User Perspectives on Electric Roads

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ABSTRACT: Electric Road Systems (ERS) is a technology area that has the potential to significantly reduce the fossil fuel dependency in the transport sector. The success of ERS depends on acceptance from potential users and it is thus crucial to study the user perspective prior to a large-scale implementation. There seems to be a general positive opinion regarding electric roads among hauliers and forwarders, but it will be crucial that large goods owners and transport buyers order transports utilizing electric roads. Innovative technology and business models could provide opportunities for actors in the transport sector and influence their ability for competition.

KEY WORDS: Electric Road System, ERS, Electric Vehicles, Dynamic Power Transfer, Sustainable Transport, User Perspective

1. INTRODUCTION

An electric road system (ERS) in which electrical energy is transferred during movement from the road to the vehicle for both propulsion and charging of battery, is a technology area with immense potential for reduced fossil fuel dependency, reduced greenhouse gas emissions, reduced air pollution, and increased energy efficiency in the transport sector. The energy transfer can be achieved through different power transfer technologies from road to vehicle, such as rail, overhead line, and wireless solutions. There are ongoing studies and development projects around the world in order to explore different technologies for energy transfer and different use cases. For example, in Sweden there are several research and innovation activities on ERS, e.g. demonstrations on public roads and studies of technology and business [1, 2, 3, 4].

An operational full-scale ERS will be a system-of-system consisting of power transfer systems, electrified vehicles, logistics system, energy system, as well as systems for safety, control and management. The success of an electric road is dependent on acceptance from users such as goods owners, transport buyers, forwarders and hauliers. The implementation of ERS at national and international levels is likely to be associated with the need to adapt logistic processes, and to develop new business models and standards. It is therefore important to study user perspectives on electric roads before large-scale implementation occurs.

2. ERS TECHNOLOGIES

2.1. Overhead line, rail and wireless solutions

Currently, there are three main concepts for road electrification: overhead conductive lines, conductive rails in the road surface, or wireless solutions. All these concepts have their advantages and disadvantages as further discussed below, and are being developed and marketed by different actors. The concepts are illustrated in Figure 1 and further explained below.

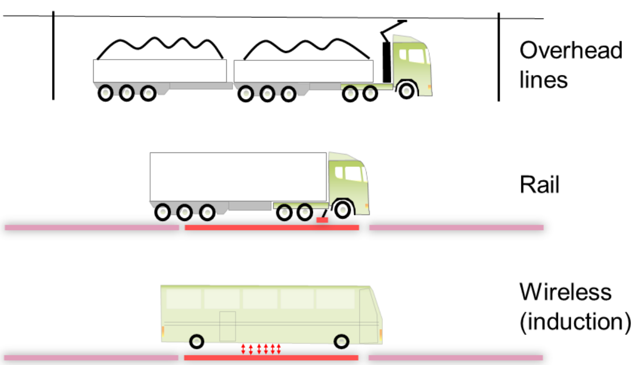

Fig. 1 The three main concepts for road electrification and electric power transfer to moving vehicles.

An overhead line solution uses conductive wire lines (also known as catenaries) above the vehicle to provide the energy. The energy is transferred to the vehicle by means of a collector device (sometimes called pantograph) installed on top of the vehicle, and which follows and detaches automatically from the overhead lines.

A rail solution for conductive energy transfer from roadway to electric vehicles uses conductive rails installed in the road to provide the needed energy. The energy is transferred to the vehicle via a robotic energy pick-up arm installed beneath the vehicle, and which follows and detaches automatically from the rail.

A wireless solution uses a magnetic field to provide the energy. Electric current in primary coils installed in the roadway create magnetic fields which induces current in a secondary coil installed beneath the vehicle.

2.2. Applications

Road electrification can be utilized for several kinds of vehicles and for several applications and use cases, such as:

- Transportation of goods with heavy trucks
- Transportation of goods with light trucks
- Public transport with buses
- Municipal service (e.g. health care)
- Maintenance service (e.g. sanitation)
- Personal transports with cars

Fig. 2 Examples of applications utilizing road electrification by means of a rail solution. Pictures courtesy of Dan Zethraeus.

