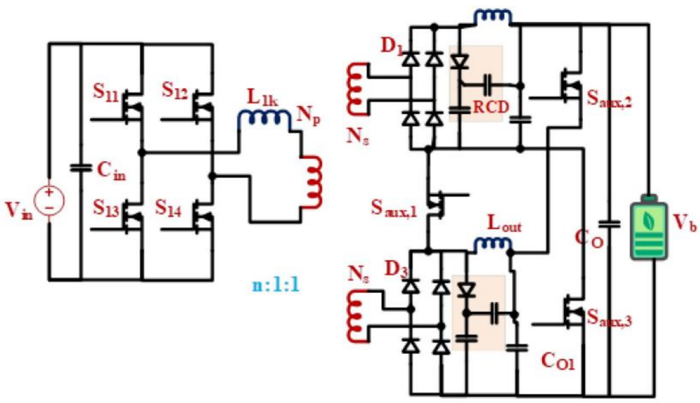

Fig.6 Multiple receiver coils with single transmission, [61].

III. SUMMARY OF THE OUTCOMES

TABLE IV. COMPARATIVE STUDY OF DIFFERENT WPT TECHNIQUES, [48].

Parameters	Capacitive Power Transfer	Inductive Power Transfer	Magnetic Power Transfer
Method of power transfer	By changing electric field	By changing magnetic field	By resonance produces between two circuits
Range of frequency	100kHz-10 MHz	10 kHz-10 MHz	Moderate 6.78 MHz
Gap among the coil	<1mm	>10cm	2m
Power density between gap	Low	High	High

Level of power	Low power application	Medium to high applications	High power application
Power density	Air gap electric field strength	Core saturation flux	-
Medium of power transfer	Passing through metal is possible	air	Objects, materials, body tissues
Requirement for high power	Low cost	High cost	High cost
Area of coupler	Less	High	High
Eddy current loss	NA	Large	Large
Power loss	High	Low	Low
Complexity	Medium	Medium	High
Size	Less	Moderate	More
Coupling efficiency	Medium	Higher	Medium
EMI	Medium	Medium	High

IV. EXISTING RESEARCH GAP

The power transfer capability in the capacitive power transfer (CPT) technique depends on the space between the transmitter and receiver, where parasitic capacitance is generated.
Inductive power transfer (IPT) is not effective at wider air gaps and necessitates shielding against electromagnetic interference. Metal items can provide a heating effect, and the transmitter and receiver must be precisely aligned for maximum efficiency.
In resonant power transfer, system costs increase with higher power levels. Additionally, this method is highly sensitive to obstacles.
Efficient cooling systems are essential to manage heat and maintain the stability and efficiency of the charging system.
High-frequency operation can lead to electromagnetic interference, which must be carefully mitigated.

V. FUTURE SCOPE

As per current requirements and the competition for plug-in chargers. We must create a charger that can fully charge a car in 15 minutes.
The main problem associated with the current system and the DWPT system are related. Infrastructure efficiency and system cost reduction are more problems.
Improved pad designs that are cheap, misalignment tolerant, and fast charging are required.
We are now combining communication and transportation mechanisms with various devices to make operations easier because of the development of web and IT technologies.

VI. CONCLUSION

Wireless power transfer has been researched and discussed in relation to electric vehicle charging. Due to its ease of use and environmental friendliness, wireless charging is thought to be an advantage to conventional wired charging methods. Additionally, wireless charging methods improve system efficiency and lessen range anxiety. In general, mutual coupling, lasers, or microwaves are used for wireless power transmission. However, for wireless charging, only methods based on mutual coupling are typically employed. Inductive and capacitive power transfer methods, which are based on mutual coupling, are used for contactless power transfer and electric device charging. While, discussing, contrasting, and comparing of these techniques, it is determined that inductive power transmission is the best option for wirelessly charging electric cars and provides benefits. This study pointed out several important concerns that prevent wireless charging systems, including health and safety, speedy charging, cyber security, connectivity, economics, scheduling algorithm, and other important issues. By removing these barriers, wireless chargers have the potential to revolutionise commercial deployment. Basic EV wireless chargers have been introduced to the market by several companies, but they still need more useful functions. Advances in WPT technology will be necessary for the automation of wireless charging systems and their broad commercialisation

