BUSINESS MODELS FOR INTRODUCING ELECTRIC ROAD SYSTEMS IN SWEDEN

Summary
The environmental impact caused by road traffic, particularly heavy-duty freight traffic, is significant and one of the biggest challenges to reduce. In Sweden, one potential solution being explored is the implementation of electrified road systems (ERS). However, if the country is to achieve ambitious environmental and sustainability targets, deeper market analysis and investigation of suitable business models, financing models and organizational solutions is required. In February 2018, EY was assigned by the Swedish Transport Administration (Trafikverket) to analyze these factors in preparation for the introduction of ERS in Sweden. The study has been performed in close collaboration with the Swedish Transport Administration and a wide number of actors in the ERS area.

Since ERS is still a relatively new transport solution, there is not yet an established market. This has made it difficult to draw any clear conclusions regarding suitable business models. The proposed business model building blocks are a suitable way of organizing the implementation and have been gradually developed and fine-tuned during interviews, meetings and workshops. Different private actors have shown interest in different parts of ERS and the four building blocks. During a transition period, governmental support (e.g. subsidies or guarantees) will probably be needed to attract private interest and support market development for ERS and ERS vehicles.

It can be concluded that the market conditions appear to be good for introducing ERS in Sweden, despite being in the very early phase. A lot of work still remains, however, before a commercial ERS can be implemented at a large scale in terms of testing, pilots and further research. Continued investments and activities from the state and the Swedish Transport Administration will be important going forward to encourage and drive private initiatives and further development, which will be needed to realize the expansion of electrified roads.

Introduction to ERS
ERS are systems that enable dynamic power transfer to hybrid electric vehicles whilst they are driving. By integrating power transfer technology into existing road infrastructure, an electrified road will be accessible to both vehicles that use power transmission and other vehicles. There are currently three main ERS technologies:

- conductive power transfer through overhead line technology
- conductive power transfer through in-road technology
- inductive power transfer through electromagnetic in-road technology

The system as a whole can be described as four main parts:

1. Existing power grid infrastructure – current power grids, connection points and power grids alongside the road
2. The ERS – power transfer technology, including utilization measurement systems
3. Related services – payment service, information management and access control
4. Responsibilities – maintenance, operation, financing and ownership

Market players and responsibilities
In ERS, effective interaction of many different actors are needed, including transport buyers and carriers, vehicle manufacturers, electricity suppliers, ERS operators, electricity distributors and road
owners. The interaction between them starts with the transport buyer hiring a carrier. In order to use ERS, the carrier requires a vehicle adapted to the electrified road, provided by the vehicle manufacturer, and an electrified road provided by the ERS operator. The ERS operator supplies electricity to the vehicle and acts as the interface to the electricity distributor and electricity supplier.

Overall costs
The costs associated with the introduction and operation of ERS are still uncertain as the technology is relatively new and is yet to be tested at a larger scale. However, expansion of ERS will drive investment in both ERS infrastructure and in power grid infrastructure. Furthermore, carriers need to invest in ERS-adapted vehicles (i.e. installing a current collector or pickup arm to connect the vehicles to the road infrastructure) and pay a fee for using the ERS.

The infrastructure investment ranges from 9 to 35 MSEK/km, depending on the type of ERS technology used. The costs of expanding the power grid ranges from 4 to 8 MSEK/km, depending on geographical factors, as well as the number of electrical substations required and capacity requirements. The costs for supplying the vehicles with current collectors or pickup arms are estimated at 0.5 to 0.8 MSEK/vehicle, and the costs for electricity consumption and distribution are estimated at 0.7-1.6 SEK/driven km.

Payment model and pricing
The payment model for ERS needs to manage payments for using the power transfer technology, electricity consumption and distribution, as well as the vehicle and pickup arms. At varying levels, possible payment models for ERS will be affected by laws and regulations. An example is Directive 1999/62/EC, which regulates charges for certain infrastructures.

A possible payment model for ERS is that the carrier pays a fee to the ERS operator for using the system, and that the ERS operator on the back-end pays the electricity distributor and supplier. Payments for vehicles and pickups are assumed to be managed as separate transactions from ERS.

Regulated pricing or unregulated prices are both options for the use of ERS-systems. The market price, however, is assumed to not exceed the effective price per kilometer using alternative fuels.

Business model building blocks
Based on the overall scope of ERS, four business model building blocks have been developed that combine physical components and services into commercially viable value propositions. The four building blocks are:

- **Building block 1: Power grid expansion** – connection point for the electrified road and the power grid alongside the road
- **Building block 2: ERS infrastructure** – power transfer technology
- **Building block 3: ERS vehicle** – vehicle, pick-up and utilization measurement system
- **Building block 4: Reading and payment system** – systems for measuring usage, payment service, information management and access control

These building blocks can be seen as the first step towards an ERS business model and may come to be combined or in any way altered prior to an actual implementation.

Financing
The introduction of electrified roads requires extensive investment and may not necessarily be an exclusive public sector responsibility. The public sector has traditionally been responsible for providing road infrastructure while fuel has been provided by private actors. ERS is a system that combines both elements and therefore no natural actor exists to take responsibility for the solution
as a whole. Private investors have shown interest in ERS implementation and consider traffic volume to be of utmost importance for the business case. At an early stage, some form of government guarantees or subsidies are probably needed, for example volume guarantees for the ERS operator, or subsidies for purchasing ERS vehicles. In Germany, the state has recently introduced a 40 000 EUR subsidy for purchasing electricity or fuel cell driven trucks.

A private financing component can be appropriate for the parts of ERS that are subject to governmental involvement. Private financing should primarily be regarded as a way to allocate risks and the often higher cost of capital compared to government financing as a risk premium the government may assume in order to reduce the eventual cost of the projects.

**Concession or public procurement**

Of the four business model building blocks, ERS infrastructure appears the most likely for governmental responsibility through the Swedish Transport Administration. Both concession and public procurement can be appropriate to acquire a pilot project while a concession model might be most suitable for a large scale expansion. In general, procurement procedures suitable for a higher level of uncertainty should be applicable for procuring ERS infrastructure. However, this will need to be more thoroughly analyzed in a pre-study prior to procurement. In addition, innovative procurement is found to be relevant for ERS infrastructure as further development and innovation, especially during a pilot phase, is important going forward.

**Recommendations for further work**

During this study, a number of areas have been identified where future research and investigations are needed to understand if – and how – the introduction of ERS might be introduced. An in-depth pre-study for the forthcoming pilot is recommended to investigate in greater detail the choice of technology, costs and risks, including financing options and procurement procedures. The pilot is further suggested to be carried out based on the building blocks developed, although the actual strategy needs to be evaluated as part of the pre-study.

Further recommendations for future research are:

- Continue to implement demonstration projects and pilots
- Assess appropriate contractual forms of connection between existing power grids and ERS
- Continue to follow the development of electricity taxes
- Continue to investigate legal aspects related to ERS
- Drive standardization of ERS technologies