2.3. Advantages and disadvantages

In recent years there has been several studies and demonstrations of solutions for road electrification, and each one has its own advantages and disadvantages. Although product development has not yet been completed for any solution, it is our opinion that advantages and disadvantages, for future deployed and operational energy transfer technologies, can be anticipated based on results from past and ongoing research.

In general, the overhead line concept provides the most mature technology and system prototype demonstrations have occurred in operational environments by Region Gävleborg in Sweden and South Coast Air Quality Management District in California, USA. But there is not yet any completed product system that has been proven through successful mission operations from end-to-end with high traffic intensity. In case of future deployed overhead line systems that are used in successful operation, we anticipate the following advantages:

- no impact on the roadway surface and interior,
- no dependency on roadway quality,

and the following disadvantages:

- negative impact on the visual impression of the road,
- allocates space over and alongside the road,
- large and heavy collector devices on the vehicles,
- not applicable for all kinds of vehicles.

A few proposed rail solutions have been validated on test tracks and there is at the moment one ongoing demonstration in an operational environment by eRoadArlanda in Sweden. In case of future deployed rail systems that are used in successful operation, we anticipate the following advantages:

- can be used by various kinds of vehicles,
- technology suitable for charging of stationary vehicles with various power needs,

and the following disadvantages:

- exposed rail in the roadway surface (more or less),
- need for maintenance due to dirt, snow and ice.

The wireless solutions are technically advanced and appealing from a user perspective, but they also provide the least mature technologies. More studies and research are needed. In case of future deployed wireless systems that are used in successful operation, we anticipate the following advantages:

- not visible for outside viewers,
- no add-on technology with moveable parts,

and the following disadvantages:

- considerable impact on the roadway during installation,
- limitation of applicable vehicle types,
- generates magnetic field.

The above reasoning about advantages and disadvantages of deployed operational systems assumes that compliance to regular requirements, e.g. on functional safety and maintenance, can be achieved.

The maturity of different technologies in terms of technology readiness levels was discussed in 2016 by Sundelin, Gustavsson and Tongur [1]. The possibility to utilize rail technologies for cars, that are stationary or moving slowly over short distances, has been discussed by Gustavsson, Börjesson, Eriksson and Josefsson [2].

3. METHOD

The development of ERS has been going on for many years in Sweden, and ERS is regarded to be a possible and cost-effective solution for reducing emissions of greenhouse gases from road transports. Although a full-scale deployment still is in the future, widely used electric roads are expected to give important contributions to Sweden’s climate goals, e.g. that by 2030, emissions from domestic transport, excluding domestic aviation, shall be reduced by at least 70 % compared with 2010 [4].

The main question for the present work is the following: What is required for electric roads to be desired and used by actors within the transport sector?

Interviews and workshops have been conducted with different actors within the transport sector: trade organizations and business associations, forwarders (that offers end-to-end logistics), and haulage contractors (also known as hauliers or trucking companies). In addition, the diversity among the haulage contractors needs to be considered: they have various kinds of customers and different kinds of contracts, the hauliers conduct their business with or without their own vehicles (and thus in the latter case depends on individual truck owners), and only one of the interviewed hauliers has experience of using an electric road.

From a technology neutral perspective – i.e. no preference towards overhead line, rail and wireless solutions – the interviews and workshops were based on the following questions:

1. What is required for hauliers and forwarders to use ERS?
2. Can ERS bring competitive advantages for forwarders and hauliers?
3. What is required for transport buyers and goods owners to order transportation utilizing ERS?
4. Can ERS represent competitive advantages for transport buyers and goods owners?
5. Will ERS bring new benefits and opportunities?
6. Is there a need for providers of additional services?

4. FINDINGS

The interviews and workshops with representatives from the Swedish transport sector (as described in the previous section about the method) have resulted in the following findings:

A general positive opinion regarding electric roads has been expressed several times. However, the representatives from the transport sector have in particular emphasized the importance of declaration of intents from large goods owners (e.g. industries) and transport buyers to order transports utilizing electric roads.

