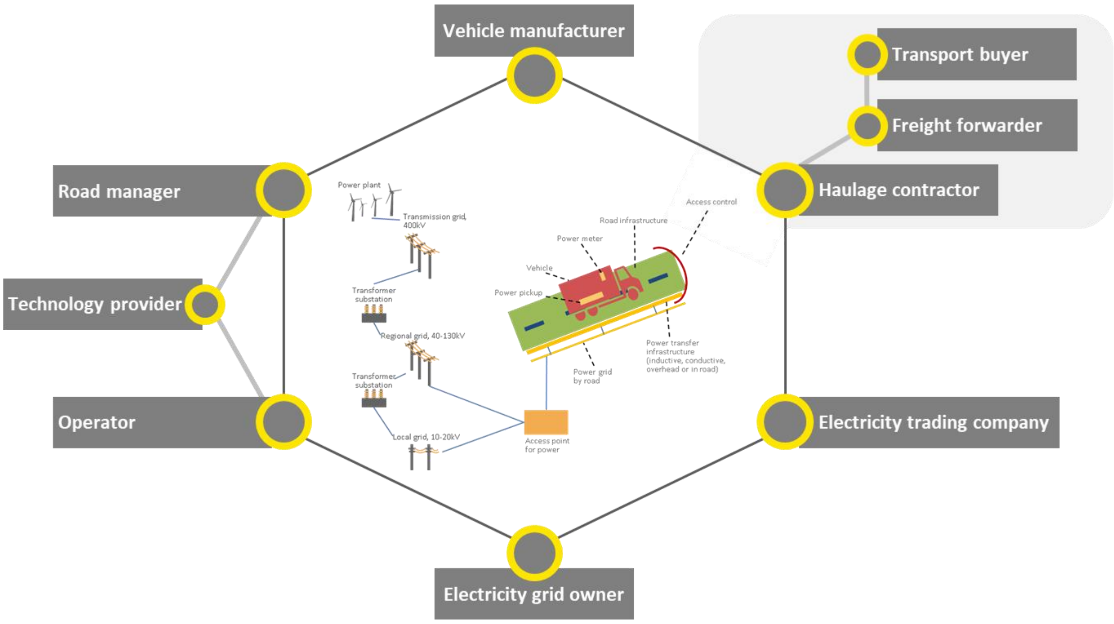
REPORT

Business models for electric road systems

Report phase 3, Operator's role, financial assessments and payment systems

Reports from EY and Governo

September 2019



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This report includes the two latest sub-reports in the Swedish Transport Administration's Electric Roads Programme in the area Business models – financing and organisation.

During 2019, the work has focused on two main areas.

- Firstly, based on previous reports (Phase 1-2) in this sub-project, to deepen the analysis of the electric road system's actors with particular focus on the role as "Operator" of the system that the Swedish Transport Administration considers may evolve. The operator may act as an intermediary between the various actors in the electric road system. Also appended to the analysis is a financial calculation for the profitability of investments for electric roads for the various actors. The calculation model has been made publicly available later during 2019. The work from this part of this report is presented in the sub-report from EY.

- Secondly, an analysis of payments and access control for electric roads. This analysis focuses on the functional requirements that may be set for electric road systems in these respects, with the starting point in the electricity legislation and road legislation. In addition, there is a review of how the payment market is currently developing and how this may affect the conditions for the design of the access control and payments functions. This analysis is presented here in the sub-report by Governo.

The analysis work has been conducted in close cooperation with the client and the project manager Björn Hasselgren. Fredrik Widegren at the Swedish Transport Administration has also participated in the management of the assignment.

The Swedish Transport Administration and the consultants (EY and Governo) have held several joint seminars with a wide participation of actors in the developing electric road market, in order to discuss the issues in this phase of the work on the Business model. The Swedish Transport Administration is grateful for the good and open cooperation with all parties in the collaboration.

The Swedish Transport Administration is publishing the two reports. The Swedish Transport Administration does not necessarily concur with all parts of the analyses and conclusions in the reports. However, they are important documents in the continued work of the Electric Roads Programme.

