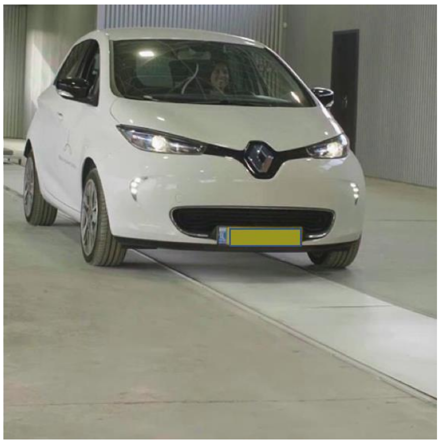
Swedish-German research collaboration on Electric Road Systems



Key Messages on Electric Roads

Executive Summary from the CollERS Project

26 March 2021

The research collaboration "CollERS" consists of the core members from the Swedish Research and Innovation Platform for Electric Roads and the two national German research projects Roadmap OH-Lkw and StratON:

- **German research partners**
  - Öko-Institut e.V.
  - ifeu – Institut für Energie- und Umweltforschung Heidelberg
  - Fraunhofer IEE – Fraunhofer Institute for Energy Economics and Energy System Technology
  - Heilbronn University of Applied Sciences
- **Swedish research partners**
  - RISE Research Institutes of Sweden
  - Chalmers University of Technology
  - KTH Royal Institute of Technology
  - Swedish National Road and Transport Research Institute (VTI)
  - Trafikverket – Swedish Transport Administration
- **Funding agencies**
  - German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)
  - Trafikverket – Swedish Transport Administration

Additional information and resources can be found on the web:
www.electricroads.org

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The pictures on the front page are courtesy of Region Gävleborg, eRoadArlanda, and Electreon, respectively.

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Introduction

Electric road systems (ERS) enable electric power transfer to moving vehicles by means of overhead lines, rails or wireless technology. ERS constitutes a new type of technological system ("permanent pick-up") that is a paradigm shift compared to traditional refuelling at fuel stations. ERS offers the possibility to electrify long-distance heavy-duty road transport, as well as buses and passenger cars, without using large batteries. ERS has the potential to reduce fossil fuel dependency, emissions of greenhouse gases (GHG), air pollutants and noise in urban environments, while increasing energy efficiency in the transport sector.

German and Swedish research organisations have conducted a joint study with the aim of (i) providing an assessment of different ERS concepts; (ii) assessing ERS markets, business models and financing strategies; (iii) researching requirements for international ERS interoperability; (iv) investigating the impact of ERS on the energy system and the environment; (v) recommending necessary policy actions to spur ERS introduction; and (vi) identifying a suitable ERS freight corridor between Sweden and Germany.

The joint study has been funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and Trafikverket – the Swedish Transport Administration.

Why ERS?

Electric road systems (ERS) can reduce greenhouse gas emissions in the transport sector. The market-ready ERS drive systems are characterised by high energy efficiency and low operational costs compared to fossil fuels and biofuels for combustion engines.

Germany and Scandinavia are strongly interlinked economically with most goods travelling by truck between the countries. At the same time, **the countries have ambitious political goals to reduce GHG emissions with the aim of zero emissions by 2050.** These goals are in line with the Paris Agreement, as is the proposed climate-neutral energy system in the European Union by 2050[1].

Even though railway infrastructure plays an important role in both Sweden and Germany, and strong efforts are underway in Europe to shift more traffic to railways, the capacity of those existing railways can only manage a limited shift. In addition, it will be difficult to replace road freight in transport segments where punctuality, reliability and flexibility are crucial. The majority of freight traffic will therefore continue to be transported by road in the future. **This is why meeting GHG reduction targets will also require alternative drive systems in the field of road transportation**. If road transport services remain at current high levels and growth rates, without changes in the drive concepts and energy supply, it will obviously not be possible to meet GHG reduction targets.

[1] A European Green Deal https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

ERS and battery electric vehicles are characterised by high energy efficiency and low operational costs in comparison with other options for decarbonising long-distance trucks. High GHG reductions can thus be achieved by ERS with comparatively low use of natural resources. Although there is a need for higher investments during market ramp-up, long-term operational costs are quite predictable and low per vehicle kilometre.

It is shown that ERS can be implemented at a large scale, and that it is still possible to **achieve an European electricity system based only on renewable energy sources by 2050**. Yet, this will require that climate policies will deliver the necessary transformation, both on the electricity supply side and on the transport demand side, including electrification of road transport.

