Electric Cars or Trucks with Just in Time Energy-Reception

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1 Introduction

Electric Vehicles (EV) are the future of transportation and a possible solution to reduce the greenhouse gas emissions. But electric vehicles are run on batteries that are less energy dense when compared to the fossil fuels used in Internal Combustion Engines (ICE). This has given rise to range anxiety along with other concerns such as expensive batteries, poor charging infrastructure and huge recharge times when compared to a fill-up at the fuel station. Automotive companies, old and new, are constantly working on improving the range on their EVs, mostly by installing batteries with higher capacities. This in turn leads to an increase in the cost and weight of the vehicle. However, there is one solution being researched that could make EVs as competent as their ICE counterparts and it involves providing them with a continuous supply of energy while on the move. The energy supply can be used either to charge the batteries or for direct propulsion purposes. With batteries being the most expensive component in an EV, a simple upgrade in the current road infrastructure could help manufacturers downsize batteries and offer their vehicles at a lower cost. Similar to electric rails, electrified roads between cities is a concept that has been gaining popularity in the world of EVs. The concept is based on the principles of dynamic charging wherein Electrified Road Systems (ERS) [1], supply EVs with energy from the grid and either directly propel or charge the batteries of an EV. With Autonomous Electric Vehicles[1] being touted as the future of personal mobility, dynamic charging systems just might be the solution enabling their growth.

2 Types of charging a EV

With the help of ERS, there are distinctive technological arrangements available that transfer energy to the vehicle from the roads. Based on the contact between the source and EVs, there are two types of charging. [2] 1. Conductive Power Transfer (CPT) 2. Inductive Power Transfer (IPT). Conductive Power Transfer technology involves drawing power from overhead transmission cables, similar to electric trains, by establishing a physical contact with the Electric Road Systems. Inductive Power transfer is wireless power transfer between the coil under the road and another coil mounted underneath the vehicle. Besides these there are a few more methods like Magnetic Gear Wireless Power Transfer, Resonant Inductive Power Transfer and Capacitive Wireless Power Transfer[2]. Resonant Inductive Power Transfer (RIPT) is a popular technique which uses two or more tuned resonant tanks which resonates at same frequency[3]. RIPT edges out IPT on increased range, higher frequency operation, higher efficiency and reduced electromagnetic induction (EMI).

2.1 Conductive Power Transfer

In conductive type, the car or truck uses energy that is directly drawn from the grid. Based on how electricity is drawn, conductive can be classified into two types: 1. Overhead/Catenary 2. In-road rail

Fig. 1 Conductive Power Transfer(Overhead) for Electric Vehicle[4]

2.1.1 Overhead/Catenary

In overhead/Catenary conduction systems, the vehicle is supplied with electricity from overhead power cables. The vehicle is equipped with an extendable pantograph power collector that can connect with the overhead cables at any highway speeds. Power is directly supplied to the vehicle's powertrain. It is a proven technology that has already been in use across the world, driving trains and trolley buses. Overtaking, first and last mile connectivity are ensured by virtue of batteries or a hybrid drivetrain which employs conventional internal combustion engines. Siemens is currently testing the technology on freight trucks in Sweden (Gavle) and Germany (Frankfurt) [1], [4] and [5].

2.1.2 In-road Rail

Fig. 2 Conductive Power Transfer(In-road Rail) for Electric Vehicle[6].

This type of conduction involves drawing power from rail tracks embedded in the road. The tracks, in or on top of the road surface, are segmented and electrified as and when an approaching vehicle is detected. Once the vehicle aligns with the groove, a moving arm attached to the bottom of the vehicle automatically lowers itself and draws power. Power is drawn from the grid with the help of conducting elements located under the road. Due to shorter distance between the power source and the vehicle, this type is applicable to all vehicles including cars, trucks and buses. This method is currently being tested by the Swedish Government on a 2km stretch near Stockholm[1].