Stockholm, September 2019,

Björn Hasselgren

Senior Advisor

Sub-project Manager, Electric Roads Programme

Table of Contents

1. The electric road system's actors and financial conditions – report from EY

The electric road system's actors and financial conditions

– An analysis of the operator's role and short and long-term scenarios

2019-09-06

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SUMMARY

Sweden's climate goals state that emissions of greenhouse gases from domestic transport (excluding domestic flights) shall be reduced by 70% by 2030 compared with 2010, and zero net emissions by 2045. To achieve the climate goals, it will require a change in contemporary transport systems in order to promote more eco-efficient transport. Against this background, the Swedish Transport Administration is working on the development of electric roads, primarily for heavy goods vehicles, in order to create greener transport. [1] [2]

During this phase, the project has focused on further examination of the Electric Road System's (ERS) actors and financial conditions. The project was undertaken during February – June 2019 and, among other things, has included four workshop sessions. Based on the project's analyses and hypotheses, the purpose of these sessions was to conduct a dialogue together with the market's actors on the operator's role and financial conditions in the Electric Road System. During the workshop sessions, the purpose of the dialogues has been to offer a platform for discussion rather than a forum for communicating concrete results or policy stances from the project or the Swedish Transport Administration.

The project has been undertaken in close cooperation with the Swedish Transport Administration where Björn Hasselgren has been the client, and is primarily based on the results of these workshop sessions together with supplementary internal investigations. The project's working group, consisting of the Swedish Transport Administration and EY, has accumulated knowledge via documentation previously produced in the Electric Roads Programme, reports from development projects in Sweden and other countries, as well as articles, seminars and conferences.

<u>The electric road system's actors, conditions and financial robustness</u>

The project has analysed financial robustness from a financial perspective for actors that can potentially be included in an electric road system. As a starting point for discussions on the conditions for various actors to achieve financial robustness within the electric road system, an economic calculation model has been developed, based on the existing socio-economic model for electric roads (Electric Road Calculator). The calculation model includes the option to experiment with input values and scenarios for the actors responsible for the investment components required for building an electric road system. In this way, different scenarios with varying input values can be tested and various approaches to organising the market can be investigated. The calculation model has been verified and discussed together with market participants. The calculation model is to be used as a basis for discussion and is used to develop an understanding of financial robustness in the system from a profit-and-loss perspective. However, the model must not be used as grounds for investment decisions.

A development of electric roads in both the short and the long term has been investigated. For the short term, the assumption has been made of a road section of 25 kilometres and traffic equivalent to 150 ADT (annual average daily traffic). For the long term, the assumption has been made of a road section of 2 000 – 3 000 kilometres and an ADT of 1 000 – 1 500. The results show that financial robustness can probably be achieved in the long term, but not in the short term, for the system as a whole. The indication from the calculation is that relatively high traffic volumes are required to finance the investments needed for developing electric roads with fees from the users, in order that the system shall achieve its own financial robustness. These traffic volumes are reasonable to generate as more electric roads become available, which conforms with a more long-term scenario.

An understanding of the driving forces behind the various actors needs to be created, starting out from the need for efforts from both the public and private sectors in the development of an electric road system, which is a basic assumption in the Swedish Transport Administration's analysis of the electric road market. This is to allow the electric road system to be designed and structured in a way that each actor, based on his or her respective conditions, has an incentive to participate, something that can be explored further during a pilot phase. An essential criterion for the bridge between the short and long-term perspectives for the development of electric roads is the management of risk, or rather how risk, uncertainty, resourcefulness and opportunities are divided between the actors involved in the system. In order to manage the uncertainty in the long-term

perspective, the Government and the Swedish Transport Administration can give clear indications about longer-term plans for the development of electric roads and thus provide the electric road system's actors with clearer conditions to adapt accordingly.

