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Research & Innovation for Electric Roads

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Summary

Research organizations, industry, and public authorities in Sweden and Norway have collaborated within the project "Research and Innovation Platform for Electric Roads" and investigated benefits of Electric Road Systems (ERS) to society, future business ecosystem, and how to support a large-scale deployment. The results cover electricity supply; environmental impact; construction, operations and maintenance; economic impact; business models; and standards.

Keywords: business model, dynamic charging, energy network, maintenance, standardization

1 Introduction

1.1 Change is necessary

One part of a complete, society-wide solution could be electric roads that supply vehicles with electricity, to both power them and charge them as they drive. With electric roads, cars can have smaller batteries than at present, but still drive long distances. Electric buses in cities would not need to stop to charge at bus stops. Of equal significance, electric roads facilitate the electrification of heavy long-distance road freight, for which battery capacity would otherwise be a challenge. See Figure 1.

Benefits of electric roads include reduced dependence on fossil fuels, reduced greenhouse gas emissions, reduced air pollution, reduced noise in urban areas, increased energy efficiency in the transport sector, and reduced need for large batteries in passenger cars.

1.2 Research & Innovation Platform for Electric Road Systems

How do we take the step from testing electric road technology to large-scale deployment? What does the business ecosystem look like and how can interfaces be standardized? What are the benefits to society?

Actors from research organizations, industry, and public authorities have collaborated in the joint project "Research & Innovation Platform for Electric Road Systems" to investigate the above questions and much more. *This article briefly presents the project's results among the areas electricity supply; environmental impact; construction, operations and maintenance; economic impact; business models; and standards.*

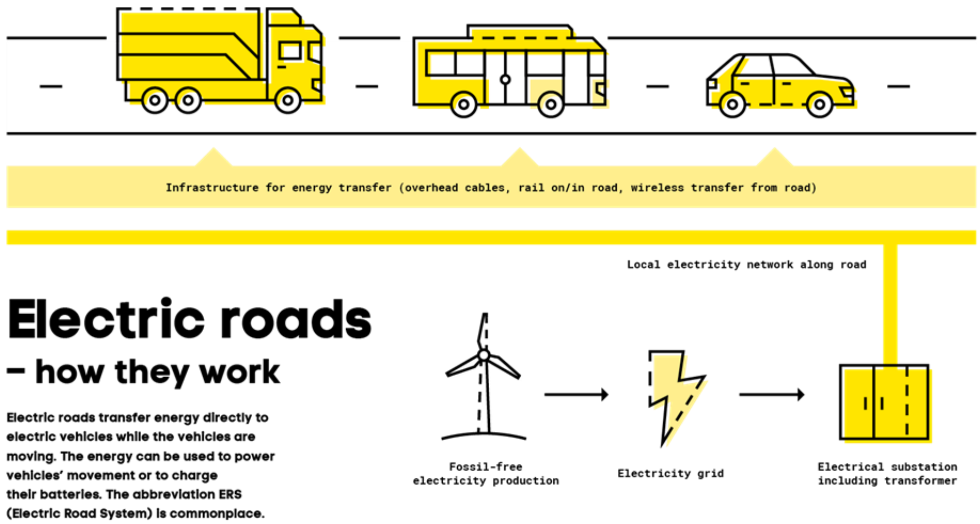

Figure 1: Electric roads supply vehicles with electricity as they drive.

The goal of the project has been to strengthen research and innovation with regards to Electric Road Systems (ERS). Together, researchers, businesses, and public sector actors in Sweden and Norway have developed a joint knowledge base. Thanks to this collaboration, we have provided clarity about the socio-economic factors, environmental benefits, and other effects related to electrical roads. The project has explored the benefits from the perspectives of different actors. We have examined implementation strategies, operation and maintenance standards, proposed regulatory systems, the factors affecting the acceptance of electric roads, and the development of international collaboration.

The project began in 2016 and knowledge building continued until 2019. In parallel, project researchers collaborated with German research organizations in a joint study called CollERS (Swedish German Research Collaboration on ERS). Knowledge and findings have been continually shared during the project through information meetings, seminars, and annual international conferences. During 2020 and 2021, the project's focus was primarily to disseminate results.

A report with the collected results [1] is available to read in full at the www-site electricroads.org where also additional research findings and material about electric roads can be found.

