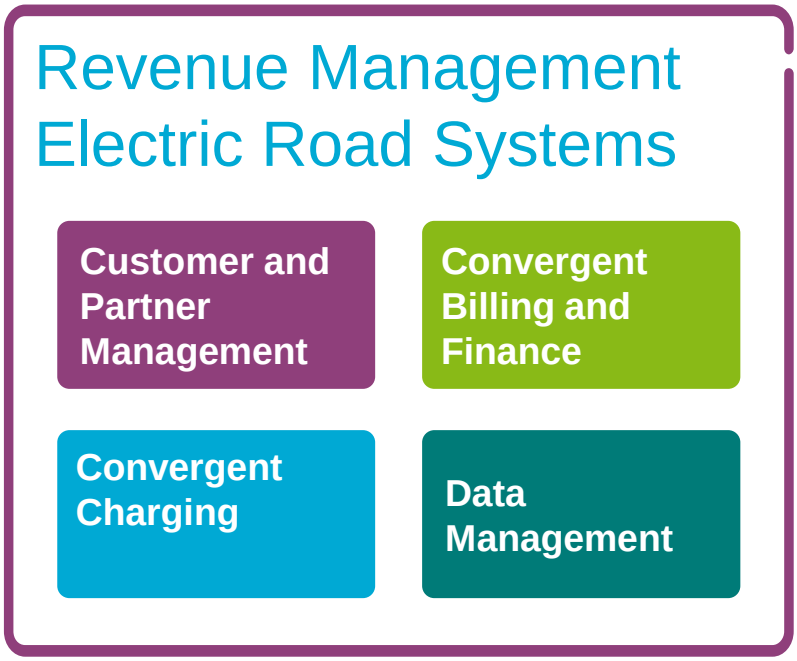
Pre-Study on Revenue Management for Electric Road Systems



Project within Efficient and Connected Transport Systems

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2015-03-27

Content

FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

Electric road systems (ERS) in which electrical energy is transferred during movement from the road to the vehicle for both propulsion and charging of battery, has great potential for reducing dependency on fossil fuels and increased energy efficiency in the transport sector. There are ongoing studies and demonstration projects around the world in order to explore different techniques for energy transfer and different use cases.

Regardless of the choice of technology for the energy transfer, the ERS deployed in commercial operation will need revenue management for billing the use of infrastructure and energy. The revenue management need to handle complex use cases with multiple actors, roles and commercial relationships. In addition, the future revenue management systems should be interoperable and independent of business models in order to flexibly meet the needs of new situations.

Rate of development, competition and especially the need to adapt to different business models has caused revenue management systems in the telecommunications industry to often be configurable to cope with changing commercial situations with multiple actors and roles, which corresponds with what the revenue management for ERS need to handle. Trading of electricity for railway transport affects fewer roles than what is expected to be the case for ERS and its revenue management system is therefore not deemed possible to reuse directly for ERS, but it is highly relevant to note the trend to calculate energy consumption based on distance reading of power consumption. A future system for kilometer tax with differentiated tariffs are likely to have similar information needs as a revenue management for ERS.

An important part of this pre-study is a proposed solution for ERS revenue management developed with inspiration from business support systems from the telecom industry and with the idea that energy calculation shall be based on the distance reading of power meters or sensors in vehicles. The next step would be a feasibility study which includes implementation of a prototype and proof-of-concept demonstration, the following step would be development of a revenue management product to be verified at a test track before deployment. Once the pre-study results go further into a feasibility study, it is important not to exclude any authority or part of the business due to choice of specific technical solution, but instead aim to include all relevant parties.

The pre-study has also studied the privacy aspects and noted that there are several reports dealing with transport informatics and integrity. There are different positions in different countries and a new EU regulation on privacy is underway. The central question is whether ERS revenue management will involve any additional privacy-related risks. This issue should be addressed in the context of a feasibility study and proof-of-concept.

It is also important to develop business models for electric road systems and to consider what should be the role and responsibility of the road operators. A possible solution might be certified service providers who will be responsible for procuring electricity, billing the use of infrastructure and energy, and offering of new innovative services.

2. Background

The electrification of road vehicles is seen by many as a possible solution to reduce environmental emissions, reduce dependence on fossil fuels and increase energy efficiency in transport. Unfortunately, most environmentally friendly energy storage systems, such as batteries, have a lower energy density compared to fossil fuel which has a major impact on the vehicle's range. A large enough battery for long-distance transport is often combined with a substantial increase in cost and weight, and thus imply a reduced potential transport volume.