The operator's role in the electric road system

An electric road system is assumed to need an actor that is a connecting link between electricity system, road, vehicles and infrastructure. Such an assignment can be held by an operator. The role is not yet defined since the electric road system and associated market are not developed and tested in their entirety. In the work to define an operator's role, three main alternatives for the responsibility areas of an operator have primarily emerged:

- To be responsible for handling all or part of the investment for the construction of the electric road infrastructure.
- To be responsible for measuring, billing and access control for transport on the electric road.
- To be responsible for the operation and maintenance of the electric road.

There may be room for several types of operators, since the areas of responsibility above have different characteristics and are suitable for various types of actors. The construction, operation and maintenance of electric roads represent one type of assignment while measuring, billing and customer interaction is another. Against this background, there are primarily two different types of operator's role: one is as operator for systems for measuring, billing and customer interaction, while the other is as operator of an electric road with regards to construction as well as operation and maintenance.

The starting point for the reasoning around the operator's role is that the operator is driven by financial incentives and must therefore be able to recognise it as an attractive proposition, which will become a key aspect for the ability to adapt the role in the future. However, it is likely that continued financial robustness will vary depending on which areas of responsibility an actor assumes as the three areas involve different amounts of risk-taking.

Recommendations for the next step

1. **The continued work to implement pilot sections should be linked with the work on business models.** By linking the choice of pilot sections with the work on business models for the electric road system, financial consequences in each potential pilot installation can be evaluated in order to create the best possible conditions for the pilot project. In addition, knowledge about the driving forces behind the actors and conditions can be passed on so that the issue of risk reduction and uncertainty can be addressed as early as possible.

2. **The understanding of calculation conditions and financial consequences should be deepened.** For the calculation model and calculations of financial consequences within the electric road system, the proposal is to conduct a more in-depth analysis of the various actors, as well as detailed financial analysis for the business case of each actor in the system. This can be performed either by the Swedish Transport Administration or by the respective actor. In addition, there is a need for a further examination of investment conditions in the electric road system.

3. **The Government should issue undertakings on its long-term intention to develop electric roads.** One way to reduce risk and uncertainty in the market is for the Government and the Swedish Transport Administration to demonstrate long-sightedness by establishing and communicating intentions and plans when it comes to developing electric roads beyond the pilot phase. If a plan is presented that demonstrates good long-term business opportunities that can cover investments with poorer business opportunities in the short term, this can contribute to creating interest in private actors to become involved at an early stage.

4. **In the short term, before the electric road system becomes financially viable, the Government and the Swedish Transport Administration should take a more prominent role than that likely to be required for the long term.**
Since there seems to be a lack of financial incentives (followed initially by low traffic volumes on electric roads and high investments) in the short term, the route towards the long-term scenario needs more comprehensive support from the Government before the system can achieve financial viability.

TABLE OF CONTENTS

1. INTRODUCTION

BACKGROUND

One of Sweden's climate goals is to reduce emissions of greenhouse gases from domestic transport (excluding domestic flights) by 70% by 2030 compared with 2010, and to have zero net emissions by 2045. From 2010, emissions have decreased by 18%, but the current rate of emissions reduction is not sufficient. With current emissions levels as a starting point, emissions will need to continue to decrease by 8% per year up to 2030 in order for the goal to be achieved. [1] [2]

In order to close the gap between the forecasted development, given current emissions and climate goals, change will be required in contemporary transport systems in order to promote more eco-efficient transport [1]. It is a challenge to meet future transport needs at the same time as meeting the climate goals [2]. Against this background, the Swedish Transport Administration is driving work on the development of electric roads, primarily for heavy goods vehicles, in order to create greener transport. The environmental effect will be particularly high if renewable electricity is used as energy source for a future electric road system, which can then be a solution for substantially reducing the emissions of greenhouse gases by the transport sector.

The work of the Swedish Transport Administration to develop and expand electric roads is organised within the Electric Roads Programme. In order to meet the climate policy goals, both for 2030 and 2045 as well as in the longer term, the starting point for the work with electric roads is to investigate both short and long-term solutions and opportunities to develop and expand electric roads in Sweden.

