35th International Electric Vehicle Symposium and Exhibition (EVS35)
Oslo, Norway, June 11-15, 2022

Volvo Cars to test new wireless charging technology in green city zone

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Summary

Volvo Cars is integrating and testing a new wireless charging technology in a live city environment together with selected partners, evaluating it as a potential alternative for future electric vehicle charging.

Over a three-year period, starting in spring 2022, a small fleet of fully electric Volvo XC40 cars with specially integrated wireless charging technology will be driven in taxi operations and charge at dedicated wireless charging stations placed in Gothenburg, Sweden.

The project was officially launched 2022, March 3 at Lindholmen Science Park as one of several pinpointed Green City Zone Test areas in Gothenburg region.

This paper is exploring the major activities and highlights seen from a car manufacturer point of view.

Keywords: charging, wireless charging, fleet, passenger car, sustainability

1 Introduction

Vehicle fleet operations are projected to become a focused area in the ongoing transformation of the automotive sector. An important way to reduce the vehicle transport related CO2 emissions is to increase the utilization of the vehicles.

When shifting to electric driven car fleets with increased utilization, the number of charging occasions will increase, and therefore the speed of charging will become more important to maintain the high accessibility to the vehicles in operation. A specific use case of interest is the taxi fleet operation, known for its high utility factor and high yearly mileage. As such the project will provide the taxi fleet with an alternative charging solution adapting to the taxi driver's need in a high-mileage scenario but also adding convenience to the taxi driver's day at work.

Wireless Charging operating at competitive power levels around 50 kW is one very interesting solution for creating an easier and more convenient journey for the taxi driver. It is also expected that the active time spent for charging could be more optimized if charging can be done close to traffic hubs where taxi operators naturally pick up people for transport service.

The wireless charging taxi test is one of the first of many initiatives outlined so far within Gothenburg Green City Zone, under which designated areas within the city are used as live testbeds for the development of sustainable technologies.

High utilization and convenience are two major contributing factors that are well supported with wireless charging. In a longer perspective, with a larger penetration of wireless charging, the vehicle battery size can be reduced to save weight, volume space and CO2.

Also, when E-mobility enters future autonomous driving modes, means of autonomous charging will become an interesting and important perspective to look further into.

1.1 Gothenburg Green City Zone

Gothenburg Green City Zone is an effort to jointly test new technologies for both vehicles and infrastructure with the aim of achieving emission free transport by 2030. What is currently unfolding is the creation of an entirely new climate-neutral transport system. A zone where we highlight new solutions, welcome innovation, and learn together. The zone is not an exclusion zone. It is a test zone where business and industry have a key role to play.

As a starting point, three areas in the Gothenburg region with different conditions of living, industry activity, demography and traffic flows are selected as suitable areas for test beds. In Figure 1.1, the city zones of particular interest and the location for the first charging station is shown.

- Lindholmen Science Park - Area with large workspace activity, education and hubs for sea and land transport. Living space is located nearby.
- Evenemangsstråket – Area with more than 10 million visitors every year.
- Forsåker – Planned area for new living space integrated together with workspace where the foreseen travel needs, to and from the area, are significant.

