



# Project TALAKO – demonstrating wireless taxi charging

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## Introduction

If a technology is not accepted by society, it can have no impact on the world. The mobility sector is currently experiencing a major technology shift towards more connected, autonomous, shared, and electric vehicles (CASE). Of these four, electric vehicles require the greatest change in user behaviour, with more frequent and longer “refilling” of vehicles. Charging is an unwanted activity for the user, so to promote acceptance of EV’s, charging should take place automatically and during down-times. This is the vision of wireless charging – motive energy is always available, and the user just gets on with their journey.

The taxi industry is a good candidate to examine EV use and acceptance. Taxis tend to drive relatively short distances per day (ca. 150 km / day for a single shift in Germany), mostly in urban areas, but with occasional longer trips to neighbouring cities. Taxi drivers wait in line for customers for long, unplannable periods in dense urban areas not currently well suited to cable-charging infrastructure, such as at train stations or airports. In addition, taxi drivers are conservative about new technology like EV’s because their livelihood depends on having reliable mobility. For EV’s to be accepted by taxi drivers, they must provide reliable mobility for day shifts and the occasional long journey, automatic and conveniently placed charging and economic viability.

To demonstrate such a mobility system, INTIS embarked on what would become the TALAKO project at the beginning of 2018, together with partners from research institutions, industry, and local government (see <https://talako.uni-due.de/en/> for more information). INTIS managed to acquire LEVC as a vehicle OEM to supply taxis and provide technical support for wireless charging technology vehicle integration. The role of INTIS in the project was the design, building, testing, and delivery of all roadside and vehicle wireless charging components. The culmination of TALAKO was the installation of six 22 kW wireless charging systems for six taxis at the central station in Cologne (figure 1).

In this article, the author will look at the wireless charging technology delivered by INTIS for TALAKO. A guest contribution by our partners from the University of Duisburg-Essen provides an introduction to the acceptance and economic feasibility of the concept.