Currently, there are two demonstration sections with conductive technologies for electric roads on public roads in Sweden, one with overhead lines in Sandviken and one with a rail in the roadway at Arlanda. An additional two demonstration sections will be built during 2019–2020, one with conductive technology and one with inductive technology. In addition to the above, the national road map for electric roads [3] includes a goal to implement a pilot project of approximately 20–30 kilometres in order to test the electric road system on a larger scale than permitted by the demonstration sections. The work to choose pilot sections is in progress within the Electric Roads Programme where two sections have been selected: E20, section Hallsberg – Örebro, as well as Route 73, section Nynäshamn – Västerhaninge. [4] [5]

Additionally, the Swedish Transport Administration participates in a research collaboration between Sweden and Germany to address the development of electrified heavy road transport within both Sweden and Germany. The collaboration is also a platform for sharing experiences and knowledge.

A calculation tool in the form of the Electric Road Calculator [6] was developed in autumn 2018 for calculating the socio-economic effects of electric roads. This calculation model has a socio-economic perspective of investments in electric roads. Based primarily on long-term uncertainties surrounding financial robustness for various actors within the electric road system, a need has been identified to build on previous work by also reviewing the system from a financial perspective.

Reports from earlier phases have been drawn up on behalf of the Electric Roads Programme within the sub-project on organisation, financing and business models for electric roads. These have included a survey of the organisation and structuring of the market for future electric road systems, and have examined practical feasible models for how the development of electric roads in Sweden can be initially implemented when it comes to organisation, roles and responsibilities. Potential actors within the electric road system have been defined according to Figure 1.

As a next stage, this project has investigated the role of operator of an electric road system. This role was partially addressed in a previous report where the role was discussed as being of interest for further analysis [7] [8].

The operator's role is one of several roles that can be considered necessary for a functioning electric road system. In addition to the operator, important actors include vehicle manufacturers, haulage contractors, electricity trading companies, electricity grid owners, technology providers and road managers. The operator's role is difficult to define and is a complex role within the electric road system since there is currently no equivalent in the market. This entails that the analysis of the role is a priority.

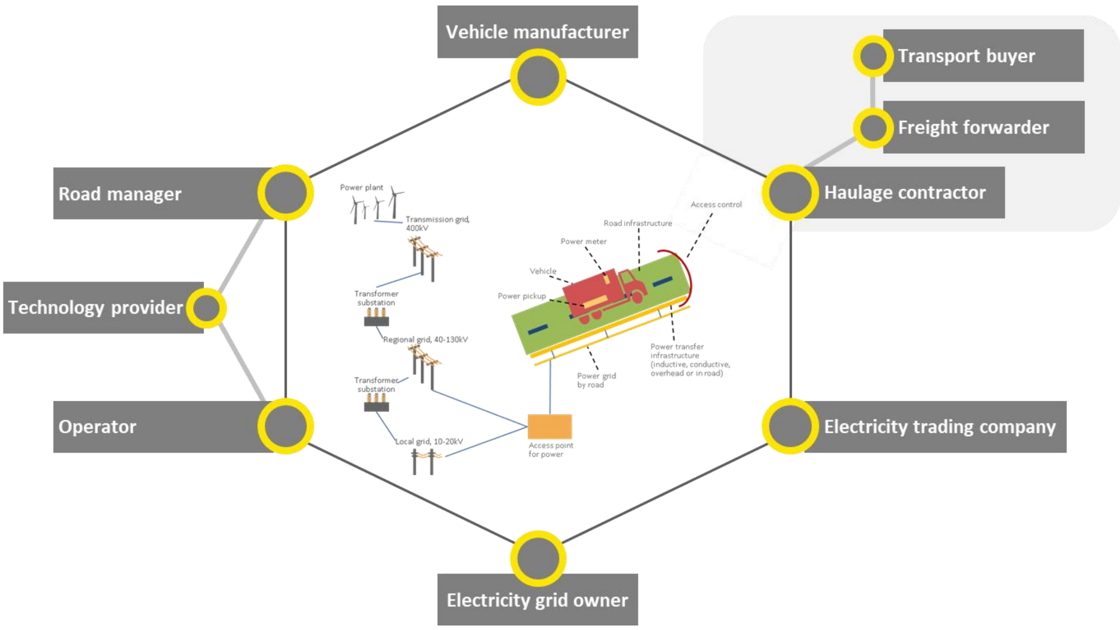

Figure 1: Overall structure of roles in an electric road system

Purpose

During this phase, the project has focused on further examination of the electric road system's actors and financial conditions, including to deepen the analysis of how the operator's role can be defined. With the starting point in the operator's role, the work has been focused on further describing the system from a financial perspective, and against a background of this, an examination has been carried out of the conditions, obstacles and incentives for each actor for the implementation of an electric road system in Sweden in the short and long term.

