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Revenue Management for Electric Road Systems

Martin G. H. Gustavsson[1], Conny Börjesson[1], and Henrik Kenani Dahlgren[2]

[1]*RISE Research Institutes of Sweden, Lindholmspiren 3A, SE-417 56 Göteborg, Sweden, martin.gustavsson@ri.se*

[2]*Ericsson, Torshamnsgatan 21, SE-164 40 Stockholm, Sweden*

Summary

Electric Road Systems (ERS) is a technology area that has the potential to significantly reduce fossil fuel dependency, reduce greenhouse gas emissions, reduce air pollution, reduce noise in urban environments, and increase energy efficiency in the transport sector. ERS deployed in commercial operation will need to charge for the use of infrastructure, electric energy and potentially other services. An ERS revenue management solution need to handle use cases with multiple actors, roles and commercial relationships. In addition, the future revenue management solutions should be interoperable and independent of business models in order to flexibly meet the needs of new situations for emerging ERS.

Keywords: business model, dynamic charging, electric drive, EV, market development

1 Introduction

An electric road system (ERS) enables transfer of electric power from a road to a moving vehicle for both propulsion and charging of battery. ERS is a technology area with immense potential to reduce fossil fuel dependency, reduce greenhouse gas emissions, reduce air pollution as well as reduce noise in urban environments, while increasing energy efficiency in the transport sector. The power transfer can be achieved through different technologies from road to vehicle, such as rail, overhead line, and wireless solutions. There are several ongoing studies and demonstration projects in Germany. Sweden and around the world with the aim to explore different technologies, business cases and user perspectives [1], [2], [3], [4], [5], [6], [7].

Future electric road systems will need some form of revenue management for billing the use of infrastructure, electric energy and potentially other services. How such revenue management shall be designed has not been determined, let alone investigated before the presented study [8].

No matter what technology solution for energy transfer chosen for future ERS there will be a business ecosystem with several actors as illustrated in Fig. 1, and with commercial relationships between different roles such as goods owners (industries), haulage contractors, road operators, electric power distributors etc. 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.

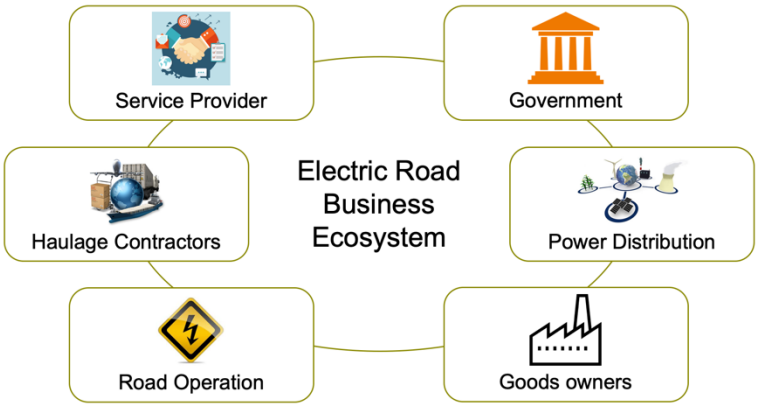

Figure 1: Business ecosystem for electric road systems with several actors and roles.

2 Revenue Management

Rate of development, competition and especially the need to adapt to different business models has caused revenue management systems used by communication service providers to often be flexible and configurable in order 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.

When designing a revenue management system for 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.

The revenue management system is here defined as a system that have access to data sources such as energy metes and that generates invoices to customers. Other systems could of course also generate invoices and pre-processed material could be sent from the revenue management system to large financial systems, but for the sake of simplicity the revenue management system is described as the one sending invoices and sending data to the financial system in order for the ledger to be updated.

2.1 Architecture for ERS

A proposal for a revenue management system architecture to be used for ERS has been 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 architecture is meant to be open, modular, scalable and enable interoperability as well as different business models.

The proposed revenue management system architecture for ERS was described in a previous Swedish report [8] and is illustrated in Fig. 2.

