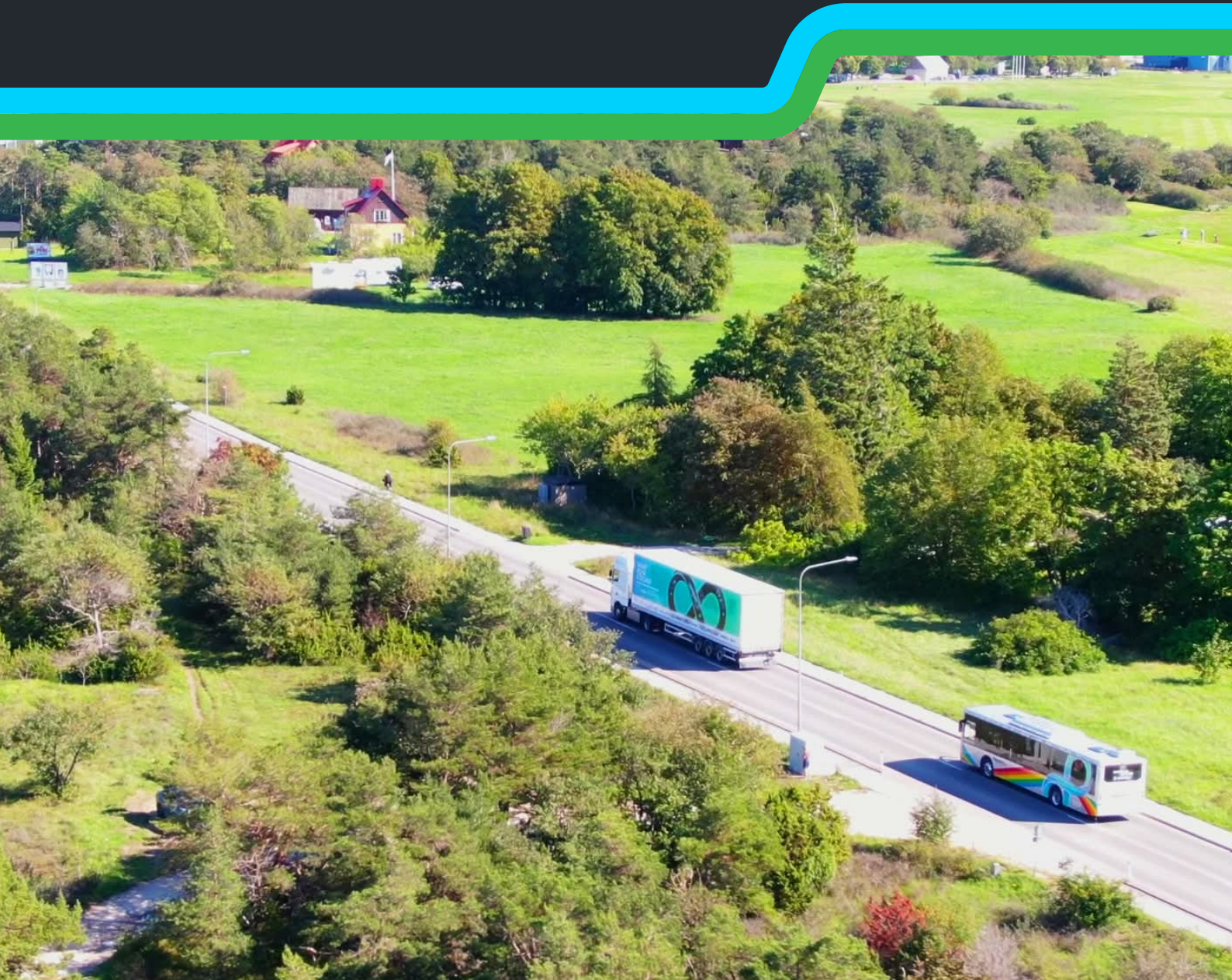




Smartroad Gotland White Paper

Findings from the World's First Public Wireless Electric
Road for Heavy-Duty Commercial Vehicles

January, 2023



Executive Summary

The Smartroad Gotland (SRG) project is the world's first public wireless inductive Electric Road for heavy-duty vehicles located on the island of Gotland, south of Stockholm in Sweden's Baltic Sea. The Electric Road is 1.65 km (~1 mile) in length and represents a groundbreaking development in the field of wireless Electric Road technology, also known as Dynamic Wireless Power Transfer (DWPT). This white paper offers a comprehensive overview of the project, its objectives and its findings in ascertaining the feasibility of implementing the technology at large-scale, to enable the transition to a net-zero electric transport sector.