Method

The project was undertaken during February – June 2019. Four workshops have been held. This report has been drawn up in close cooperation with the Swedish Transport Administration where Björn Hasselgren has been the client.

The project's working group, consisting of the Swedish Transport Administration and EY, has accumulated knowledge via documentation previously produced in the Electric Roads Programme, reports from development projects in Sweden and other countries, as well as articles, workshops and conferences. Based on the project's analyses and hypotheses, the purpose of the workshops were to conduct a dialogue together with the market's actors on the operator's role and the financial calculations that have been developed. Each workshop session has focused on the following areas:

1. Description of the operator's role – *held 11 March 2019*
   The focus of this workshop was to test different hypotheses about the operator's role, which resulted in an analysis of various approaches such as: business model, assignment, interface, responsibilities/activities, additional services, mandates as well as risks and opportunities.
2. Calculation and business case – *held 5 April 2019 and 2 May 2019*
   The aim of this workshop was to objectively test and verify the calculation model developed for

calculating the financial robustness in the electric road system, with the starting point in the earlier work with the Electric Road Calculator.

3. Measuring, billing and access control – *held 3 June 2019 by Governo and reported in a separate report.*

The actors participating in the workshop sessions have been organisations with knowledge about, or interest in, electric roads. The purpose of assembling these various actors for a dialogue has been to create a common perspective of the operator's role among the actors that may be participants in the emerging market for electric roads. It has also been of interest to discuss with these actors the calculation conditions, financial consequences and financial robustness for such a role and for the electric road system as a whole. As mentioned in earlier reports, some of them are potential holders of an operator's role [8].

Market participants involved in the workshops have included:

- Alstom
- Fuel Companies Association
- Electric Road E16
- Eitech
- ElonRoad
- Elways
- Swedish Energy Markets Inspectorate (Ei)
- E.ON
- KTH Royal Institute of Technology
- Mannheimer Swartling
- Nokia
- RISE
- Scania
- Siemens
- Swedish Association of Road Transport Companies
- Swedish Transport Administration
- Swedish Confederation of Transport Enterprises
- Vattenfall
- Volvo
- WSP

Some participants have been involved via Skype while the majority of the actors attended the workshops in person. In addition to the workshop sessions, separate meetings have also been held with some actors in order to obtain a deeper understanding of, for example, input values for the calculation model developed by the project. The project has also verified the results from dialogues during the workshops, reviewed the calculation model as well as reported the status of ongoing work for the Electric Roads Programme.

DELIMITATIONS

The contents of this report are primarily based on dialogues between the project and market participants during the workshop sessions and individual meetings, as well as analyses of these. This means that the results, in particular in terms of the operator's role, will be limited to the qualitative opinions that have emerged from active participants. However, the analysis of financial robustness for the electric road system as an entirety is a more objective analysis in order to form the basis for the calculation model that has been developed.

The dialogues during the workshop sessions have been non-binding, and the purpose of the workshop sessions has been to offer a platform for discussion rather than a forum for communicating concrete results or policy stances from the project or the Swedish Transport Administration. The discussions during these sessions have covered the development of the electric road market in both the short and the long-term. In the longer term, the specific conditions for a more large-scale development beyond a pilot phase are yet unknown, which is why this work is characterised by working hypotheses. Further analyses of the electric road system in general, and the operator's role in particular, can be made using the starting points of this report and the calculation model developed as soon as clearer directives have been issued on which road sections should be electrified and what distance should be covered.