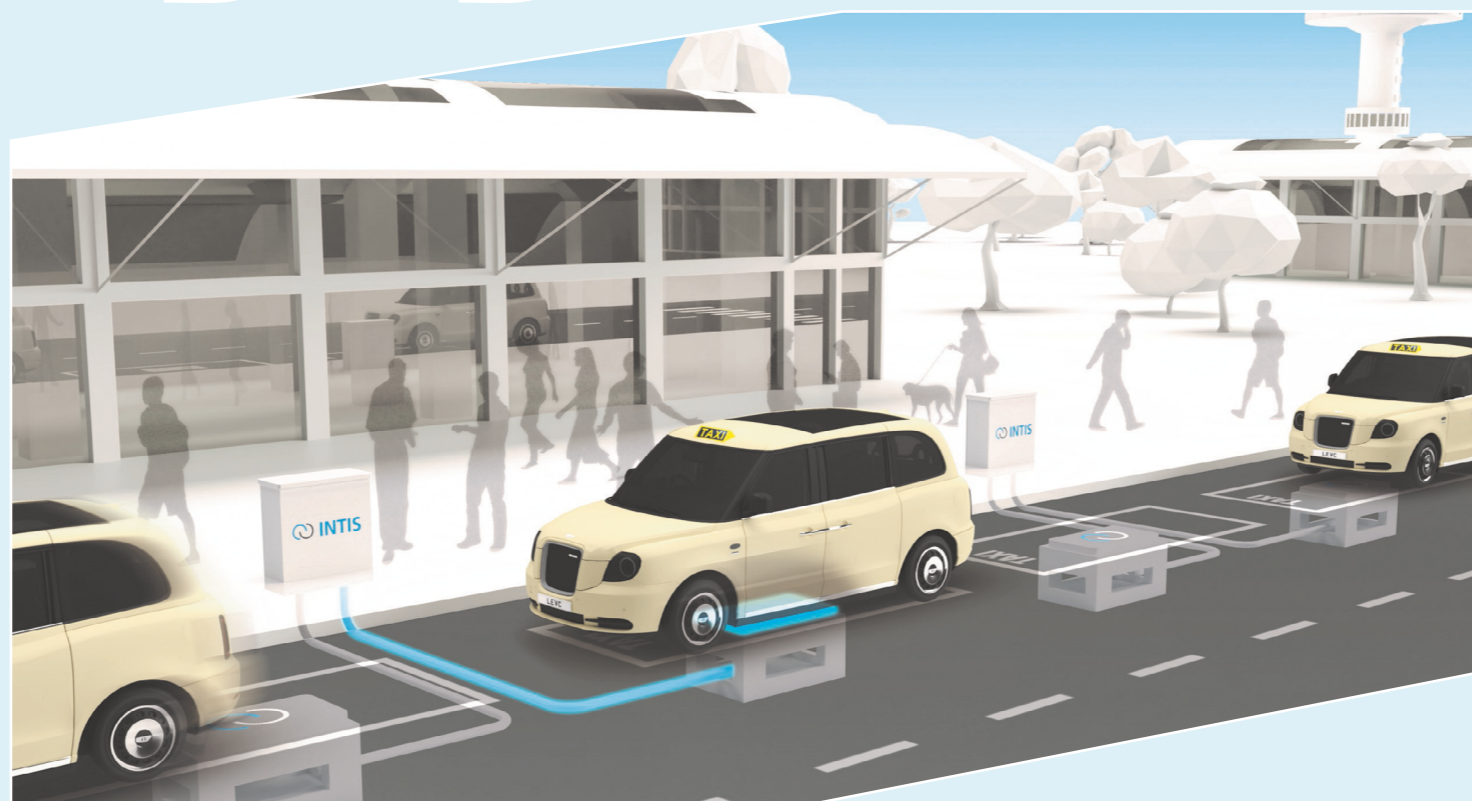


Figure 1 - Depiction of 22 kW wireless charging for taxis Implementation

## Implementation

Two of the key requirements for the mobility system and wireless charging technology were mentioned above:

1. **Provide an automatic and convenient charging solution**
2. **Enable EV taxis to outperform combustion engine taxis**

The first requirement was solved by implementing INTIS’ wireless charging technology at Cologne central station, the second, by using LEVC TX vehicles. The LEVC TX, a PHEV with a series range extender and a 30 kWh battery, is an evolution of the classic London cab. Taxi drivers can run most of their journeys in EV mode, while having the security of the range extender for longer journeys (up to 600 km), or if charging infrastructure is inadequate.

LEVC and INTIS carried out three development cycles to integrate the wireless charging technology into the TX vehicle. This resulted in INTIS becoming an official retrofitter of wireless charging technology to LEVC vehicles, meaning the vehicle’s warranty is maintained.

Components in the vehicle are a charging coil attached beneath the battery (figure 2), an electronics box in the boot and a display in the cabin as an HMI. Although technically feasible, it was not practical to directly interface to the vehicle BMS; instead, the standard CHAdeMO DC fast charging interface was used for communication with the battery. OEM original cables, connectors and attachment points were used, meaning the vehicle can be returned to its original condition easily, if required. This is important to ensure ease of disassembly for vehicle maintenance or repair and to maintain residual value for the taxi owners.

The positioning assistant as implemented by INTIS starts automatically when the vehicle is near the charging station, supporting the driver to park over the coil. Once positioned, charging starts automatically when the driver turns off the ignition. Charging can be stopped by pressing a button on the HMI, at which point the driver can turn on the vehicle ignition and move forward.



Figure 2 - 22 kW wireless charging vehicle coil installed under the battery



Since the average taxi wait time at Cologne central station is 30-40 minutes (determined in a study by the University of Duisburg-Essen), INTIS' 22 kW 85 kHz wireless charging technology provides enough energy to cover a complete taxi shift with just two visits to the charging lane per day. What's more, while taxi drivers wait to pick up passengers, they can keep their vehicles climatized in summer and winter without draining the battery.

