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Static public inductive charging in Germany

Ilona Friesen[1], Doris Johnsen[2]

[1]*TÜV Rheinland Consulting GmbH, Uhlandstraße 88-90, 10717 Berlin, Germany, ilona.friesen@de.tuv.com*

[2]*Institute for Innovation and Technology, Steinplatz 1, 10623 Berlin, Germany, Johnsen@iit-berlin.de*

Summary

This conference contribution gives an overview of the status quo and current developments of static public inductive charging in Germany. It outlines German research activities in this field, analyses the German light vehicles market, assesses the demand and relevant business models for public inductive charging and demonstrates the progress of standardization and the impact of German calibration law on the potential roll-out of static public inductive charging.

Keywords: Wireless charging, EV, research, market development, RCS

1 Introduction

For this paper, inductive charging as one type of wireless charging will be examined. An inductive charging system consists of a primary coil, usually installed on or in the ground and connected to the electric grid, and a secondary coil, usually integrated into the vehicle underbody and connected to the battery of the vehicle. Once electricity runs through the primary coil, a magnetic field is build and this induces electricity flow in the secondary coil, which charges the battery of the vehicle. Energy is transmitted through the air gap. Inductive charging systems can be static (stationary traffic) or dynamic (moving traffic). Dynamic charging distinguishes static inductive en-route charging (e.g. while waiting at traffic lights) and dynamic inductive en-route charging (e.g. charging while on the highway).

In Germany, the number of newly registered electric light vehicles (without hybrids) has more than doubled from 2016 to 2017 (from 11.410 new registrations in 2016 to 25.056 new registrations in 2017) [1] [2]. It is expected that the German automobile manufacturers will bring many electric car models to market starting in 2020, which is expected to let the amount of electric vehicles increase on German streets. According to the Federal Network Agency (Bundesnetzagentur) there are 7.730 public charging stations in Germany with 15.392 charging points, of which around 10% are charging points higher than 22 kW (as of 08 February 2019) [3][1]. The necessary amount of public charging infrastructure depends on the amount of electric vehicles and on the predicted charging behaviour of EV users [3]. In order to lay the foundations for a successful market launch of electric vehicles, Germany's goal is to install 100.000 more charging points until 2020, of which one third is supposed to be charging with more than 22 kW [4].

[1] Different sources publish different numbers for charging points in Germany. This source only shows those public charging stations for which there is an obligation to notify the Federal Network Agency and where the operator agrees to publish the information. The real number of public charging points in Germany is most probably higher.

Considering that inductive charging has entered serial production for light vehicles since July 2018 (BMW), the question that should be addressed is whether and how this technology should be accounted for in the roll-out of public charging infrastructure. The goal of this conference contribution is to demonstrate current developments surrounding the static inductive charging in public spaces in Germany with regard to the following questions: Is inductive charging relevant for the public space? How did research projects evaluate the use of inductive charging in public spaces? Will we experience a roll-out of public inductive charging infrastructure in the next five years?

The hypothesis of this paper is that slow progress in standardization, low demand for public inductive charging infrastructure and missing business models for its operation will make the big roll-out of public inductive charging infrastructure in the next five years unlikely.

1.1 Approach, definitions, methodology

The systematic focus of the topic of this paper is on inductive public charging infrastructure for light vehicles in Germany. A recharging point accessible to the public is defined in the Alternative Fuels Infrastructure Directive (2014/94/EU, AFID) as an interface that is capable of charging one electric vehicle at a time [13]. It takes into account cable connectors as the current technology, but anticipates a possible update of the directive to take into account future technologies such as wireless charging. In Germany, parts of the Alternative Fuels Infrastructure Directive were translated into national law with the so-called Ladesäulenverordnung (“charging station decree”, LSV). According to the LSV, a charging point can be situated on public street space or on private ground and is publicly accessible when the parking space can be accessed by an indeterminate group of people [5]. When the charging point is placed on private ground such as at the parking space of a supermarket or a hotel, it is publicly accessible as long as it is not specifically designated for a definite person or group of persons (e.g. for a car with a certain license plate). With reference to dynamic inductive charging, it is not clear whether this definition of a recharging point is applicable, because it is theoretically possible to charge 2 vehicles with one primary coil.