The need for the operator's role and its scope are based on hypotheses from work previously carried out. There are therefore no clear statements or decisions on policies to the effect that this particular type of role should exist in order to achieve a functioning electric road market. This report, and the Swedish Transport Administration in its work, hold a neutral perspective regarding potential holders of an operator's role.

Choice of technology for electric roads is one of the issues investigated using demonstration road sections, internal projects within the Electric Roads Programme, as well as various research initiatives. In the current situation, the Swedish Transport Administration has a neutral position regarding choice of technology, a starting point shared by this project and this report.

Input values in the calculation model are based on qualified estimations, assumptions and facts from various market participants, as well as ongoing projects within the Electric Roads Programme. A next stage needs to clarify and refine, for example, the contents of various investment packages within electric road infrastructure. The calculation model has been developed based on the Swedish Transport Administration's model for socio-economic calculation. Several assumptions verified by market participants and within the Electric Roads Project have been added.

The purpose of the calculation model is to provide a basis for discussion in order to simply and transparently create an understanding of financial robustness for the various actors within the electric road market with the opportunity to experiment with different assumptions. The result from the calculation model is limited to focusing on financial robustness for various actors at system level in an electric road system based on a profit-and-loss perspective and one year at a time. The calculation model does not cover the socio-economic effects of electric roads. Socio-economic limitations can be found in the Swedish Transport Administration's tool, Electric Road Calculator. The calculation model should not form the basis for any investment decisions, rather the model should primarily be seen as a support for general considerations on the future development of the electric road market.

The legal aspects have not been subject to further examination. However, this work takes place within the framework for the Electric Roads Programme, and it is important to consider in future work, as it largely defines the conditions for the system's commercial design and relationships.

Assumptions and starting points - the role of the Swedish Transport Administration

The main function of the Swedish Transport Administration in the development of electric roads in Sweden is to create the framework and conditions for this development. The Swedish Transport Administration has no assignment or responsibility to define commercial relationships within the electric road system. In addition, the role of the Swedish Transport Administration may vary over time. The Swedish Transport Administration has had a leading role in the development and building of a pilot section, given the short time horizon and the considerable uncertainties. It is clear that the Swedish Transport Administration will not have as active a role in a more long-term and large scale roll-out.

A starting point of this investigation is that the Swedish Transport Administration is one of several actors in an electric road system. The Swedish Transport Administration has an obligation of long-term responsibility for components in the roadway, but for where there may be permission for the provision of road furniture within the roadway for electricity transmission, rather than for taking a commercial role as operator or distributor of electricity for the vehicles.

2. THE ELECTRIFICATION ROAD SYSTEM'S ACTORS, CONDITIONS, AND FINANCIAL ROBUSTNESS

The following chapter describes financial robustness from a financial perspective for the actors that can potentially be included in an electric road system. The chapter covers the discussions held with market participants in order to create knowledge of the electric road system, its organisation and maintenance in the short and long term, based on the cost of construction as well as the conditions and possible roles of the actors in such a system.

METHODOLOGY

Within the framework for the Electric Roads Programme, the Swedish Transport Administration has previously developed a socio-economic calculation model, the so-called "Electric Road Calculator". The economic calculation model (hereinafter, the *calculation model*) that this project has developed has been designed based on the Electric Road Calculator. [6] The calculation model has been devised as a margin calculation, in other words the model calculates the changes, in comparison with the "underlying" business for each actor, that an electrification of heavy goods vehicles would involve. For the haulage contractor, it is, for example, the additional investment in the vehicle required by electrification that is calculated (installation of pick-ups on the vehicle, as well as the additional cost for the electrification of the vehicle). Electrified vehicles may also have a service life that is different from diesel vehicles, and maintenance costs that will probably be lower. The calculation model is designed to be simple to use with transparent calculations and a clear logic to follow.