Smartroad Gotland (SRG) Key Findings: Milestones and Accomplishments



A shared charging platform for all vehicles

In June 2021, Electreon became the first company globally to charge two commercial vehicles simultaneously from the same public road; showcasing the technology's shared charging platform functionality. The vehicles, a 40-ton electric truck and a 12.5-meter electric bus, had differing battery systems and power requirements.



High power capacity

In September 2023, the electric truck received 100 kW charge from the road while driving at speeds of up to 80 km/h (50 mph), the maximum permitted speed for trucks with trailers on roads in Sweden.



Smooth and continuous commercial vehicle operations

In June 2022, the electric bus began operating commercially on the Flygbussarna's regular route while charging wirelessly from the road and at the stationary charging station, the operator, driver and passengers reported being highly satisfied with the technology.



Durable technology for harsh winter conditions

The technology underwent rigorous testing over four years (2019-2023). Independent third parties found that the technology does not impact the roadway structure, quality, or lifespan; and can withstand temperatures of -23 °C, without impacting charging, proving the technology's suitability for harsh winter and arctic climates.

An Overview of the SRG Project

The Swedish government came to the conclusion that plug-in charging infrastructure alone may not be enough to facilitate the transition to sustainable zero emission vehicles (ZEV) and began investigating alternative solutions to achieve its 2030 net-zero goals a decade ago. The Swedish government has played a pioneering role in enabling innovative charging technology research, feasibility studies and demonstrations, including Electric Road System (ERS) projects. This project was designed to investigate all technical, logistical and economic aspects regarding the implementation of a wireless Electric Road System.

The Swedish Transport Administration (Trafikverket)

commissioned Electreon AB, along with a consortium of partners to deploy the SRG project in order to further knowledge and assess the feasibility of the technology to minimize transport emissions and accelerate the adoption of Electric Vehicles (EVs); particularly heavy-duty commercial freight and logistic fleets vehicles that travel long distances on highways and face additional challenges in the pathway to carbon neutral electrification.

The SRG project was located on a 4.1 km (2.5 miles) stretch of road between Östercentrum, in the town of Visby, and the airport on Gotland Island. The project featured the following:

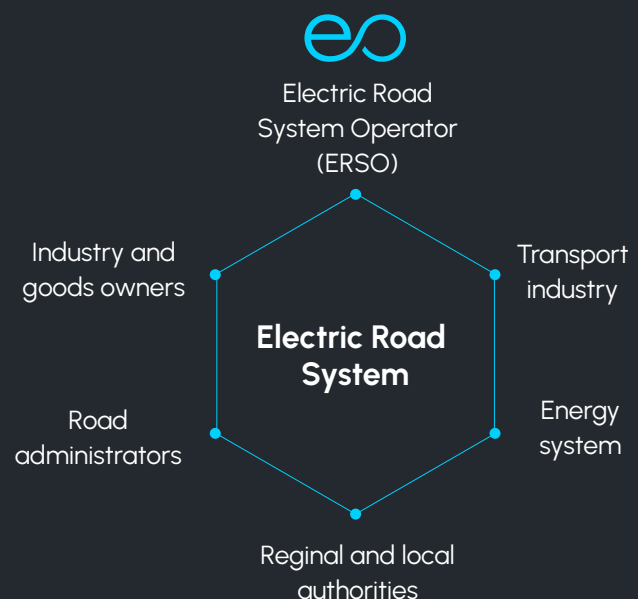
- **Two wireless Electric Roads** - a 600 meter road for lower driving speeds and a 1000 meter road for higher driving speeds
- **A static wireless charger** - to charge the vehicles when parked
- **Solar panels** - that generated renewable power for the road