For the purpose of this paper, charging infrastructure will be considered public when it is situated on public street space and can be accessed by an indeterminate group of people; charging infrastructure will be considered semi-public when it is situated on private ground, but can be accessed by an indeterminate group of people.

First, a research landscape for inductive charging projects in Germany will be created. It will give an overview of research activities with relation to public wireless charging with the help of desktop research and a keyword search on the website of the TIB (Leibniz-Informationszentrum Technik und Naturwissenschaften und Universitätsbibliothek). Second, a market research of inductive charging infrastructure for light vehicles of German car manufacturers is performed with the help of desktop research. Third, the demand and business models for inductive charging will be assessed with the help of the insights of research projects and an expert discussion, which took place at the Networking Conference Electric Mobility 2018 of the Federal Ministry for Economic Affairs and Energy in Berlin. Fourth, the state of standardization of inductive charging solutions will be demonstrated and the effect of German calibration law on inductive charging infrastructure will be explained.

2 Current state of static public inductive charging in Germany

2.1 Research landscape in Germany

In Germany, research related to inductive charging of electric vehicles has been funded at federal level quite intensely since 2010. In 2009, the German federal government passed the second fiscal stimulus package with which measures for research in the area of electromobility were funded [6]. It was followed by research programmes such as “Erneuerbar mobil”, “Spitzencluster Elektromobilität Süd-West”, “Schaufenster Elektromobilität” and “ELEKTRO POWER II”. The research projects funded under these programmes have focused on the technical development and standardization of inductive charging systems and integration into the energy grid (see Table 1: Overview of German research landscape related to inductive charging). Inductive charging infrastructure has been installed in these projects, however, they are not open to the public [7].

			Duration									
Ministry[2]	Funding programme	Project	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
BMU	Stimulus package 2009	Conductix	■	■								
BMU	Stimulus package 2009	W-Charge	■	■								
BMU	Erneuerbar mobil	InterOp			■	■	■	■	■			
BMBF	Spitzencluster Elektro-mobilität Süd-West	BiPolPlus				■	■	■				
BMVI, BMWi, BMBF, BMU	Schaufenster Elektromobilität	E-Bus Berlin				■	■	■	■			
BMVI, BMWi, BMBF, BMU	Schaufenster Elektromobilität	Induktiv-Laden				■	■	■	■			
BMVI, BMWi, BMBF, BMU	Schaufenster Elektromobilität	Primove					■	■				
BMWi	ELEKTRO POWER II	STILLE							■	■	■	
BMWi	ELEKTRO POWER II	BiLawE							■	■	■	■

Table 1: Overview of German research landscape related to inductive charging (not exhaustive)

2.2 Market research

Buses are charged inductively in several research projects, however, this inductive charging infrastructure cannot be perceived as publicly accessible, so inductive charging of buses will be neglected. Concerning light vehicles, the wireless charging technology has been introduced for series production in 2018 by BMW. The BMW 530e iPerformance can charge wirelessly with 3.2 kW if the consumer decides to buy this optional equipment [8]. The primary coil in form of a charging plate can be installed at the domestic parking spot or garage, where most EVs are charged during nights.

The first Audi e-tron is available on the market, however, it does not yet have the inductive charging possibility. Future e-tron models can be charged with the Audi Wireless Charging system [9]. With regard to security aspects for the air gap, the BMW system monitors the air gap and stops the charging process if necessary, while Audi Wireless Charging lifts the primary coil to minimize the air gap between the coils. The Porsche Mission E shall go into serial production in 2020 and shall have the possibility to be charged inductively [10]. Daimler planned to offer inductive charging for the Mercedes-Benz S 500 e, starting in 2017, however, decided to refrain from introducing it to serial production for now [11]. Tests have been performed in 2011 and 2014 but according to Daimler the charging capacity of the system does not suffice yet to charge the battery in a reasonable time.