2.2 Inductive Power Transfer

Inductive Power Transfer (IPT) is a contactless power transfer system that supplies electricity to vehicles without any mechanical contact. The principle of IPT is the same as that of a transformer, but the distance between the coils is larger in IPT. The primary coils are installed into the road and the secondary coils are firmly fixed underneath the vehicles. On supplying high voltage, high frequency AC source to the primary coil, the EV receives a magnetic field when it passes over these coils and converts the AC to DC either to charge the battery or for propelling the vehicle. Considering present generation EV's, IPT method reduces the total battery requirement by 20% .

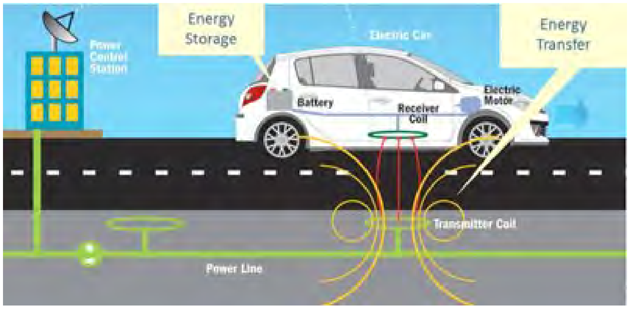

Fig. 3 Inductive Power Transfer for Electric Vehicle[7].

Fig. 4 Inductive Power Transfer for Electric Vehicle[7].

3 Future Concepts

3.1 Primove Highway- Bombardier

The Primove Highway system by Bombardier[9] uses inductive charging to charge the heavy vehicles and power transfer above 150kW is achieved for speeds between 20-70(km/h).Very small magnetic fields which are below the standard exposure limits are found and this system is designed to operate in all conditions.

3.2 Dongwon OLEV

Dongwon OLEV charges electric vehicles wirelessly while moving by using electromagnetic induction. An efficiency of 91% is achieved with power ranging between 12-85kW and suitable for buses, passenger vehicles and Light Duty Vehicles[1].

Table 1 Comparison of different Power Transfer Systems[2] and [8].

Type of charging	Cost (Million Euros)	Efficiency	Power	Frequency(kHz)	Safety
CPT(Overhead)	1.7-4.1	Medium/High	High	16-100	Low
CPT(In rail road)	1-1.5	Medium/High	High	16-100	Higher
IPT	1-2	Medium	Medium/High	10-50	Medium
RIPT	1-2	Medium	Low/Medium	10-150	Low

eHighway by Siemens , Elways by Elways AB and eRoadArlanda, Slide-In/ APS by Alstom and Volvo, ElonRoad by Elon Road Inc. and Lund University are the ongoing research works using conductive power transfer. [1]. INTIS by Integrated Infrastructure Solutions(Sweden) , Momentum Charger by Momentum Dynamics, Unplugged by European Consortium are a few of the ongoing researches involving inductive power transfer.[1]

3.3 Hybridization of Energy Storages

The hybridization of energy storage involves combining two or more energy storages together for better overall performance. Hybridization of chemical battery with an ultracapacitor can achieve high specific energy and high specific power. Hybridization of the fuel cell system with a peaking power source is also an effective technology to provide excess energy when required [10].

4 Conclusion

Conductive and Inductive Power Transfers have a lot of potential as they can be implemented with minimal improvements to the present infrastructure. Even though Conductive Power Transfer (CPT) technology has been in use for decades, CPT-overhead cannot be uniformly applicable to every type of vehicle due to the variation in sizes of light motor vehicles and heavy duty vehicles. While In-road rails can be used by vehicles of all sizes, the rail grooves can prove dangerous to motorcyclists plying on these roads. Inductive Power Transfer (IPT) and Resonance IPT are more convenient in this regard, but they do not have a power transfer rate high enough to meet the requirements of heavy duty vehicles. With the backing of Governments, more research and experiments are underway to improve on these technologies and Just in Time Energy-Reception in EV's could soon be the norm.

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