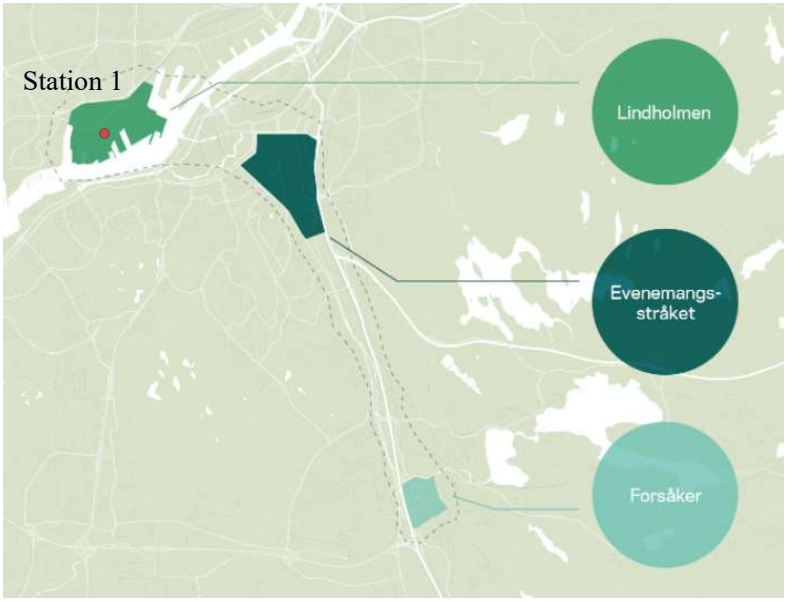


Figure 1.1 Gothenburg Green city Zone test areas

2 Taxi fleet in Gothenburg to drive electric cars from Volvo, testing wireless charging

Volvo Cars is integrating and testing wireless charging – an additional alternative for electric car charging. The project fleet will be running in the city centre and the regional area around Gothenburg.

From spring 2022 a local Gothenburg based taxi company, Cabonline, will drive Volvo Cars XC40 Recharge Battery Electric Vehicles for three years and test the new technology and the opportunities the wireless charging technology will contribute to.

Volvo Cars, through the Taxi company drivers, will test different charging possibilities in Gothenburg where the wireless charging stations will be present at least at two different locations.

The user experience is always of high importance to Volvo Cars why we collect driver experiences and user data on a continuous basis. This is also the first test of Battery Electric Cars in commercial use. The cars will be used more than 12 hours a day and drive at least 100,000 km per year.

Volvo Cars will regularly gather vehicle data as well as driver and customer feedback to explore and further improve the charging experience

2.1 Project stakeholders

The project is based on a collaboration agreement between stakeholders listed below:

- Volvo Cars, delivering XC40 Recharge electric vehicles adapted for wireless charging in taxi operation.
- Volvo Bil / Volvo Cars Retail, delivering sales, service, and maintenance of the taxi fleet during its full operation time.
- Cabonline, the Gothenburg based organiser for taxi operations active in the Nordic countries.
- Momentum Dynamics, the supplier for the wireless charging technology including both equipment for the wireless charging stations as well as equipment for the wireless charging subassemblies mounted as additional parts to the vehicle.
- Vattenfall In Charge, acting as Charge Point Operator, supporting the charging system authorisation and billing.
- Göteborg Energi, The Gothenburg municipal energy company handling the charging station site builds with connections to the electricity grid and station communication. For the groundwork and electrical installation services, an industrial electrical installation company ex-te EL AB was contracted.
- Business Region Göteborg, Gothenburg Regional Business Administration supporting the stakeholder project and project coordination

A project like this is calling for agreements between all parties involved but also need agreements between individual partners when it comes to warranty, sales, service, and operation.

