Wireless Charging of Electric Automobiles in Africa: Opportunities and Challenges

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Abstract--- The use of wireless charging has attracted a lot of attention as electric vehicles (EVs) gain popularity as an environmentally friendly mode of transportation. The advantages and disadvantages of wireless charging for electric vehicles in Africa are examined in this paper. The paper aims to offer a detailed analysis of the viability of wireless charging in Africa considering the distinct context of the continent, including infrastructure limitations, affordability concerns, and technological considerations. This paper aims to shed light on the prospects of wireless charging in Africa by analyzing the state of the EV infrastructure, assessing the potential advantages and disadvantages, and discussing the necessary steps for successful implementation. Since no primary survey was done, it is noteworthy that the study draws conclusions from the body of existing literature and data sources.

Keywords--- wireless charging, electric vehicles (EVs), Africa.

I. INTRODUCTION

The urgent need to battle climate change and cut greenhouse gas emissions has given the adoption of electric vehicles (EVs) a considerable boost globally. EVs present a promising way to lessen the negative consequences of traditional internal combustion engines as a green and ecologically friendly form of transportation. The widespread use of EVs, however, presents difficulties, particularly with relation to the accessibility and availability of charging infrastructure. Range anxiety, the fear of running out of battery power without knowing where to recharge, is a common concern among EV owners and potential buyers. Wireless charging technology has become a viable answer to these problems.

In Africa, where EV infrastructure is still developing, wireless charging holds particular promise. By offering a user-friendly and convenient charging solution, it has the potential to overcome infrastructure limitations and encourage the transition to electric vehicles.

This study investigates the potential of wireless charging for EVs in Africa while considering infrastructure restrictions, financial considerations, and technological limits. By investigating EV infrastructure, weighing its advantages and disadvantages, and outlining major implementation phases, it seeks to evaluate the possibility of wireless charging. The study offers insightful information for decision-makers, researchers, and industry stakeholders, and recommends wireless charging as a workable alternative for electric mobility in Africa.

II. OVERVIEW OF WIRELESS CHARGING TECHNOLOGIES, ADVANTAGES AND LIMITATIONS

Due to its capacity to do away with the requirement for conductive materials and enable continuous power transmission without the use of wires, Wireless Power Transfer (WPT) has attracted a lot of interest from a variety of industries. There are various types of WPT technologies, and the choice of a particular technology depends on a number of factors, including operating power range, operating frequency range, operating distance, efficiency, Electric Magnetic Interference (EMI), device size, safety considerations, and system complexity. This paper discusses two technologies:

A. *Inductive power transfer (IPT).*

Inductive Power Transfer (IPT) is a widely used technology in wireless power transfer systems. It is based on the principle of electromagnetic induction, where power is transferred between two coils—one in the transmitter (primary) and the other in the receiver (secondary).

In IPT, alternating current is applied to the primary coil, creating a magnetic field. This magnetic field induces a voltage in the secondary coil, enabling power transfer. The efficiency of IPT systems depends on factors such as coil design, coupling coefficient, and operating frequency.

Inductive power transfer is commonly used for near-field applications, where the distance between the primary and secondary coils is relatively short. It finds applications in various fields, including electric vehicle charging, consumer electronics, and medical devices.

While inductive power transfer offers the advantage of high efficiency and relatively simple implementation, it does have limitations. These include limited transfer distance, sensitivity to misalignment between the coils, and potential electromagnetic interference.

Overall, inductive power transfer is an important technology in wireless power transfer, offering a practical and efficient solution for short-range power transmission in numerous applications.

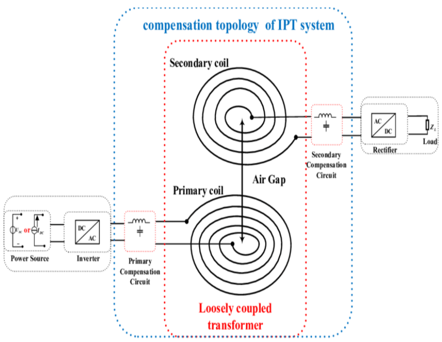

Fig 1. Inductive coupling.

B. Inductive resonant power transfer (IRPT).

Inductive resonant power transfer is an advanced form of inductive power transfer that utilizes resonant circuits to enhance the efficiency and range of wireless power transmission. It operates on the principle of electromagnetic resonance, where the transmitter and receiver coils are tuned to the same resonant frequency.

In this technology, the primary and secondary coils are equipped with capacitors or inductors that allow them to store and exchange energy. When the primary coil is energized with an alternating current, it generates a magnetic field that resonates with the secondary coil. This resonance enables efficient power transfer over longer distances compared to traditional inductive systems.

The use of resonance in inductive power transfer offers several advantages. It enables a greater degree of spatial freedom, allowing for more flexible coil placement and alignment. Resonant systems are less sensitive to coil separation and orientation, reducing the need for precise alignment. Additionally, they can transfer power through non-metallic obstacles to a certain extent.

However, resonant power transfer systems are more complex to design and require careful tuning of the resonant frequency. The presence of multiple resonant frequencies and electromagnetic interference can also pose challenges. Despite these considerations, inductive resonant power transfer has gained prominence in applications such as wireless charging for consumer electronics and electric vehicles, offering improved efficiency and convenience for wireless power transmission.