Purpose of the calculation model

The calculation model is a tool designed to create a more in-depth understanding of the financial consequences for various actors in an electric road system, based on a profit-and-loss perspective. The calculation model provides a basis that can help to create an understanding of what different conditions mean for the operator and other actors in the system. Conditions such as traffic volume, the expanded section of road, the cost for infrastructure and technology, as well as an understanding of how the outcome is affected by the distribution of responsibility for investments within different parts of the system. The model is useful as a basis for discussion and to provide an illustration of financial robustness within the system, given various scenarios for expansion, costs, responsibility areas for actors, etc. The calculation model must not be used as a basis for investment decisions or other financial decisions.

Calculation model structure

The calculation model has been developed with a starting point in the investments necessary for an electric road system, as well as related operating and maintenance costs for the infrastructure. The model is based on a number of input values, some of which have a starting point in the socio-economic calculation, Electric Road Calculator [6], while other components have been added specifically for this model where information has been retrieved from previous reports, ongoing investigations within the area, and dialogues with market participants [7] [8] [9] [10] [11]. These input values are adjustable and can be changed by the user based on existing knowledge and the test scenarios desired.

At an overall level, the calculation makes the assumption that it is cheaper for the haulage contractor to drive a certain section powered by electricity than by diesel. The resulting difference when the haulage contractor has paid its alternative costs for transport (electricity and truck adapted for electric roads) can be allocated in the model to cover investments and operating costs that are required in infrastructure, vehicles, etc. See Figure 2.

In this way, the difference will be the revenues, or user fees, in the system. In the calculation alternatives where a surplus remains after all costs have been covered, there is a quantified financial robustness for changing over to electric roads.

The model consists of three main parts: one part with general input values, one part where costs and revenues for each investment area are calculated, and a results part where investments, costs, revenues as well as annual result are reported for all actors. The model's input values are intended to be adjusted when better estimations of these are obtained. The calculation model therefore needs to be updated continuously in line with the progress of ERS development. The input values have been divided into different categories.

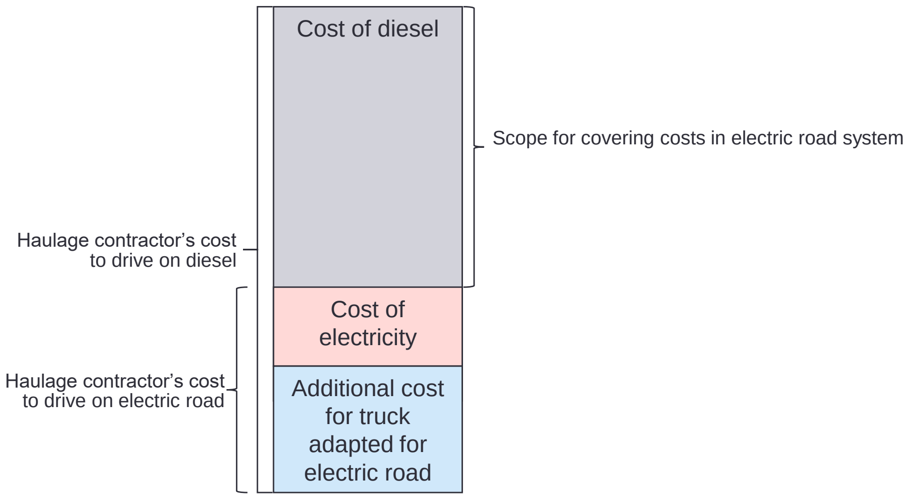

Figure 2. Illustration of how the capacity for financial space for investments and costs in the electric road are calculated

Workshop and acceptance meetings for quality assurance and verification

For the analysis of the financial conditions in the electric road system, the project has held two workshops and several individual dialogues with market participants.

During each workshop, discussions have been held with the starting point in the operator's activities in order to have an overview of the revenues, costs and financial robustness of both operator and other actors. The workshop sessions have also functioned as a platform to establish and create a common perspective of input values for the calculation model, as well as review the logical structure of the calculation and its results. In this way the calculation model has been calibrated based on the accumulated knowledge held by these actors.

The calculation model and its input values were presented during the first workshop session. The participants were then divided into groups in order to experiment with the calculation by testing various investment packages with various responsible actors, based on the discussions that evolved at the previous workshop.