REFERENCES

[1] H. M. Y. H. R. H. B. A. K. Al Sallami, "Design Cosideration of Capacitive power transfer systems," IEEE ACCESS, 2023.
[2] F. Z. S. A. H. R. J. S. M. S. Xiaoyu Liu, "Wireless power transfer system design for implanted and worn devices," 2009.
[3] D. E. PK Joseph, "A review on renewable energy powered wireless power transmission techniques for light electric vehicle charging applications," Journal of Energy Storage, 2018.
[4] M. A. B. V. M. S. EM Ali, "Efficient wireless power transfer via magnetic resonance coupling using automated impedance matching circuit," Electronics, 2021.
[5] K. K. R. K. B. S. B. Kantipudi VVSR Chowdary, "Kantipudi VVSR Chowdary, Kundan Kumar, Ranjan KumaOverview and Analysis of Various Coil Structures for Dynamic Wireless Charging of Electric Vehicles," IEEE International Conference on Power Electronics, Smart Grid and Renewable Energy, 2020.
[6] N. M. R. P. V. M. B. K. M. A. R. P. T. Yuvaraja Shanmugam, "A systematic review of dynamic wireless charging system for electric transportation," IEEE Access, 2022.
[7] J.-W. J. Sadeq Ali Qasem Mohammed, "Sadeq AA comprehensive state-of-the-art review of wired/wireless charging technologies for battery electric vehicles: Classification/common topologies/future research issues," IEEE Access, 2021.
[8] S. A. D. Venkatesh Boddapati, "Design and feasibility analysis of hybrid energy-based electric vehicle charging station," Alternative Energy Journal, 2022.
[9] J. G.-G. J. A. A Trivino, "Wireless power transfer technologies applied to electric vehicles: A review," Energies, 2021.
[10] H. Wu, "A survey of battery swapping stations for electric vehicles: Operation modes and decision scenarios," IEEE Transactions on Intelligent Transportation, 2021 .
[11] N. E. J. S. M. P. F Tauchnitz, "Development and evaluation of a smart charging strategy for an electric vehicle fleet based on reinforcement learning," Applied Energy, 2021.
[12] H. W. Laura Soares, "A study on renewed perspectives of electrified road for wireless power transfer of electric vehicles," Renewable and Sustainable Energy Reviews, 2022.
[13] D. S. A. B. C. N. M. R. H. K. A. E. Venkatesan Ramakrishnan, "A Comprehensive Review on Efficiency Enhancement of Wireless Charging System for an Electric Vehicles Application," IEEE Access, 2024.
[14] A. C. J. ,. A. C. E. Brown, "Electric vehicle charging infrastructure trends from the alternative fueling station locator: Third quarter 2023," OSTI, 2024.
[15] M. E. H. M. T. A. N. H. K. N. H. A. M. T. Sithara S. G. Acharige, "Review of electric vehicle charging technologies, standards, architectures, and converter configurations," IEEE Access, 2023.
[16] K. C. X. T. H. W. Z. H. Wei Liu, "Smart wireless power transfer — opportunities and challenges," Renewable and Sustainable Energy Reviews, , 2023.
[17] D. D. C. L. C. B. G. C. L. V. d. P. L. D. S. J Van Mulders, "Wireless power transfer: systems, circuits, standards, and use cases," Sensors, 2022.
[18] E. O. S. L. A Nespoli, "User behaviour clustering-based method for EV charging forecast," IEEE Access, 2023.
[19] Q. M. L. X. Hua Wang, "HuaElectric-vehicle charging facility deployment models for dense-city residential carparks considering demand uncertainty and grid dynamics," Transportation Research Part C: Emerging Technologies, 2024.
[20] M. Z. Erel, M. T. A. Kamil Cagatay Bayindir and J. M. G. Sanjay K. Chaudhary, "A comprehensive review on wireless capacitive power transfer technology: Fundamentals and applications," IEEE Access, 2021.
[21] C. X. L. L. X Xie, "Wireless power transfer to multiple loads over a long distance with load-independent constant-current or constant-voltage output," IEEE Transactions on Transportation Electrification, 2020.
[22] B. C. L. M.-P.]A Mahesh, "Inductive wireless power transfer charging for electric vehicles," IEEE access, 2021.
[23] D. E. S. M. K. A. SS Rashid, "SS Rashid, DHigh-Performance Multi-MHz Dynamic Capacitive Wireless Power Transfer System Using Asymmetric Couplers," IEEE Wireless Power Technology Conference and Expo (WPTCE), 2024.
[24] H. G. J. L. H Deng, "A Novel Compensation Circuit of the Capacitive Power Transfer System with High Performance of Anti-misalignment," IEEE Access, 2024.
[25] O. S. M. A.-A. A. F. A Mohammed, "Strategies and sustainability in fast charging station deployment for electric vehicles," Scientific Reports, 2024.
[26] S. M. K. A.S Sinha, " Comparison of large air-gap inductive and capacitive wireless power transfer systems," IEEE Applied Power Electronics Conference and Exposition (APEC), 2021.
[27] T. I. Y. H. H Namiki, "Unified Theory of Non-Resonant and Resonant Circuits in Inductive Power Transfer and Capacitive Power Transfer," IEEJ Journal of Industry Applications, 2024.