The transport sector seems to be willing to pay a fee to use an electric road, provided that it does not eliminate the potential for cost reductions and better margins. The total cost of operations is key and investments in new trucks and add-on power collector devices are subordinate to a considerable extent or even negligible. There is tough competition among forwarders and hauliers, as well as pressure from transport buyers. ERS could therefore provide opportunities to positively influence the situation for forwarders and hauliers that are apt for utilizing innovative technology and business models. Novel kinds of partnerships could also occur with, for example, electricity companies. The willingness among forwarders and hauliers to make investments include new vehicles and add-on technology, but they are unwilling to finance the large-scale investments needed for the ERS infrastructure. This is expected to be financed by other actors such as the government or large business actors.

Hauliers could become the best advocates of ERS and influence individual truck owners that need to prioritize current day-to-day business before strategies. The hauliers also have an influence through the dialogue with their customers, such as major transport buyers and goods owners with sustainability policies.

Actors within the transport sector begin to recognize future opportunities where ERS has a given role. An exciting technology development and large-scale implementation of ERS would greatly affect the transport business. Ideas on new logistics solutions that make benefits of electrical roads and strengthen competitiveness have begun to spire.

An implementation of ERS will affect the business models within the transport sector. The business ecosystem for the transport sector when ERS has been adopted will contain familiar actors, e.g. goods owners (industries), haulage contractors and road operators. But there will also be new actors, especially from the energy sector that will handle power distribution, as well as new roles for existing actors such as road operators and government on local, regional and national levels. The interviews and workshops with representatives from the Swedish transport sector have confirmed this overall view of the future business ecosystem for electric road systems as also illustrated in Figure 3. Similarly, Tongur [3] has analysed the development of ERS from a business models perspective.

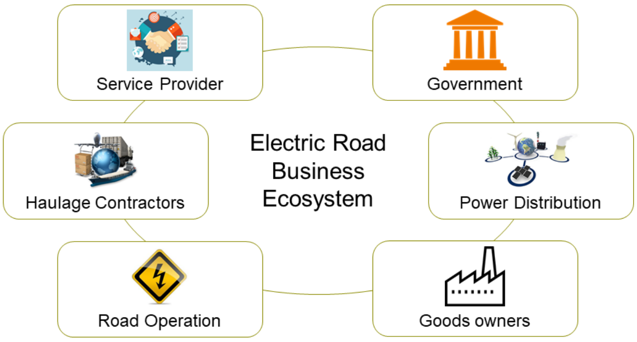

Fig. 3 Business ecosystem for electric road systems with several actors and roles.

Forwarders and hauliers would like to avoid, for natural reasons, intermediaries that reduce the potential for cost savings and better margins. External service providers may be accepted if they add value to the existing actors in the transport sector.

5. OUTLOOK

The future is promising for ERS and applications for cars, buses and trucks. Research and innovation on wireless solutions goes on around the world. Overhead lines have been demonstrated on public roads in Sweden and the USA, and soon also in Germany (i.e. the projects ELISA, FESH and eWayBW). One rail solution is demonstrated on a public road in Sweden. Furthermore, the Swedish Transport Administration has recently issued a precommercial procurement with the intent to use demonstrations on public roads as means to get knowledge about more solutions. Conclusions about nominal cost of different ERS technologies as well as about viable business models are expected to arrive from these demonstrations and associated research.

6. CONCLUSIONS

This study indicates that there is a general positive opinion regarding ERS among hauliers and forwarders. However, it will be crucial that large goods owners and transport buyers order transports utilizing electric roads. Fees for using a future ERS infrastructure must not eliminate the potential for cost reductions and improved margins within the transport sector.

Innovative technology such as ERS and related novel business models could provide opportunities for actors in the transport sector and influence their ability for competition. The willingness among forwarders and hauliers to make investments include new vehicles and add-on technology, but the electric road infrastructure is expected to be financed by other actors.

Hauliers could become the best advocates of ERS and influence individual truck owners. The hauliers also have impact on major transport buyers and goods owners with sustainability policies. This underlines the importance of demand among the customers for sustainable transports.

There might be a need for providers of additional services, but forwarders and hauliers would prefer to avoid intermediaries that reduce the potential for cost savings and better margins.

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