2.2 Wireless Charging Principle

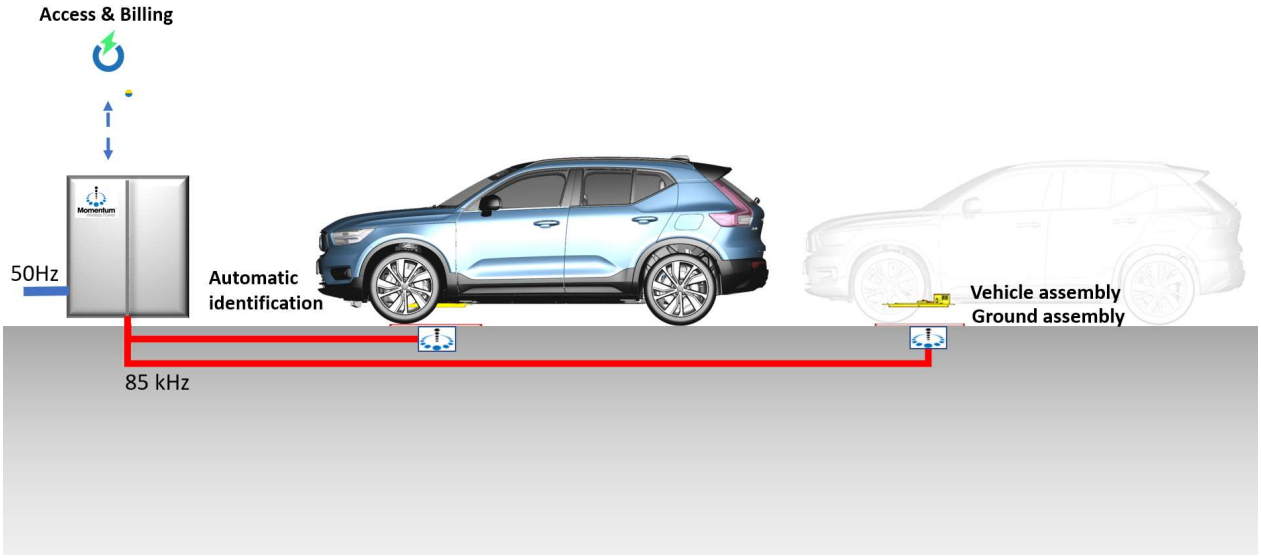


Figure 2.1 Wireless Charging Principle

The wireless charging station, together with technology integrated in the car forms the key elements of the highly convenient wireless charging system. For the XC40 wireless charging test project this means following:

- The wireless charging stations build ups in Gothenburg Green City Zone test fleet can support two ground assemblies meaning that two cars can be charged simultaneously within the same charging area.

- Alignment between the vehicle pad and the ground pad is handled by the driver steering the car to the optimal position. The driver is receiving feedback from the camera vision system in the vehicle.

- Once the car is aligned with enough precision over the ground pad, the vehicle identification check is starting which sends requests to start charging. Data exchange is handled through communication over OCPP (Open Charge Point Protocol) sending information between to the CPO (Charge Point Owner) and the wireless charging station. When access is granted, meaning that the vehicle pad is identified by the CPO, the charging starts automatically! No other identification methods are needed. This lifts the charging to a true autonomous charging experience.

- At the charging station, electricity grid voltage at 50 Hz frequency is converted to provide an AC fit frequency of around 85 kHz that stimulates an electromagnetic resonance circuit including the inbuilt coils of the ground assembly and the vehicle assembly. The coils are acting together in a transformer circuit. At the optimal frequency, the electromagnetic field is passing through the pads over an airgap with minimal losses.

- When the wireless charging energy has reached the vehicle, the voltage created in the secondary coil is rectified and moved to the battery terminals. The energy will normally start to increase the battery charge capacity (SOC) but also support the vehicle loads like heating, cooling and entertainment systems in parallel.

- Stopping of the charging process is made simply by pressing a “Stop Charging” icon in the car’s centre display. When stop charging is activated, parking brake is released and the vehicle can be driven for the next journey.

3 Project targets matching the Green City Zone objectives

In the project formulation, several common targets were identified as the common foundation for a joint project with the identified and committed stakeholders.

- A collaboration effort to contribute to fossil-free transport system in Gothenburg 2030. Electric vehicle transport in fleet application is a good match.
- Measure, communicate and demonstrate the transformation of a key segment in the transport sector
- Contribute to the automotive sector's transformation to offer fossil-free transport solutions and increased business opportunities for Sweden
- Install and commission charging stations for inductive fast charging in strategic locations
- Test, demonstrate and operate taxi services with inductive fast charging in a reality-based environment for 36 months
- Study taxi drivers' experience of inductive fast charging, charging needs for taxi owners overnight, inductive influence of fast charging on batteries
- Investigate other applications for inductive fast charging and the possibility of a test bed environment.

3.1 Steps in the project setup

The joint project started off with several parallel activities where needed collaboration and project coordination was identified. A shared storage was set up by Volvo Cars to collect and store any common information. Major project tasks are listed below:

- Creating necessary collaboration agreements among the project stakeholders agreeing on the common goals and timelines. (Lead by Volvo Cars)

- Creating contracts between individual stakeholder when needed. In several cases individual contracts was set up to control pier to pier business relations meeting the common goals.

- Engineering and project management for integration of the supplier technology into the car platform. (Lead by Volvo Cars, supported by Momentum Dynamics)

- Car manufacturing and rebuild for the wireless charging equipment. (Internal project within Volvo Cars)

- Setting up public charging station including ground sockets, power wiring, charging cabinet, ground assembly installation and commissioning. Lead by Göteborg Energi together with subcontractor ex-te. and heavily supported by Momentum Dynamics

- Onboarding of taxi drivers. Lead by Volvo Cars, supported by Cabonline

- Data collection and analysis. Information around the fleet progress will be collected by measuring data from different sources form the cars and the charging stations but also the taxi operation as well as the driver through interviews.