[28] H. E. F. A. L. I. B. T Bouanou, "Design methodology and circuit analysis of wireless power transfer systems applied to electric vehicles wireless chargers," World Electric Vehicle Journal, 2023.
[29] Z. T. X. Z. Y. Q. H Zhao, "Non-Resonant Compensation Optimization for Efficiency Improvement of Wireless Power Transfer System with Relay Coil," IEEE Transactions on Power Electronics, 2023.
[30] H. G. J. L. H Deng, "HA Novel Compensation Circuit of the Capacitive Power Transfer System with High Performance of Anti-misalignment," IEEE Access, 2024.
[31] T. D. K. S. K. M. J. O. G. A. C. Brian S. Gu, "Optimised magnetic core layer in inductive power transfer pad for electric vehicle charging," IEEE Transactions on Power Electronics, 2023.
[32] S. M. M. S. M. Saeid Ghazizadeh, J. Chandran and A. Stojcevski, "Performance Evaluation of Coil Design in Inductive Power Transfer for Electric Vehicles," IEEE Access, 2024.
[33] M. A. C Bharatiraja, "Fault Tolerant Multileg Inverter Fed Roadway Wirelessly Powered Charging System," IEEE International Transportation Electrification Conference (ITEC-India), 2023.
[34] H. H. H. M. M. F. S. M. A. A. A. S. A. A. Abdelfatah Ali, "A comprehensive review on charging topologies and power electronic converter solutions for electric vehicles," Journal of Modern Power Systems and Clean Energy, 2024.
[35] S. M. M. M. M. S. M. Hassan Khalid, "Advancements in inductive power transfer: Overcoming challenges and enhancements for static and dynamic electric vehicle applications," Energy Reports, 2023.
[36] L. Z. B. L. Xiaoju Yin, "Design and Performance Analysis of New Coupling Magnetic Core Structure for Dynamic Wireless Charging System of Electric Vehicle," Energy Technology, 2024.
[37] B. C. M. M. R. A. D. S. A. N. M. R. T. A. H. A. Venugopal Ramadoss, "Research Insights on Recent Power Converter Topologies and Control Strategies for Wireless EV Chargers: A Comprehensive Study," IEEE OPEN Journal of power electronics, 2024.
[38] F. M. R. M. R. B Panda, "Wireless charging of electric vehicles through pavements: system, design, and technology," Handbook of smart energy systems, 2023.
[39] Q. L. X. Y. Y. Z. J Yang, "Multi-objective optimization of inductive power transfer system with reconfigurable topology for misalignment tolerance," IET Power Electronics, 2024.
[40] L. L. X. B. H. L. G. L. W. Y. Y Guo, "Designing high-power-density electric motors for electric vehicles with advanced magnetic materials," World Electric Vehicle Journal, 2023.
[41] I. E. G. E. V. F. V. D. A. C.-M. E. A. Raquel Ramirez-Vazquez, " Raquel Ramirez-Vazquez, Isabel Escobar, GuyA. E. Vandenbosch, Francisco Vargas, David A. Caceres-MMeasurement studies of personal exposure to radiofrequency electromagnetic fields: A systematic review," Environmental Research, 2023.
[42] P. A. A. B. Sourav Das, "Charging scheduling of electric vehicle incorporating grid-to-vehicle and vehicle-to-grid technology considering in smart grid," IEEE Transactions on Industry Applications, 2020.
[43] S. K. R. N. S. D. M. Dibya Jyoti Mukherjee, "A miniaturized, low-frequency magnetoelectric wireless power transfer system for powering biomedical implants," IEEE Transactions on Biomedical Circuits and Systems, 2024.
[44] L. D. S. B. A. K. P. B. S. B. B. A.Pranjal Barman, "Renewable energy integration with electric vehicle technology: A review of the existing smart charging approaches," Renewable and sustainable energy review, 2023.