The electrification of long-haul heavy-duty freight transportation has been the driving force for ERS and continues to be the focus for several activities, since the heavy demands of this segment remains a challenging use-case for battery-electric drive systems. However, ERS can be applied for other use-cases and, depending on the ERS technology, road electrification can be utilised for light and medium-sized vehicles and thus decrease the need for large batteries in those segments too.

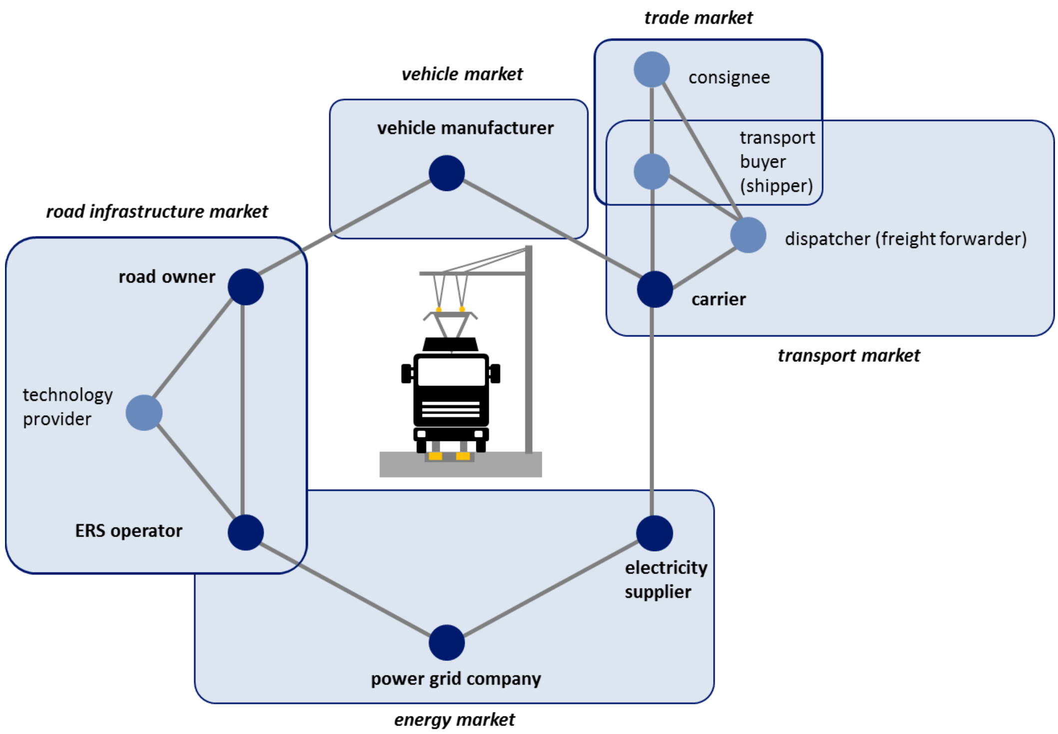
In recent years, ERS has been demonstrated for heavy-duty vehicles on public roads and significant amounts of experience regarding building, operating and maintaining ERS has been gathered. **The main conclusion is that ERS works for vehicles in motion on public roads – it is possible to transfer power to a moving vehicle.**

Requirements for (international) ERS introduction

Market design

The introduction of ERS will depend on governmental support, balancing the overall need for GHG-reduction with the business perspectives of the transport market and the energy market.

Both markets for road transport and electricity generation in the EU are organised as deregulated markets with open competition, while road management and electric power distribution operate under regulated conditions. **As ERS is located in between these markets, the implementation of ERS contains both market elements: open competition (freight forwarding and power generation) and regulated conditions (road management and power distribution)**. The conventional ownership configurations – i.e. public road agencies, a regulated energy business under private law and a highly competitive transport market – will be contested by new types of network-structured market organisation.



By including all aspects of a future ERS in a common market analysis with different perspectives (transport, trucks, energy, road infrastructure, trade), the main differences between the transport market's expectations of ERS (profitably operating ERS trucks), and the energy perspective (profitably selling green power for ERS) becomes evident. **Two main developments can be anticipated**:

- The transport market will be interested in acting as an initiator for ERS, if ERS shows it can become an efficient and competitive way of road freight. Then carriers might start to ask for ERS vehicles. Consequently, if the demand for ERS trucks on the vehicle market increases, the demand for ERS roads from the users' perspective will increase, and power for ERS needs to be provided by the energy companies.
- Alternatively, the energy market can be the driving force for ERS, as the deployment of ERS opens up new business opportunities for actors on the energy market to sell more (green) electric power. This may result in the energy market making a new product offer to the transport market in the form of ERS. However, this may not be economically interesting for truck operating companies.