2 Electricity supply

We have made an evaluation of the impact of electric roads on the electricity system and the interaction between the two, in terms of the use and distribution of electricity. We have also assessed the climate benefits of various types of electrification, with regards to reduced greenhouse gas emissions.

If electric road technology were installed and used on Sweden's five busiest roads, the road transport sector would reduce its carbon dioxide emissions by approximately 20 percent. There would also be an increase in electricity demand of maximum 4 percent during the peak consumption hour.

If electric road technology were installed on all European and National roads in Sweden, this would reduce carbon dioxide emissions from heavy traffic by more than 60 percent. Even with complete electrification of the road transport sector, the increased electricity demand could be met through an increase in generation from mainly wind and solar power.

Through electric road simulations, we have found that a single truck with a total payload of 60 tonnes can travel the entire Swedish section of the E6 with the help of a 40 kWh battery. The battery acts as a supplementary power source to deal with height variations and other breaks in the electricity infrastructure.

3 Environmental impact

We have reviewed the possible environmental impact of introducing electric roads – for example the effects on air quality and noise pollution – resulting from both traffic and from management of the surrounding infrastructure.

There are several reasons to invest in electric roads. Among them is the potential of decreasing our dependence on fossil fuels and reducing noise levels in cities. But to realize a low environmental impact when installing ERS technology, it is important to examine the amount of material used and its wear resistance. There is a risk otherwise that wear from electric roads could increase the number of airborne particles, rather than contributing to a reduction.

When preparing for the installation of electric roads, it is also necessary to investigate the effects of electromagnetic fields. The feasibility of using different shielding technologies should also be considered, to protect people and electrical appliances in the vicinity of electric roads.

4 Construction, operations, and maintenance

We have reviewed the various types of electric roads and examined the impact of their construction and maintenance in comparison to ordinary roads. Among other subjects, we highlight the issue of winter road maintenance.

Electric road technologies that are physically embedded in the road – regardless of whether the energy transfer takes place wirelessly or via contact with rails – can affect the strength of the road when under traffic load. Any installation made from material other than that of the existing road can create settlements, cracks, and deformations in the body of the road, when under unusual traffic load. Therefore it is important to test all electric road technology that is to be installed in existing roads. It is especially important to monitor the transverse cables that connect the electrical circuit to the mains so that they do not damage the construction of the road.

Removing snow from electric roads can be problematic because of guardrails. These need to be placed alongside roads with overhead lines, but they risk damaging plow blades. Plow trucks need to maintain a distance of at least 30 cm from the railing to avoid damage to the blades and/or the railing.

Other potential problems with snow removal on electric roads depend on the type of technology employed. For example, it may be difficult to clear snow from rails in or on the road, or rails could be damaged by plow blades. One solution could be heated rails, or in some cases the use of special-designed brushes or plow blades that would not damage rails.

5 Economic impact

We have studied what data and prerequisites are required to adequately inform decision-making on the construction of electric roads, and we have also compiled previous findings from socio-economic analyses.

Introducing electric roads nationally and internationally will involve major investment, so it is important to examine the economic effects and benefits to society. We have found that the large-scale introduction of electric roads would lead to important gains in terms of the costs of energy used in the transport sector.

Interviews have been conducted with companies in the transport and electricity sectors, to understand what is required for electric roads to be desired and used by different actors.

The transport industry has mainly emphasized the importance of a sustainable business economy, load capacity, and incentives to increase the demand for sustainable transport. The electricity industry highlighted the importance of knowing how electric roads will be connected to the electricity grid, so that they can make appropriate investments in the existing grid.

6 Business models

We have studied how the business models of different ERS actors can interact in a business ecosystem. Around Sweden, the formation of consortia that could build and operate sections of electric road is being discussed.

6.1 ERS actor constellations

The introduction of electric roads affects a number of public and private actors. The organization of actors in different ownership configurations and financing models (public-private partnerships [PPP], for example) has a major influence on the design of possible value propositions and revenue models. Road operators, transport operators, and energy companies must work together for ERS expansion to take place.

New roles and business models can also be developed when established roles are disturbed by additional investment, see Figure 2. The role of the ‘Electric Road System Operator’ (ERSO), that is, the actor responsible for the operation of the road, is an example of a central actor who doesn’t yet exist and whose potential identity is not yet established. We have defined possible components of the ERSO role and improved understanding around what is required for such a role to be established.