[45] A. M. S. P. S. T. K. D. G. Amit Nikam, "Contactless Power Transfer Systems for On-line Electric Vehicles”,," IEEE Engineering Informatics, 2023.
[46] Q. W. Q. W. L. X. W. Z. J Li, "A Wide Input Voltage High-Frequency Current-Fed Resonant Inverter for HFAC Electric Vehicle Auxiliary Electrical System," IEEE Applied Power Electronics Conference and Exposition (APEC), 2023.
[47] S. M. N. M. N. M. A. K. M. A. A. M. Z. Z. M. A. Masood Rehman, "A Review of Inductive Power Transfer: Emphasis on Performance Parameters, Compensation Topologies and Coil Design Aspects," IEEE Access , 2023.
[48] H. M. S. I. S. Ahmed A. S. Mohamed, "Wireless charging technologies for electric vehicles: Inductive, capacitive, and magnetic gear," IET Power Electronics, 2023.
[49] V. G. SV Kamble, "A contactless power transfer in electric vehicles for battery charging," IEEE International Conference for Women in Innovation, Technology & Entrepreneurship (ICWITE), 2024.
[50] F. H. C. L. H. K. P. T. J. S. N.B. X. Nguyen, "A constant current and constant voltage compensation scheme for wireless charger," IEEE 4th International Future Energy Electronics Conference (IFEEC), 2019.
[51] N. M. R. P. V. C. B. T. G. T. D. R. G. P. K. Rahul Kumar J., "A review on resonant inductive coupling pad design for wireless electric vehicle charging application," Energy Reports, 2023.
[52] C. L. M. Z. X. M. Y. Z. Yuanchao Wu, "An Antioffset Electric Vehicle Wireless Charging System Based on Dual Coupled Antiparallel Coils," IEEE Transactions on Power Electronics, 2023.
[53] C. L. M. Z. X. M. Y. Z. Yuanchao Wu, "Yuanchao Wu, Chao Liu, Mingzhou Zhou, XiAn Antioffset Electric Vehicle Wireless Charging System Based on Dual Coupled Antiparallel Coils," IEEE Transactions on Power Electronics, 2023.
[54] Z. S. Y. G. D. X. Yijie Wang, "Overview of megahertz wireless power transfer," Proceedings of the IEEE, 2023.
[55] D. Q. X. S. B. Z. W. X. Y. C. Wenchao Gu, "A constant output capacitive wireless power transfer system based on parity-time symmetric," IEEE Transactions on Circuits and Systems II, 2023.
[56] J. M. Lifang Yi, "An LC/LCLC Compensated Capacitive Wireless Power Transfer System for Constant Current Output," IEEE Energy Conversion Congress and Exposition (ECCE), 2023.
[57] D. T. G. Q. Z. S. X. D. V. C. M. L. Jianshan Zhou, "Energy-Efficiency Optimization with Model Convexification for Wireless Ad Hoc Networks with Multi-Packet Reception Capability," IEEE Transactions on Mobile Computing, 2024.

[58] A. K. M. A. N. S. P. M. B. A. K. Amritansh Sagar, " Amritansh Sagar, Arun Kashyap, Morteza Azimi Nasab, Sanjeevikumar Padmanaban, ManueleA comprehensive review of the recent development of wireless power transfer technologies for electric vehicle charging systems," IEEE Access, 2023.
[59] R. S. X. H. J. X. C. G. Zhong Zheng, "Simulation of the magnetic coupling phenomena in electric vehicle wireless charging," The Journal of Engineering, 2018.
[60] J. D. M. L. M. D. Z. W. Wenbo Wang, "Arbitrary power distribution and efficiency optimization for dual-receiver inductive power transfer system with variable coupling," IEEE Transactions on Transportation Electrification, 2024.
[61] Z. L. T. F. S. G. G. K. M. M. H. Peng Liu, "Optimization of multivehicle charging and discharging efficiency under time constraints based on reinforcement learning," Alexandria Engineering Journal, 2024.