Since neither one of these market perspectives can be ignored**, the introduction of ERS will depend on governmental support**, balancing the business perspectives of the transport market and the energy market at an early market stage. This will be necessary, in particular, within the transition stage and during first pilot projects.

For this reason, different market mechanisms have to be addressed in the early market stages of ERS:

- Cutting the costs (or at least not increasing) of transport to convince the logistics market, and to support the change towards new types of electric truck drive-systems on the transport and vehicle market.

- Enabling new market opportunities for energy and infrastructure companies to address the strong interdependencies in ERS between transport, energy and infrastructure, and to foster change in the energy and infrastructure business.

However, in later lifecycle phases, when critical numbers of ERS trucks are reached, the ERS market may function like other markets without such government intervention.

Standardization

There is an urgent need to establish standards for core components and important interfaces in order to build confidence among potential ERS users.

Different configurations of ERS are possible with regard to vehicle concept, degree of electrification and technical solution of the energy power transfer. From a European market perspective, standardisation is particularly important because there are different technology components for ERS being developed concurrently. A seamless European transport system necessitates compatibility between these technologies, but so far there are no dedicated draft or published standards covering ERS. Moreover, in order to build confidence among potential ERS users, ERS infrastructure operators, and equipment suppliers, it will be necessary to establish standards for core components and important interfaces as soon as possible.

The CENELEC TC9X technical committee is currently working on two draft *technical specifications* covering aspects of ERS[2]. Typically, technical specifications are drafted in areas of evolving technologies and can be prepared with a faster, less extensive, voting process than is required for a full standard. Technical specifications may act as trial or pre-standards and can later be adapted into full standards. At present, the standardisation work with technical specifications for ERS in TC9X among other things considers the important interfaces of vehicle and road infrastructure. In addition, the CENELEC SC9X subcommittee has added an *informative* annexe with relevance for ERS in a standard,[3] and the IEC TC69 technical committee is working with a new work item proposal that is also relevant for ERS[4].

Electricity supply

Since ERS will take time to scale up, we should begin to transform the electricity system to meet the demand for ERS while also meeting GHG reduction goals aligned with strong climate policies.

It can be concluded from modelling and analyses of road traffic data of the CollERS corridor that implementation of ERS will increase the peak power demand (i.e., the net load) in the electricity system. However, the modelling results from the project

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[2] CLC/prTS 50717: Project 70196 (Technical Requirements for Current Collectors for ground-level feeding system on road vehicles in operation) and CLC/prTS 50712: Project 70743 (Railway applications - Current collection systems - Technical criteria for the interaction between pantograph and overhead lines on electrified roads

[3] EN 50119:2020: Project 62186 (Railway applications - Fixed installations - Electric traction overhead contact lines), Annex C

[4] Project IEC 63243 ED1 (Interoperability and safety of dynamic wireless power transfer (WPT) for electric vehicles)

shows that additional electricity demand from a large-scale implementation of ERS can be primarily met by investments in wind power in Sweden and investments in both wind and solar in Germany. The extent of thermal peak power still required will depend on how efficient the solar and wind power is integrated – the more storage possibilities in the system, the less need for thermal peak power.

Given ERS will take time to scale up, it can be concluded that there should be enough time for the electricity system to be transformed to meet the demand for ERS while also meeting the goals on GHG reduction. This conclusion is based on energy systems modelling. The modelling compared a base-case system without electrification of the transport sector to corresponding systems with i) ERS and direct charging of passenger EVs; and ii) ERS combined with smart charging of passenger EVs, including Vehicle-to-Grid for the EVs, which optimizes the charging to minimize the cost of electricity supply.

It can be concluded that although ERS increases the peak power demand in the electricity system, smart integration with other electricity loads (such as optimisation of the static charging at the home location of passenger cars) can facilitate efficient use of renewable electricity to minimise reliance on thermal peak power. Thus, **ERS must be evaluated and assessed together with assumptions on electrification technologies of passenger cars and other sectors**, in particular the industry sector where there are already plans for electrification (e.g. iron and steel, cement and petrochemical industries). To realise a transition similar to what has been obtained from the modelling, there is an obvious need for clear and sufficiently robust climate policies reaching across the electricity, industry and transport sectors.