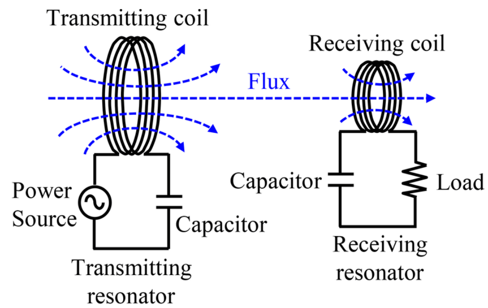

Fig 2. Inductive resonant power transfer.

Advantages and Limitations:

For electric vehicles, wireless charging has various benefits. One notable advantage is the elimination of the need for different cords and adapters at charging stations. With no need for wires or physical connections, it offers convenience and ease of usage. By lowering the possibility of electric shock and the damage brought on by careless handling of cables, it improves safety. Extended charging ranges and flexibility in charging sites are features of wireless charging methods, particularly inductive resonant power transmission. Additionally, by limiting greenhouse gas emissions and reducing reliance on fossil fuels, wireless charging helps achieve the aims of sustainable transportation.

There are some drawbacks to consider, though. Due to wireless charging's potential decreased efficiency compared to conventional methods, devices may take longer to charge and use a tiny bit more energy. Infrastructure and financial issues may arise when implementing wireless charging infrastructure. For wider implementation, technological constraints including power availability and compatibility problems must be resolved. Additionally, effective thermal management techniques are needed since wireless charging generates heat.

III. WIRELESS CHARGING METHODS FOR EVS

1. Static Wireless Charging

Electric vehicles (EVs) can be wirelessly charged while parked or otherwise immobile using a technique called static wireless charging. Utilizing charging stations or pads that deliver power via electromagnetic fields is involved. The electric vehicles (EVs) have receiving coils that collect electromagnetic energy and transform it into useful electricity for recharging the battery. Static wireless charging improves safety by lowering the possibility of electric shock while providing convenience and eliminating the need for physical connections.

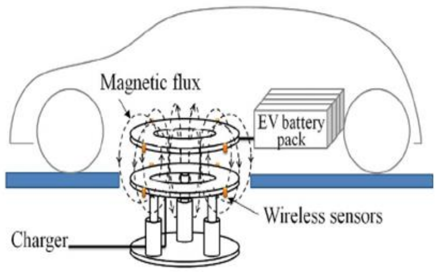

Fig 3. Static wireless charging.

2. Dynamic Wireless Charging.

Dynamic wireless charging enables EVs to receive power wirelessly while in motion. An electromagnetic field is produced when infrastructure is being charged beside or underneath roads. Reducing range anxiety and the need for frequent charging stops, EVs with receiver coils absorb the energy generated by the infrastructure as they pass over lanes that have been installed. Improved land use and convenience result from integration with current roads. Cost, infrastructure-vehicle alignment, and power transfer efficiency are problems. The rapid adoption of dynamic wireless charging for EVs is being fueled by ongoing research that aims to increase effectiveness and lower prices.

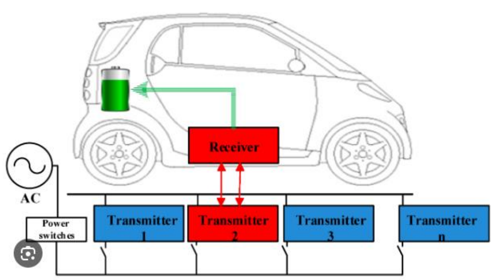

Fig 4. Dynamic Wireless Charging.

IV. Wireless charging in sync with renewable energy sources

The incorporation of renewable energy sources is crucial for improving the sustainability of wireless charging for electric vehicles in Africa. Africa has a lot of promise for renewable energy thanks to its plentiful sun, wind, and hydroelectric resources. Wireless charging technologies and renewable energy sources can work together symbiotically to provide sustainable and eco-friendly mobility options.

An eco-friendly and clean power source for wireless charging infrastructure can be obtained from renewable energy sources. Wireless charging systems can use solar energy, which can be captured by solar panels put on carports or close-by charging stations, to generate electricity. Wireless technology can be supported with electricity produced by wind turbines located in suitable areas.

V. Conclusion

The benefits and drawbacks of inductive power transmission and inductive resonant power transfer are examined in this paper, which looks at the possibilities of wireless charging for electric vehicles in Africa. In addition to eliminating wires and adapters, extending charging ranges, and lowering greenhouse gas emissions, wireless charging also offers benefits for convenience, security, and sustainability. when dynamic wireless charging eases range anxiety when moving, static wireless charging permits stationary charge. The efficiency and affordability of dynamic wireless charging are being improved by ongoing study. Infrastructure, financial, and technological obstacles must be overcome in order to implement wireless charging. Overall, wireless charging shows promise for developing eco-friendly mobility in Africa. To fully use its potential, integrating renewable energy sources demonstrates a superior alternative. Wireless charging systems may function sustainably, lower carbon emissions, and improve energy efficiency by utilizing abundant and clean energy sources like solar, wind, and hydropower. This combination offers a promising route towards a greener future for both Africa and the rest of the globe.

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