- Roadside assistance and fault tracing. In case of any trouble the taxi drivers are supposed to use the car's inbuilt telematics system for e-call with the intention speaking to the Volvo organised roadside Assistance service. Depending on the nature of the problem, the operator from the call-centre will pass on information about the problem nature to the appropriate receivers than can fix the problem. (Lead by Volvo cars)

4 Technical deep dives

4.1 Volvo XC40 Recharge – Battery electric vehicle

The Volvo XC40 Recharge is Volvo Cars first battery electric vehicle and is based on the CMA platform.

Specification: XC 40 Recharge Taxi

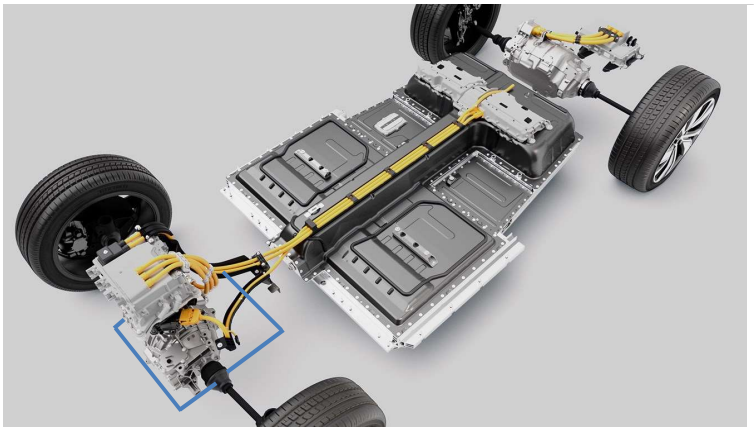
(CMA = Compact Module Architecture)

Vehicle Type:	Compact SUV
Year Model:	2022.
Battery Energy Capacity:	78 kWh.
Electric Drive Peak Power:	300 kW.
On-Board AC Charging:	11 kW.
DC fast Charging:	150 kW.
Wireless Charging power:	43 kW.

Figure 4.1: Volvo Cars XC40 BEV – charging at Lindholmen station

4.2 In Car Integrated Wireless Charging Technology

The Integration of the wireless technology into the car is mainly consisting of physical integration + hardware and software adaptions.



Mechanical Integration inside vehicle

CAE work and packaging

Changes to vehicle chassis

Changes to electrical high voltage design

Adaption of low voltage wiring design

Cooling design and routing

Brackets and protection covers

Figure 4.2: Volvo Cars XC40 BEV Recharge – Propulsion system

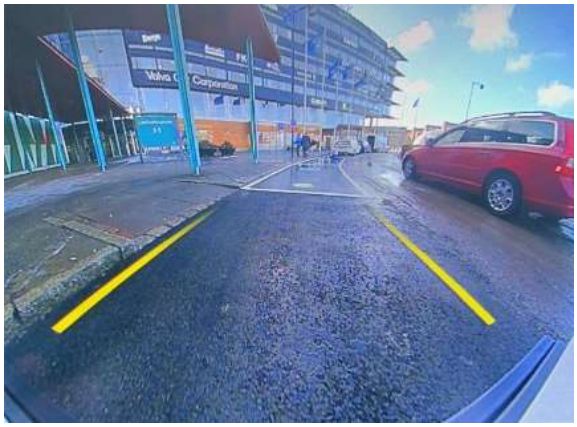
In total, following additional steps has been taken in the integration of wireless technology into the vehicle platform

- Mechanical integration of vehicle pad to the car chassis system (Figure 4.2)
- Adaption of under floor shields to the charging plate mounts
- Cooling system adaption to include the wireless pad in the vehicle low temperature cooling circuit
- High voltage wiring connection connecting the wireless power circuit to the vehicle battery
- Low Voltage wiring harness to adopt the added electronics and communication network
- Communication bridges between the vehicle networks and the added wireless charging system
- Function and SW development for the additional functionality needed together with wireless charging
- Design of charging monitoring APP (Figure 4.3)

From decision to execution, it took around one year to set up all the activities to prepare for the taxi fleet vehicles to be engineered, built, tested, and commissioned. In parallel, wireless charging stations for internal use was set up for the test and product validation purpose. (Figure 4.5)

A massive testing activity by the Volvo Cars Product validation team was also added to the project to verify proper functionality and find faults both about vehicle integration but also around the charging system.