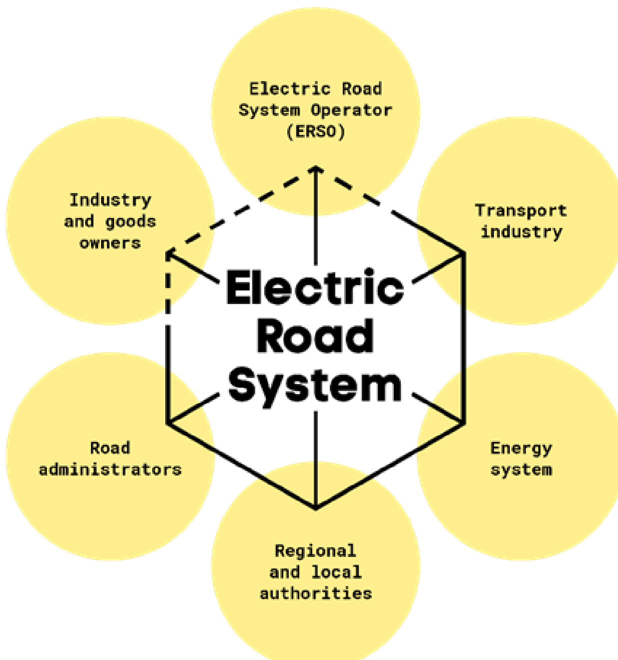

Figure 2: Business ecosystem with different actors and new roles.

6.2 Access control and payment

Access control is a crucial part of the interaction between the ERS and the vehicles traveling on it. It will be important to check that every vehicle on an ERS is authorized to use it, and has the right technical capabilities to do so safely. A possible way forward is to integrate or base upcoming ERS access system solutions with existing fleet management and information systems.

Electric road users will have to pay both for electricity and use of infrastructure, and payment may be divided into both fixed and variable costs. Payment systems will thus be necessary and should be flexible and adaptable.

There are existing technical solutions that could be applicable to ERS. However, further clarification is needed around how a payment system solution should be divided into components installed in vehicles and those installed on the road.

7 Standards

We have contributed knowledge around regulations and standardization, the latter in particular, with respect to the development, creation, design, function, and administration of electric roads.

Since ERS is a relatively recent field of emerging technology, there is, at present, neither specific regulation nor dedicated standardization. For ERS to take off successfully, matters such as security, safety, the environment, and technical requirements must be properly considered.

It is still not known to what extent it is possible to use present legal frameworks and standards, or if entirely new ones need to be created.

We have done a preliminary mapping and analysis of both published standards and standards under development in order to get a clearer picture of the needs in the field of ERS.

Acknowledgments

The full report [1] can be found at the www-site electricroads.org. The report is by researchers from RISE Research Institutes of Sweden, Chalmers University of Technology, KTH Royal Institute of Technology, Lund University, The Institute of Transport Economics (TØI) and The Swedish National Road and Transport Research Institute (VTI). The results of the project also include a proposed ERS architecture [2] and a compilation of standards [3].

The project partners were Airport City Stockholm, Chalmers University of Technology, Fortum, KTH Royal Institute of Technology, Lund University, Norwegian Institute of Transport Economics (TØI), Profu, Region Gävleborg, Region Kalmar, RISE Research Institutes of Sweden, Scania CV, Swedish Electromobility Centre, Swedish National Road and Transport Research Institute (VTI), Trafikverket – Swedish Transport Administration, and Vattenfall.

The reference group for the project has played a crucial advisory role, and has consisted of representatives from Alstom, Bombardier, Elonroad, the National Electrical Safety Board, Elways, Energiforsk, E.ON, Ericsson, Ernst Express, FKG, NCC, NEVS, Postnord, Siemens, SSAB, Swedish Energy Agency, TRB, and Volvo Cars.

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Author

Martin G. H. Gustavsson has a Ph.D. degree in Physics and has a profound experience of product management and business development in telecommunication. He has for several years at RISE been involved in several activities concerning sustainable mobility. Martin Gustavsson has managed projects on research and innovation for electric road systems, charging infrastructure, automatic charging of electric cars, telecom-based human mobility analytics for buses etc.