Role of public actors

There is a need to clarify whether an ERS system is part of the road infrastructure market or the energy market, and to define the role of the public sector in ERS deployment.

Even though considerable government involvement seems to be necessary for the testing and roll-out of ERS, there is still a possibility that such a system can be organised by private sector actors at a later stage. By the stage of market deployment (at the latest) **clarity is needed on whether an ERS system is judicially part of the road infrastructure market or of the energy market**. The outcome of this will determine whether ERS should be organised and subjected to public or private law.

Considering this, different views on how to organise the deployment of ERS and what the division of responsibility between the actors involved should be, might lead to different ownership configurations along the corridor and different degrees of public involvement.

Public-private ownership with different owners in the corridor countries is not a problem as long as the system is easy to access for carriers. Among other things, this means that the user interface should preferably be seamless when travelling on stretches crossing different jurisdictions.

In any case, a certain public commitment towards ERS technology based on their sustainability and system efficiency benefits in the long run is indispensable for the successful large-scale introduction of ERS. A strict “technology-neutral” policy will always benefit drive systems with short-term financial advantages, but result in only minor GHG reductions (e.g. combustion engines with LNG), and could undermine solutions with much greater long-term advantages, such as ERS, that are characterized by high initial investments.

Role of international transport corridors for ERS

Since a significant part of long-haul road freight transport is international, ERS deployment will benefit from cross-country cooperation.

ERS technologies are network-bound drive systems. First, that means that system introduction will benefit a great deal from standardisation. Second, the value of the system will scale with its extension in a non-linear way. Since a significant part of freight transportation is international and the ERS technology is associated with high up-front investments, its deployment will benefit from **cross-country cooperation.** Generally speaking, an international ERS corridor project could:

- emphasise the principal strengths of ERS
- trigger strategic coordination between the participating countries
- foster national ERS roll-out due to synergy effects
- raise awareness for ERS at the EU level

Within the CollERS project, feasibility criteria have been developed in order to assess the potential of specific ERS corridor projects:

- Technical aspects: Which technical prerequisites exist for ERS corridors and to what extent can they be expected to be met?
- Environmental aspects: Which effects can be expected on key environmental indicators?
- Economic aspects: Can an ERS corridor pose a strong business case?
- Political aspects: Would an ERS corridor implementation be aligned with socio-political goals besides climate ambitions?

The developed criteria may serve as a toolbox for scrutinising future transnational ERS corridor projects. In order to illustrate their application, we used them to analyse a potential roll-out of an Electric Road System on a selected highway corridor (424 km) connecting **Sweden** and **Germany**, but mainly located on Danish territory. Based on traffic flows and patterns along the corridor route, it was found:

- A considerable part of the total truck mileage on the corridor is done by vehicles with a rather limited driving distance for pre- and post-haul, assuming the corridor is realised as a stand-alone project, and
- the CO_2 emissions (well-to-wheel) of truck traffic along the corridor route can be significantly reduced if electric trucks are powered by the national electricity mixes expected for the year 2030, and even more if it would be powered purely from renewables.

Although a continuous ERS on the complete corridor route would not be economically feasible under current conditions, the analysis pinpoints sections along the route where the traffic volumes are already sufficently high. These sections are located in the metropolitan areas of Malmö, Copenhagen and Hamburg. For implementation, peculiarities of the local markets and regulation should be considered, as well as country-specific priorities on decarbonizing road freight transport. Additionally, the identified ERS potential for medium distances will depend on the technical and cost development of battery trucks.

The developed analytical framework is well-suited for investigating other possible ERS corridors in Europe (and elsewere) and can help towards designing more comprehensive European roll-out strategies for ERS.

CollERS Publications

The CollERS project has produced several reports:

“Overview of ERS concepts and complementary technologies”

“Real-world experiences of ERS: Best practices from demonstration projects in Sweden and Germany”

“Connecting Countries by Electric Roads: Methodology for Feasibility Analysis of a Transnational ERS Corridor”

“Business Models, Ownership, and Financing Strategies: Implications of the introduction of electric road systems on markets and possible business models”

“National and EU freight transport strategies: Status quo and perspectives and implications for the introduction of electric road systems (ERS)”

“Standardisation of Electric Road Systems: Report from workshop at FIRM19, 28 March 2019, Brussels”

“Electricity supply to electric road systems: Impacts on the energy system and environment”

These reports are published on the website https://www.electricroads.org/collers.