Figure 3 - LEVC TX and 22 kW wireless charging installation at INTIS' test centre Germany

INTIS developed a new 22 kW coil design with extended tolerances in the direction of travel ( $\pm 50$  cm) to ensure ease of use for taxi drivers. This coil design was developed with interoperability and standardisation in mind; all current and expected taxi vehicle types should be chargeable using this coil design, which INTIS is considering for recognition in the upcoming IEC 61980 standard WPT 4 category. Each charge point operates independently, which increases reliability by ensuring that any single failure will not compromise the function of the complete charging lane. A vehicle localisation system was developed by the University of Duisburg-Essen NES, using a camera and pattern recognition system. Data from this is combined with INTIS' supplied magnetic field-based system.

An important consideration was road integration; the taxi lane is heavily used and can, in case of emergency, be traversed by fire trucks weighing up to 40 t. To meet this requirement, INTIS turned to commercially available road construction components. All six charge points use off the shelf GRP covers, which are rated for traversal by 40 t vehicles (figure 3). This had the added advantage of simplifying integration because the components are well known to road construction companies.

Overall, we successfully implemented 22 kW wireless power transfer systems optimised for this application, while achieving a grid to battery efficiency of above 90%. Electromagnetic field values are well below ICNIRP reference values in public areas, as verified by project

partners the Bergische Universität Wuppertal. System emissions remain below EMC limits according to DIN EN 55011 Class A for non-residential equipment.

### Guest contribution by the University of Duisburg-Essen

The University of Duisburg-Essen, more specifically the Chair of General Business Administration & International Automotive Management (Prof. Dr Heike Proff), is primarily responsible for the project management and coordination of the TALAKO project but also for the research field of business administration.

In step one, scientists from the University investigated the acceptance of the charging concept by taxi companies and carried out surveys to create an acceptance model, including relevant determinants. This model describes the acceptance of electric vehicles and wireless charging solutions at the main railway station to taxi companies in major German cities. The results show that taxi drivers accepted wireless charging solutions when the usage:

1. leads to a higher social reputation (like being considered innovative),
2. improves the environment,
3. simplifies the taxi drivers work significantly,
4. the technology is reliable and efficient and
5. there are sufficient charging points available.

In addition, the value proposition of wireless charging infrastructure was queried, and the results show that individualisation, integration, and service are of particular importance. It can be concluded that the charging solution must be interoperable, i.e., compatible with all expected taxi vehicles and that the charging of the taxi has to proceed smoothly. Equally important is that services (e.g., automated payment or invoicing) can be added to the system and are offered directly.

The next step was to investigate taxi customers' willingness to pay for transportation with an electric taxi compared to a conventional one. A price comparison using Van Westendorp's Price Sensitivity Meter shows a slightly higher price willingness of potential customers for an electric than for a conventional taxi. This investigation can lead to first implications for a business model analysis.

Finally, a Total Cost of Ownership (TCO) analysis was used to investigate and optimise the costs for different vehicles and a standardised data sheet was developed. The data basis for acquisition, maintenance, and repair costs as well as operating costs was a qualitative surveys of car dealers and manufacturers for different vehicle models. Moreover, it was possible to increase government subsidies for electric taxis, persuade manufacturers to offer discounts on electric

vehicles and get energy suppliers to subsidize electricity in the initial phase. The results of the TCO analysis reveal that in the mid-term, taxi companies can save by using electric vehicles because of lower operating costs. Due to the current subsidies, electric vehicles can have a payback period of less than one year compared to vehicles with combustion engines. As the TALAKO project will run until the end of September 2022, the TALAKO-ecosystem and the operating model are still being investigated.

### Looking forward

As a provider of wireless charging technology, INTIS is keen to move the TALAKO concept towards a roll-out and is investigating both a follow-on R&D project, and potential commercial ventures. "Wireless charging offers significant advantages for the electrification of taxis" says Dr Ralf Effenberger, CEO of INTIS. "This automatic, hands-free charging will support the transformation to taxi vehicles with electric drivetrains." As the first project of its kind in Germany, TALAKO offer the opportunity to prove the concept of wireless charging for taxis under busy, real-world conditions.

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