One option could be to transfer the energy during movement from the road to the vehicle for both propulsion ad battery charging. An expansion of an Electrified Road Systems (ERS), between major urban centers would mean that vehicles for most of the route could run on electricity from the road network and for the remaining part could run on energy from potentially smaller batteries optimized for routes within an urban area.

In principle there are three different types of energy transfer from road to vehicles: conductive transfer from overhead lines where vehicle-mounted pantographs are pressed up against the power lines above the road surface, conductive transfer from the roadway where vehicle-mounted are pantographs pressed against rails in the roadway, and inductive transfer where electric current is induced in vehicles using varying magnetic field from the roadway. Techniques for energy transfer exists from e.g. Alstom, Bombardier, Siemens and Elways.

Future electric road systems will need some form of revenue management for billing the use of infrastructure and energy. How such revenue management shall be designed has not been determined, let alone investigated before this study.

No matter what technology solution for energy transfer chosen for future ERS there will be commercial relationships between different roles such as freight forwarders, trucking, road authorities, electricity distributors and traders. Although a single actor may take care of more than one role, it will likely be a complex situation where multiple actors shall get paid. Since it is presently not known to what extent ERS will be used and which business models that will be used, ERS revenue management shall have an open and scalable architecture that enables interoperability and different business models.

There are lessons to be learned from the telecommunications industry that have revenue management systems which manages the roles of communication, application, content and payment. The telecom industry has also gone from transaction-centric systems to account-centric systems to facilitate operations in real time of complex commercial situations and different business models. A pre-study on ERS revenue management should also draw lessons from existing revenue management for railway transport since this area includes trading of electricity for transport.

ERS opens new needs and opportunities where information and data exchange between vehicles and infrastructure is essential for the usage. Information and data exchange can be viewed as three layers where the first is the basic for the ERS function that currently is covered by energy transfer technology. The second layer is what needs to be added to create data for the revenue management and the third may be traffic information. This means that data on energy, position, time (and thus indirectly also speed) will be connected to the vehicle and possibly to person.

Thus there is a need to study relevant privacy issues concerning revenue management and traffic information for electric road systems. Lessons can probably be drawn from existing systems such as toll roads and congestion pricing.

3. Objective

The purpose of the pilot study was to clarify concepts, identify needs, study privacy issues and draw lessons from existing revenue management.

The overall objective of the pre-study was, in line with the general aim of FIFFI, to improve the conditions for implementation of the revenue management for electric road systems, and create knowledge about privacy issues and existing revenue management for telecommunications, internet services and railway transport.

ERS revenue management is an unexplored area and the idea of the pre-study was, in line with the overall FFI objectives, to increase research and innovation capacity in Sweden and to promote cross-sectoral collaboration between Swedish automotive industry, telecom industry and research institutes.

4. Project realization

A start meeting was conducted 2014-09-02 with the participation of all project partners and project supporters, a detailed project plan was established at this meeting. Agreement on the details of the project agreement was reached 2014-09-05.

The project partners have individually and collectively worked to analyze actors, to draw lessons from existing revenue management and to analyze privacy issues. The project was presented at a seminar for FFI Transport Efficiency 2014-09-11 where the audience showed great interest and asked several questions.

A status meeting with the participation of project partners and project supporters were conducted 2014-12-02, in order to go through the results of the first phase of the study and to plan the second and final phase of the study.