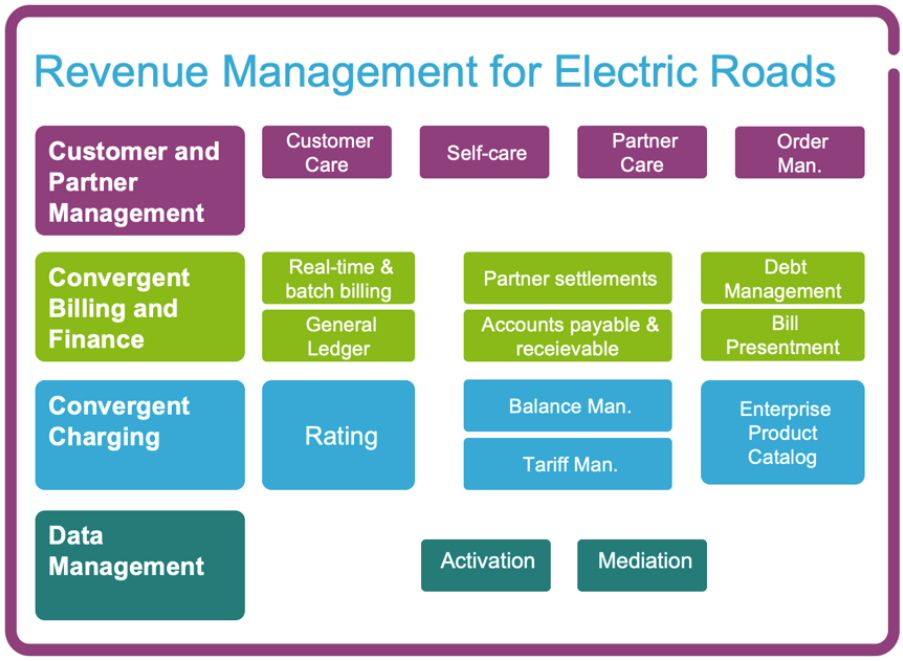

Figure 1: Revenue management system architecture for electric road systems.

The revenue management system consists of four parts:

- Customer and Partner Management
- Convergent Billing and Finance
- Convergent Charging
- Data Management

These four parts each have a number of modules with different functions:

- *Customer Care:* Manages the customer service interface.
- *Self-Care:* Manages the internet portal where the customer can make settings and changes.
- *Partner Care:* Registration and management of partners.
- *Order Management:* Manages all customer orders and the ordering process.
- *Real-Time & Batch Billing:* Generation and updates of invoices.
- *General Ledger:* Maintains the ledger in the financial system.
- *Partner Settlement:* Calculation of partner balance.
- *Accounts Payable and Receivable:* Management of income and outgoing payments.
- *Debt Management:* Retains any debt in the system.
- *Bill Presentment:* The interface that presents invoices and communicates with the printer or third party that sends invoices.
- *Rating:* Sets the price of each record according to the current price list.
- *Balance Management:* Maintains the balance of each customer's account.
- *Tariff Management:* Configuration of price models, discount structures and price levels.
- *Enterprise Product Catalogue:* The complete product register with allowed customers, prices to apply and when a product can be offered etc.
- *Activation:* Communication with the electricity meter and the control system in the energy transfer infrastructure.
- *Mediation:* Responsible for extracting, transforming and normalizing all data sources in and out of the system.

These modules are meant to be integrated with each other and not always possible to remove without affecting the entire system, i.e. the revenue management system will not be fully modularized in order to achieve the best system efficiency.

2.2 Extra functionality

2.2.1 Net charging

The revenue management system could support bi-directional power transfer, i.e. an ERS vehicle that drives downhill can either charge the internal battery or feed electric power from the battery to the grid and get paid for the transferred energy if this is regarded as a profitable option for the given case.

2.2.2 Dynamic prices

Automatic variation of the electricity price based on the network load and historical use within predetermined parameters could be utilized for influencing drivers to take a break when the actual network load is at its highest and the electricity price is thus higher. This has impact on traffic management and traffic control – parameters such as traffic situation and power availability naturally affect when control might be needed. Management of dynamic prices requires communication to the users in order to give them a possibility to make their own decisions.

2.2.3 Different prices

The revenue management system should be prepared to handle a large number of offerings and price plans that can change based on different parameters such as type of vehicle (e.g. car, bus or heavy-duty truck), environmental classification (e.g. proportion of renewable energy in the electricity mix), and electricity grid. It is also possible to use a planned price and direct price, i.e. one price for routes that are planned ahead, and one price for those who have not planned but just started driving on the ERS. This could stimulate freight forwarders to inform about their transports in advance that in turn would make the network load more predictable.

2.3 Information and data exchange

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

3 Conclusions

Regardless of the choice of technology for the energy transfer, 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.

It is important to develop business models for electric road systems and to consider what should be the role and responsibility of the road operators. 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 anticipated communication systems part of the 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.

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 forthcoming research studies and interviews with relevant stakeholders. This work has assumed distance reading of power meters and sensors in vehicles.

There are pre-developed management systems that are able to handle very complex revenue streams. Interviews with several suppliers indicate that it would take approximately six months to configure and deploy a system to be used for ERS and that can be expanded with services as they occur. Future adjustment of the revenue management should be possible by changing the configuration.

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Authors

Martin G. H. Gustavsson has a Ph.D. degree in Physics from Göteborg University since 2001. He has a profound experience of product management and business development from Ericsson. Currently engaged as Senior Researcher at RISE Research Institutes of Sweden and has for several years been involved in research and innovation on electromobility and electric roads systems.

Conny Börjesson holds a B.Sc. in Electrical Engineering and has extensive expertise from automotive industry and Saab Automobile, Volvo Cars and GM. Currently engaged as Senior Researcher at RISE Research Institutes of Sweden and has for several years been involved in standardization and state-of-the-art issues connected to electric road systems.

Henrik Kenani Dahlgren holds a M.Sc. in Informatics from Umeå University with a long background in different Monetization and Revenue Management solutions. Currently engaged as Head of Partnership and Ecosystems for IoT at Ericsson.