The first serial inductive charging systems are proprietary solutions, meaning that vehicles can only be charged with their matched systems (e.g. BMW 530e iPerformance can only charge on BMW Wireless Charging systems). In order to enable unmatched charging (e.g. BMW 530e iPerformance can charge on Audi Wireless Charging), standardization is necessary to ensure technical interoperability of the inductive charging systems. Proprietary systems can only be offered as optional equipment for private charging, which makes them costly for the OEM. This could explain why other OEMs do not yet follow BMWs example.

[2] BMU = Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety);
BMBF = Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research);
BMVI = Bundesministerium für Verkehr und digitale Infrastruktur (Federal Ministry of Transport and Digital Infrastructure);
BMWi = Bundesministerium für Wirtschaft und Energie (Federal Ministry for Economic Affairs and Energy)

2.3 Demand and business models

With the insight from the research programme "Schaufenster Elektromobilität", the programme support team has published an extensive document on the demand-oriented charging infrastructure from the point of view of the consumer [12]. It identifies the demand for charging infrastructure in the public space and depicts preferences of the consumer concerning charging capacity and billing methods, amongst others. It finds that most charging processes take place at private infrastructure (meaning both home and work). However, the user group defines which charging infrastructure is used most. There are groups of consumers who don't have charging possibilities at home or work and are dependent on public charging infrastructure solely, and there are those consumers who only charge at home and work and carefully plan their trips accordingly (public charging is only supplementary). According to the consumers, public charging can be slow when the car will be parking for a longer time; semi-public charging (eg at supermarkets) should be at least 22 kW and the consumer will only decide to charge the car when parking for 15 minutes or longer. Charging at semi-public spots is most attractive when it is cheap or free of cost. Public and semi-public charging at the highway for long distance travellers should be fast (at least 50 kW, but rather even higher). Consumers state that there is a demand for more semi-public and public charging infrastructure than is available at the moment. Concerning billing methods and the willingness to pay, consumers are willing to pay higher prices than for their household electricity for high charging capacity; for charging with less than 11 kW consumers are not willing to pay the household electricity price. In conclusion, it is hard to establish a business model for charging points with less than 11 kW based only on selling electricity.

Different pricing models have been developed to address the problem of profitably running charging infrastructure. The following models have been discussed with experts at the last Networking Conference Electric Mobility 2018 of the Federal Ministry for Economic Affairs and Energy. A pricing model with the potential to make the operation of charging infrastructure profitable is the so called contracting: particular prices for the charging of corporate fleets are combined with a comprehensive integrated solution for the running of the whole fleet. With the customer loyalty model, charging your electric vehicle at a public station with your domestic electric service provider is for free, because it is believed that most charging processes will take place at home anyway and the electric service provider will make profit with the private charging. In the commodity model, charging at semi-public spaces such as the supermarket could be offered for free so as to attract more customers and make them stay longer and thus generate more revenue from the main business.

The following can be inferred from these insights for the demand for inductive charging infrastructure. Inductive charging infrastructure can only be rolled out if there is a good business model. The problem with the business model is that publicly accessible conventional slow charging infrastructure is hardly used and will be used even less when one has to pay for the electricity. With a power of 3.2 kW, it will be hard to operate a inductive charging infrastructure profitably. Supermarkets, companies, energy service providers and municipal utilities will have to develop sensible pricing models for the operation of public inductive charging infrastructure. To be able to bill the charging, it has to be clear how and where the inductive power transfer can be measured. In Germany, industry and calibration law representatives still need to settle on a feasible metering point that also protects the consumer.

2.4 Standardization and calibration law

The first inductive charging systems are proprietary, so charging is only possible with matched charging systems. Standardization efforts try to establish interoperability between the charging systems in the near future. Directive 2014/94/EU on the deployment of alternative fuels infrastructure (AFID) states that "the Union shall pursue the development by the appropriate standardisation organisations of European standards containing detailed technical specifications for wireless recharging points" (Article 4, Nr. 13) [13]. According to mandate M/533 CEN-CENELEC is the appropriate standardization organization for this task. CEN-CENELEC has established the eMobility Coordination Group (eM-CG), which deals with the electric mobility aspects of the AFID. Mandate M/533 requests that the standardization for the static wireless charging (IEC 61980, ISO 19363, ISO 15118) should be finalized for the large part by the end of 2019. The research project STILLE of the ELEKTRO POWER II programme examines inductive power transmissions with up to 22 kW and introduces their findings in the standardization process [17]. Last technical issues with respect to the mechanical positioning of the car above the primary coil and responding security concerns are anticipated to be solved soon. As of now, there is an ongoing discussion about the usage of frequency bands by wireless charging systems [14]. The European Commission can adopt delegated acts to update the Directive 2014/94/EU according to the standards that CEN/CENELEC develops with regard to wireless charging.