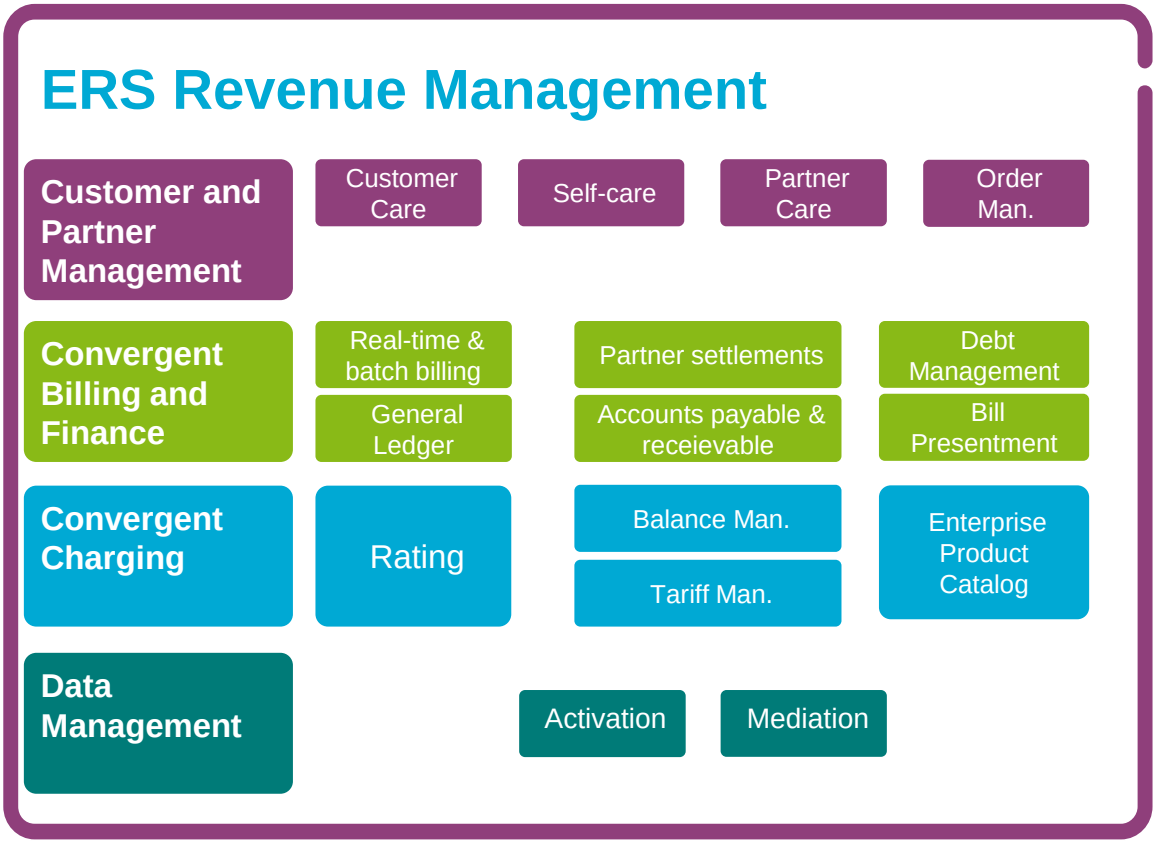
The project partners have individually and collectively worked with conclusions and a solution proposal for revenue management for ERS. The project and preliminary results were presented at the conference 2015-01-08 Transport Forum 2015 during a session on ERS, the audience once again showed great interest and asked several questions.

A closure meeting with the participation of project partners and project supporters were conducted 2014-02-17 in order to examine the pre-study technical report and to discuss a possible continuation project.

5. Results and deliverables

The pre-study has clarified concepts and studied needs by describing the current situation surrounding ERS, as well as actors and roles in road operation, transport of goods, public transport by bus and electric power supply. A specific work package have studied and described privacy issues linked to transport informatics, ERS and revenue management. Lessons are taken from telecommunications, electricity consumption for railway transport, kilometer tax, HCT etc.

An important part of this pre-study is a proposed solution for ERS revenue management developed with inspiration from business support systems from the telecom industry and with the idea that energy calculation shall be based on the distance reading of power meters or sensors in vehicles.



5.1 Delivery to FFI-goals

The proposed solution for ERS revenue management and description of relevant use cases means that the conditions for implementation has increased. This proposal, together with other documented knowledge, mean that the research and innovation capacity has increased. The pre-study has involved cross-industry collaboration between the automotive companies AB Volvo and Scania, the telecom company Ericsson, the Swedish Transport Administration, and the research organizations Viktoria, SP and Energiforsk.

6. Dissemination and publications

6.1 Knowledge and results dissemination

The next step would be a feasibility study which includes implementation of a prototype and proof-of-concept demonstration, the following step would be development of a revenue management product to be verified at a test track before deployment. Once the

pre-study results go further into a feasibility study, it is important not to exclude any authority or part of the business due to choice of specific technical solution, but instead aim to include all relevant parties.

The pre-study has also studied the privacy aspects and noted that there are several reports dealing with transport informatics and integrity. There are different positions in different countries and a new EU regulation on privacy is underway. The central question is whether ERS revenue management will involve any additional privacy-related risks. This issue should be addressed in the context of a feasibility study and proof-of-concept.