Fig 4.3: Wireless Charging car APP



4.4: Vehicle alignment support

4.3 Wireless Charging stations

In a wireless charging system, the cars and infrastructure must work together to achieve successful charging events. Control of the energy throughput is provided from the charging station but communication with the vehicle system is also needed to control that the charging power level will not exceed any limits set by the car but also provide information back to the charging station, if there is any error occurring. Through the architectural design and software integration it was possible to integrate the additional functions needed for wireless charging to be similar in behaviour, close to the existing conductive charging functionality.

4.3.1 Wireless charging stations at the Volvo Cars facilities

Early in the project phases, the needs to provide testing and validation came up and it was foreseen that charging stations is an important part to create and verify the best possible integration. Also, without a charging station, it will not be meaningful to integrate a system solution in the vehicle. Starting off with one single charging ground pad at VCC R&D operations in Torslanda served the engineering needs quite well from the beginning.

Later phases in the project concluded that it is important to visualise and test wireless charging as close to the realistic use cases as possible using the actual test fleet. A second test station was built at Volvo Proving Ground facilities outside Borås. This facility is located 50 km East of Gothenburg. The functional targets for the new station were set to reflect the specification for the public charging stations that was in planning phases for use in the public areas.

Figure 4.5 Charging stations for internal use (Torslanda site to the left and Hällered site to the right)

4.3.2 Public stations

In the Gothenburg Green City Zone wireless charging collaboration project it was decided from start to build at least two charging stations at two different locations consisting of 2 charging pads each.

The first station was built during winter 2022 and was ready and commissioned just before the public launch in beginning of March, 2022.

A second station is under development and planned to be ready for use in June 2022. This second site will be physically located in the central area of Gothenburg city.

Figure 4.5: Construction work preparing for installation of the ground assemblies

Figure 4.6: Charging space with two pads ready for launch

5 Ready For Launch

5.1 Foiling the cars

Close in time with going public with the test fleet, it was identified that the cars would be more easily identified by the public if they were equipped with an identifier. Decision was made to use a car foiling with a specific Green City Zone message. The QR code is directing the viewer to the Gothenburg Green City Zone home page.

Fig 5.1 Foiling of taxi with attached QR code

5.2 Onboarding the taxi owners and drivers

Before the taxi explore owners and/or drivers received their new cars there was set up an information meeting intended to inform the taxi owners/drivers about the project and how to use the vehicles together with integrated wireless charging. Information about project mission, charging in general, wireless charging test fleet and detailed car functionality was explained. The onboarding activity included both theoretical lesson and practical tests with the new vehicles to learn about handling, including alignment and car charging in practical use.

5.3 The Launch

Finally, after almost two years of hard technical work with a dedicated team at Volvo Cars and one year of discussions with stakeholders around collaboration, timing, common goals and deliverables it was finally time for Launch. On March 3, at 10AM the project went live at Lindholmen Science Park, synchronised with press releases and information in various media channels.

Read more on the Volvo Cars Global Newsroom

Figure 5.2 Vehicle in line charging at the Lindholmen station

5.4 Short view on results

At the time of writing this paper the taxi fleet has been operating for almost two months. It is too early to draw final conclusions but there are some findings that can be shared already.

- Positive experience in general reported from the taxi fleet drivers
- Training is important
- Charging stations needs to match number of vehicles and geographic operational area
- High awareness and interst from all around; drivers, stake holders, media and public

Acknowledgments

In a project like this it is impossible to to acknowledge all people involved inside and outside Volvo Cars. Without mentioning any specific person, a big applause should be sent to all the dedicated ple inside Volvo cars, R&D senior Management, business office for their help with the contractual work, technical developers, test object and vehicle build coordination and testing personnel, and not to forget the personnel supported the media and public relation activities. Such a great team!

Many thanks must also be sent for the appreciated support given by Momentum Dynamics, both locally in Sweden and from technical R&D organisation in The United States.

Finally, the project team members from the stakeholder companies. The willingness to make this happen, finally got this project to a successful launch!

Authors

Robert Eriksson has a M.Sc. in Electrical Engineering from Chalmers University. Robert has more than 30 years of experience at Volvo Cars working with various electrification research and development programs and holds a role as Senior Technical Leader in the field of Electric Propulsion Architecture and Electromobility. Robert is actively leading number of activities with external partners in the global arena closely related to the automotive industry transformation with a sustainable society in focus.