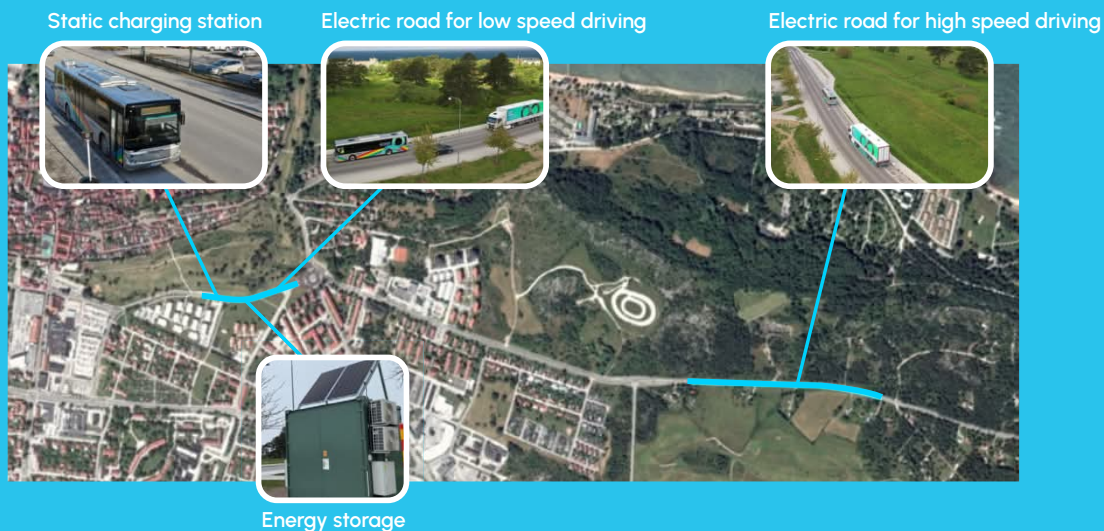
- **An energy storage device** - 330 kWh battery used to store solar power for ERS charging
- **Two commercial vehicles** - a 12 meter electric bus with a minimal 40 kWh supercapacitor battery, and a 40 ton retrofitted electric truck with a minimal 200 kWh. Both were installed with Electreon's vehicle receivers and drove and charged simultaneously from the electric roadway at various speeds and underwent rigorous testing in Sweden's demanding winter climate.



Additional project consortium partners include

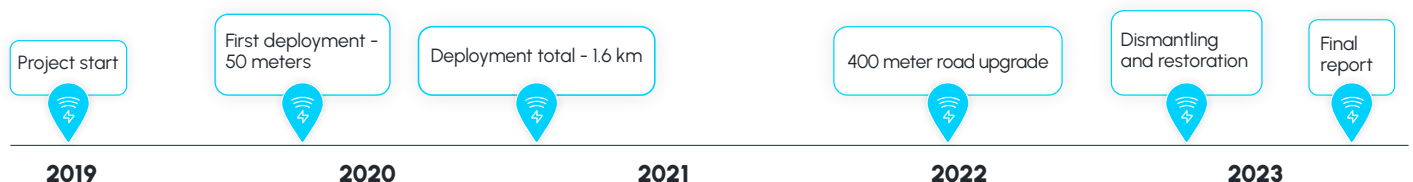
- **Transport operators** - Gotlands Bilfrakt and Flygbussarna
- **Automotive partners** - Higer, Eforce and GINAF
- **Engineering and construction partners** - EiTech, NCC, Davitor and Caverion
- **Energy partner** - GEAB
- **Governmental and local stakeholders** - Region Gotland, Swedavia Airports, Science Park Gotland and Gotland Ring
- **Environmental, academic and advisory partners** - World Ecological Forum, CFRAM and RISE





The SRG project received approximately 85% of its funding from the Swedish Transport Administration and the rest came from the consortium members. The project ran from 2019-2023, during which time Electreon AB delivered a total of 13 reports to share knowledge and learnings from this groundbreaking project with the Swedish Transport Administration.

The SRG Project Timeline



Electreon's Wireless Charging Technology

1. **Aboveground Management Unit (AMU)** transfers energy from the grid to the charging infrastructure
2. **Underground Management Unit (UMU)**. Same functionality as AMU without any visual impact
3. **In-road copper coils** transfer power to the vehicles' receivers
4. **Vehicle's receiver** installed on the EV to transfer energy directly to the engine
5. **Management Software** monitors & manages optimal EV charging in real time



The Smartroad Gotland Project Findings

Deployment and Environmental Impacts

Executing the deployment of Electreon's road infrastructure did not require a complete reconstruction of roadways, installation of new roadway foundations, removal of fauna, or deforestation of the surrounding environment adjacent to the road. The installation of roadway segment coils was easy and had minimal disruption to traffic (up to 1 km can be installed in one night) and occurred only several centimeters (6 – 10cm) below the top layer of asphalt, thus minimizing the total installation time and power transfer requirements.

These installations proved the flexibility of the technology in fitting in with road and city planning needs and challenges. In the SRG project, the installation of the



wireless Electric Road successfully incorporated the requirements and considerations of the Hanseatic Town of Visby, a UNESCO World Heritage site. The installation also required no additional service roads or road areas to be constructed, thereby maintaining the town's landscape historic architecture integrity and showing that the technology can also be advantageous for dense urban environments.