It is also important to develop business models for electric road systems and to consider what should be the role and responsibility of the road operators. A possible solution might be certified service providers who will be responsible for procuring electricity, billing the use of infrastructure and energy, and offering of new innovative services.

6.2 Publications

Dissemination of knowledge has i.a. been made by the publication of the technical report on https://www.viktoria.se/projects/ers-billing, and presentation at the conference Transport Forum 2015 during a session on ERS.

7. Conclusions and future research

The completion of the feasibility study that resulted in this report was motivated by:

Electric road systems (ERS) in which electrical energy is transferred during movement from the road to the vehicle for both propulsion and charging of battery, has great potential for reducing dependency on fossil fuels and increased energy efficiency in the transport sector. There are ongoing studies and demonstration projects around the world in order to explore different techniques for energy transfer and different use cases.

Regardless of the choice of technology for the energy transfer, the ERS deployed in commercial operation will need revenue management for billing the use of infrastructure and energy. The revenue management need to handle complex use cases with multiple actors, roles and commercial relationships. In addition, the future revenue management systems should be interoperable and independent of business models in order to flexibly meet the needs of new situations.

The opinion underlying the above reasoning has been strengthened during the pre-study and is still present for a feasibility study with well-defined and committed actors such as

the Swedish Transport Administration and a potential revenue management system provider.

Rate of development, competition and especially the need to adapt to different business models has caused revenue management systems in the telecommunications industry to often be flexible and configurable to cope with changing commercial situations with multiple actors and roles, which corresponds with what the revenue management for ERS need to handle. Trading of electricity for railway transport affects fewer roles than what is expected to be the case for ERS and its revenue management system is therefore not deemed possible to reuse directly for ERS, but it is highly relevant to note the trend to calculate energy consumption based on distance reading of power consumption. A future system for kilometer tax with differentiated tariffs are likely to have similar information needs as a revenue management for ERS.

When designing ERS, it is important to understand and define the various actors in commercial terms in order to ensure that the revenue management will support a variety of possible business models. With clearly defined and committed entities in the ERS structure, there is great opportunity to avoid a situation where different competitors position themselves with proprietary systems, but instead take advantage of a situation where the actors share a given framework. The latter type of competition leads to diversity and encourage innovation.

An important part of this pre-study is a proposed solution for ERS revenue management developed with inspiration from business support systems from the telecom industry and with the idea that energy calculation shall be based on the distance reading of power meters or sensors in vehicles. The next step would be a feasibility study which includes implementation of a prototype and proof-of-concept demonstration, the following step would be development of a revenue management product to be verified at a test track before deployment. Once the pre-study results go further into a feasibility study, it is important not to exclude any authority or part of the business due to choice of specific technical solution, but instead aim to include all relevant parties.

The pre-study has also studied the privacy aspects and noted that there are several reports dealing with transport informatics and integrity. There are different positions in different countries and a new EU regulation on privacy is underway. The central question is whether ERS revenue management will involve any additional privacy-related risks. This issue should be addressed in the context of a feasibility study and proof-of-concept. There is also a need to identify what impact electrification of the major highways will have on future needs and expectations of traffic and operating information through research studies and interviews with the relevant stakeholders. The need for interviews has been limited during the pre-study due to a considerable knowledge among project partners and project supporters.

It is also important to develop business models for electric road systems and to consider what should be the role and responsibility of the road operators. A possible solution might be certified service providers who will be responsible for procuring electricity, billing the use of infrastructure and energy, and offering of new innovative services.

It is also important to develop business models for electric road systems based on experience gained from this pre-study and previous studies on business models. In this context, one should consider what should be the role and responsibility of the road operators. A possible solution might be certified service providers who will be responsible for procuring electricity, billing the use of infrastructure and energy, and offering of new innovative services. With help of the anticipated communication vehicle/road/infrastructure and sensors in the vehicle/road system, added value could be created by third-party developers who access or buy some of the information. It is only the imagination that limits the amount and types of new innovative services.

In summary, it is recommended that this study is followed by:

- Feasibility study of revenue management for electric road systems which includes implementation of a prototype and a proof-of-concept demonstration.
- Work on identified privacy risks in connection with a feasibility study.
- Development of business models for electric road system including consideration of the road operator role, service providers and thoughts on new innovative services.

8. Participating parties and contact person

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