Every public charging infrastructure needs a meter to measure the electrical power consumed in order to be able to bill the charging. The German calibration law (Mess- und Eichrecht) is applicable for the meters used in the context of electric mobility and it ensures the accuracy of measuring the supply of electricity of the meters. This is true for conventional contact-charging as well as inductive charging. In the past, a committee (Regelermittlungsausschuss) consisting of experts from the calibration authorities, conformity assessment bodies, test centers, trade and consumer associations and the Physikalisch-Technische Bundesanstalt, which holds the chair of the committee, have determined rules about the requirements for such meters [15]. By the end of 2018, the committee met with representatives of the industry and other stakeholders to discuss requirements for meters used for inductive charging processes. As stated above, the main point of discussion was how and where the inductive power transfer can be measured. A metering point still has to be determined, which is technically feasible (where can existing meters actually measure the supply of energy) and protects the consumer (transparent communication of the measuring point and the transmission losses).

3 Results

The goal of this conference contribution was to demonstrate current developments surrounding the static inductive charging in public spaces in Germany. Inductive charging is relevant for the public space, because it is a charging technology that can be used once interoperability has been established with standardization. Even though OEMs have announced the serial production of light vehicles with the inductive charging possibility, only BMW has made this a reality for private charging in 2018. The other OEMs have postponed this step. Theoretically, it is also possible to install inductive charging solutions at work, the supermarket, or in public car parks. Two-thirds of the 100.000 additional charging points planned in Germany will be with less than 22 kW - in contrast to the necessary fast-charging at highways, slow inductive charging with 3.2 kW suffices at work or leisure activities [16]. However, from experience with conventional public and semi-public charging infrastructure it is hard to operate them profitably. The same will most probably apply to inductive charging infrastructure. Supermarkets, companies, energy service providers and municipal utilities will have to develop sensible pricing models for the operation of public inductive charging infrastructure.

Standards are the necessary pre-requisite for exploring use cases for public and semi-public inductive charging such as for corporate fleets; however, standardization for wireless power transfer will not be finalized by the end of 2019. A roll-out of public inductive charging infrastructure in the next five years seems unlikely from today’s point of view. Even if interoperability is achieved soon, the test of inductive charging infrastructure for different public and semi-public use cases (e.g. corporate car fleets, supermarket parking space) and an analysis of different pricing models in form of research projects would be a sensible next step, not a serial roll-out. Research projects can also include aspects such as the autonomous parking, which can be combined with inductive charging.

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Authors

Ms Friesen is a consultant at TÜV Rheinland Consulting GmbH, where she works at the research management division. She supports the implementation of funding programmes of the Federal Ministry of Transport and Digital Infrastructure and the Federal Ministry for Economic Affairs and Energy in the wider topic of mobility. She received the B.Art degree in European Studies and holds a Master of Public Policy.

Ms. Johnsen studied Geography, Urban and Regional Planning and Economics. She has been working as a consultant at the Institute for Innovation and Technology (iit) since September 2017. In particular, Ms Johnsen deals with mobility and energy related issues in national and international contexts. She focuses on sustainable urban and transport development, innovative mobility services and mobility concepts, electric mobility, and digital transformation. Ms. Johnsen has 15 years of experience in innovative mobility solutions, sharing services, electric mobility and transformation processes and advised federal ministries, European and international organizations on topics of sustainable mobility, transport, and energy efficiency. Currently, she supports the Federal Ministry of Economics especially on topics of electric mobility and smart services and supports municipal transformation processes.