The following features gives Electreon's inductive charging technology major advantages compared to other electric charging road technologies:

1. The charging segments are installed below the road surface, road maintenance is not affected.
2. Management units can be placed both above and below ground, making the system installation flexible for location-specific conditions.
3. No loose or movable parts, hence no impact from snow, ice, wind or physical sabotage.



Technology: Testing and Optimization

The bus drove at various speeds and successfully charged from the road, while the bus was driven by three different drivers, and bus operations were not impacted.

SRG offered a unique opportunity for continual testing and optimization of Electreon's wireless Electric road technology. Thanks to continued technology optimizations throughout the project, measurement results towards the end of the project show that as the truck drives across the road, it receives 100 kW, regardless of driving speed.

Tests with the truck show how the energy transfer is independent of speed (traveling up to 80 km/h). The truck received 100 kW regardless of speed.

Rigorous testing showed the suitability of the technology for a wide variety of charging use cases, including static charging (stationary), dynamic charging (while driving) and semi-dynamic charging (i.e., at a combination of stationary and low speed, e.g. bus stops, taxi queues, and loading docks).

Electromagnetic (EMC and EMF) testing was conducted by multiple separate agencies - the National Electrical Safety Board, the Civil Aviation Administration, the Swedish Defence Research Agency, the Swedish Post and Telecom Authority and other research institutes of Sweden. The tests showed that the system operates safely within all limit values.



Energy

The project included the incorporation of energy storage and a small-scale solar panel installation to demonstrate that the combination of wireless Electric Road technology and renewable on-site energy generation can offer a highly sustainable pathway to net-zero transport emissions; suitable as part of the energy mix, and to both small projects such as this, and larger scales.



The Road in Harsh Winter Climate Conditions

The technology was not affected by snow, ice or precipitation, or by their removal during the entire length of the project and inspections conducted in October 2023 revealed no damage or deviations to the road surface; rutting was minimal and the road body remained unaffected.



Roadway Integrity

Third party stress and endurance testing completed by the Swedish National Road and Transport Research Institute (VTI) in late 2022 verified that Electreon's inductive charging technology does not negatively impact the roadway's lifetime or quality. The testing utilized a heavy vehicle simulator (HVS), and applied more than 30,000 passes of its load to sections of sample roadway with installed Electreon technology with varying axle weights, types of wheels, and ambient temperatures over the course of several months. The maximum axle weight permitted in Sweden is 10.5 tons, however, axle weights of up to 16 tons were tested. The tests also verified that Electreon's technology is already compatible with roads on which High-Capacity Transportation vehicles will operate.

Based on rigorous testing and evaluation by independent third-parties, testing demonstrated that Electreon's technology had no impact on the quality of the road structure; and leaving the coil segments under the asphalt after the project ended would not affect the quality or structure of the road in any way.

Public Engagement and Local Stakeholder Feedback

The SRG project managers frequently engaged with the public through guided bus tours and seminars, increasing awareness and interest in the technology, and addressing questions that arose throughout the project.

The truck driver, the bus drivers and passengers were overwhelmingly positive about the SRG project and the technology testing.

The flight tower at Visby airport confirmed that neither they, nor anyone in flight operations has noticed any impacts to their operations or flights since the project began.

"It's really fun with this new technology. The bus is very quiet and fun to drive, the charging is easy and noise free, which makes it comfortable for the passengers as well."



- Ulrika Runesdotter Carlsson,
Flygbussarna bus driver

Disassembly and Recycling Management

As this project was commissioned for four years the project infrastructure had to be dismantled and removed. The dismantling and road restoration process involved careful removal of charging coil segments, cables, and the top asphalt layer. Charging segments and cables were sorted, recycled, and processed in an environmentally responsible manner.

Conclusions

The Smartroad Gotland project has proven the viability of Electreon's wireless Electric Road technology in real-world conditions. As the first of its kind, this project signifies a major leap toward sustainable and energy-efficient road transportation. With demonstrated benefits and a global reach, wireless Electric Roads offer a promising solution to drive the transition to electric and environmentally responsible transportation.

The interest in wireless Electric Roads by many stakeholders is based on experienced benefits such as minimal visual impact, simple and space-efficient installation, high traffic safety, simple and cost-effective maintenance, proven ability to reduce the size and weight of on-board vehicle energy storage systems, and suitability to charge different EV types and classes simultaneously.

