The Optimal Location of the Wireless Electric Vehicle Charging Infrastructure with Multi-trip

Elbaz Hassane[1], Elhilali alaoui Ahmed[2]

[1] Faculté des Sciences et Techniques de Fès B.P. 2202 – Route d'Imouzzer, Maroc-Fes
hassane.elbaz@usmba.ac.ma

[2] Université Euro-Méditerranéenne de Fès, BP 51, Fès principale – Maroc-Fes
a.elhilali-alaoui@ueuromed.org

Keywords: *electric vehicles, multi trip, mathematical programming.*

Abstract

During the last few decades, environmental impact of the petroleum-based transportation infrastructure, along with the fear of peak oil, has led to renewed interest in an electric transportation infrastructure. The limited battery capacity is the major barrier to the widespread adoption of electric vehicle (EV). To mitigate this, a good method seems to be the innovative wireless charging technology. The wireless charging EV is one of emerging transportation systems in which the EV's battery charged via wireless power transfer technology. Wireless charging EV is a type of EV in which charging is done using wireless power transfer technology, which does not require any physical contact in the process of transferring electric energy. The main tasks to override the high cost of this technology is to determine economically how to allocate the power transmitters on the given routes and how to evaluate the right battery capacity for the vehicles. The allocation of the power transmitters and the size of the battery capacity directly affect the initial infrastructure cost.

The main contribution of this works is to propose the strategic location of inductive power transmitters especially when there are several routes between an origin and a destination, which allows each vehicle to go from the origin to the destination and to return to the origin. Our goal is to find a compromise between the cost of installing the inverters (in our case an inverter can be used by segments of both ways) and power segments and the cost of the battery while maintaining the quality of the vehicle routing.

Before all in our work, we explain the wireless charging technology. Then we propose a nonlinear integer programming to reach a compromise between the cost of the battery and the cost of the power transmitters. The model is solved using the IBM ILOG CPLEX 12.6 Optimizer. The results analyzed and discussed in order to point out the efficiency of our model. Finally a conclusion about the position of a wireless charging infrastructure for a transport network, especially when there are several routes between an origin and a destination, which allows each vehicle to go from the origin to the destination and to return to the origin.

Literature review

The researchers have introduced several ideas for new vehicles transportation systems several decades ago in response to rising demand for greener transportation solutions. A wireless charging electric vehicle has among the ideas in the past few years, but the commercial version are relatively

new. There are two types of the wireless charging electric vehicle. We find in [4] a description of the charging issue:

- The stationary wireless charging electric vehicle: this charging mode is similar to using a charging cable and the vehicle charged when it is stopped [8].
- Charging an EV while in motion is called dynamic wireless charging, where the charging can be done while the EV is in transit, [2] reviewed the development of wireless charging technologies for EV described in the literature, and discussed the companies working on this charging system. The first commercial dynamic wireless charging electric vehicle, the On-Line Electric Vehicle (OLEV TM), was deployed in 2009 by the Korea Advanced Institute of Science and Technology (KAIST), South Korea [1,5,11,3]. First, it installed in Seoul Grand Park as a pilot project in 2009. It travels on a 2.2 km circular route around the park. Two OLEV buses have also been serving as shuttle buses in Daejeon since 2012 and the international in Yeosu. One of the largest industrial cities in South Korea was installed in Gumi City in 2013.The 35 km route is serviced by six buses (added two buses in 2016) [15].

Recently the majority of research focused on optimal charging allocation issues, Although these researches discuss a network composed of a single path [6,7], or a particular case of going from an origin to a destination in a network with several lines can share the same portion of road between origin–destination pairs [9,10]. In this study, the objective to search an optimal location of the infrastructure along the route with multi-path network (round-trip between the origin and the destination) by installing the induction recharging power segments and the inverters in the network.

References

[1] AHN, Seungyoung, SUH, Nam Pyo, et CHO, Dong-Ho. The all-electric car you never plug in. IEEE spectrum, 2013.

[2] FISHER, Taylor M., FARLEY, Kathleen Blair, GAO, Yabiao, et al. Electric vehicle wireless charging technology: a state-of-the-art review of magnetic coupling systems. Wireless Power Transfer, 2014, vol. 1, no 2, p. 87-96

[3] FOOTE, Andrew et ONAR, Omer C. A review of high-power wireless power transfer. In : 2017 IEEE Transportation Electrification Conference and Expo (ITEC). IEEE, 2017. p. 234-240.

[4] “Going Electric”, The Institute, IEEE, September 2011.

[5] SUH, N. P., CHO, D. H., et RIM, C. T. Design of on-line electric vehicle (OLEV) plenary presentation. In : CIRP design conference Nantes. 2010. p. 19-21.

[6] COVIC, Grant A., ELLIOTT, G., STIELAU, Oscar H., et al. The design of a contact-less energy transfer system for a people mover system. In : PowerCon 2000. 2000 International Conference on Power System Technology. Proceedings (Cat. No. 00EX409). IEEE, 2000. p. 79-84.

[7] WANG, Chwei-Sen, STIELAU, Oskar H., et COVIC, Grant. Design considerations for a contactless electric vehicle battery charger. 2005.

[8] JANG, Young Jae, SUH, Eun Suk, et KIM, Jong Woo. System architecture and mathematical models of electric transit bus system utilizing wireless power transfer technology. IEEE Systems Journal, 2015, vol. 10, no 2, p. 495-506.

[9] Mouhrim, Nisrine, Ahmed El Hilali Alaoui, and Jaouad Boukachour. "Optimal allocation of wireless power transfer system for electric vehicles in a multipath environment." 2016 3rd International Conference on Logistics Operations Management (GOL). IEEE, 2016.

[10] Mouhrim, Nisrine, Ahmed El Hilali Alaoui, and Jaouad Boukachour. "Pareto efficient allocation of an in-motion wireless charging infrastructure for electric vehicles in a multipath network." International Journal of Sustainable Transportation: 1-14 (2018).

[11] KIM, Jiseong, KIM, Jonghoon, KONG, Sunkyu, et al. Coil design and shielding methods for a magnetic resonant wireless power transfer system. Proceedings of the IEEE, 2013, vol. 101, no 6, p. 1332-1342.

[12] JEONG, Seungmin, JANG, Young Jae, et KUM, Dongsuk. Economic analysis of the dynamic charging electric vehicle. IEEE Transactions on Power Electronics, 2015, vol. 30, no 11, p. 6368-6377.