A further workshop session on financial conditions in the electric road system was held in order to review the calculation model more thoroughly and to obtain additional inputs for the different input variables. This session was primarily a further verification of the calculation model.

In addition to these workshops, the calculation model has been verified and calibrated within the Electric Roads Programme. As a supplement, individual dialogues have also been conducted with certain market participants in order to gain a more in-depth understanding of underlying calculations and to reflect over the results for different scenarios. This has allowed the calculation to be developed, refined and quality assured in pace with the accumulation of knowledge.

Delimitations and limitations in the calculation model for financial robustness

The calculation model has certain delimitations and limitations that should be taken into consideration:

- The calculation model has its starting point in a financial profit-and-loss perspective and therefore shows costs, revenues and results for a given year. Consequently, the model does not calculate discounted cash flows over time, cash flows or balance sheet effects.
- The calculation model **cannot and must not** be used as the basis for investment decisions, but should rather be viewed as a tool that can indicate which additional analyses may be interesting to perform.
- The project has taken into consideration whether to maintain the calculation model at a system-wide level, which is why more detailed calculations for each actor and investment component may be required.
- The starting point for the calculation model is not in socio-economic effects. For the socio-economic effects of electric road investment, see the Electric Road Calculator [6].
- The calculation model does not primarily take account of the current legal restrictions that may limit, for example, potential forms of ownership, resource availability and payment options within the roadway.
- The values used for an analysis of investments in the long term should be viewed with caution. Values in the long term are primarily an indication of how the financial robustness can appear. For example, it is likely that more and more knowledge will be accumulated over time, which may mean a changed valuation of these input values.
- The calculation model should be updated continuously to reflect the current level of knowledge at any time.

REVIEW AND APPLICATION OF THE CALCULATION MODEL

This section contains a review of the input values used in the calculation model. For a short-term perspective, the starting point is a pilot section of approximately 25 – 30 kilometres of electric road, and the equivalent distance for the long-term scenario is a more developed electric road system of approximately 2 000 – 3 000 kilometres of electric road. It is important to note that both the short and long-term perspective are hypothetical scenarios. This section describes how the input values for the analysis affect the calculation, how the responsibility areas can be divided between different actors, as well as the results from the model in the short and long term.

Input values for the calculation model

The calculation model is based on different input values that can be adjusted in order to test different scenarios. These input values are divided into different groups according to Figure 3 and are described below.

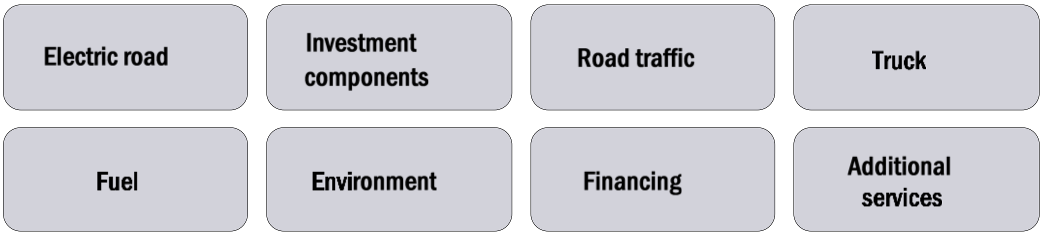

Figure 3. Categories of input values for the calculation model

Electric road

One input value for the calculation model is the length of the electric road. For a scenario with a pilot, the section is assumed to be approximately 25 kilometres long, compared with a developed electric road system of 2 000 – 3 000 kilometres. The section of electric road of 25 kilometres, for example, means a section of road of 50 kilometres if a lane in each direction is electrified. It is also of significance to include how large a proportion of the road is electrified. It is possible, for example, to have 80% of an electric road section electrified and 20% left unelectrified. This can be justified by tunnels or similar in the roadway that make it difficult to electrify, depending on technology chosen, or quite simply to reduce the need for investment in the infrastructure for the electric road. However, it should be noted that if a section is electrified by 80%, it means electric road infrastructure (e.g. overhead lines, rail in the ground or induction components) on 80% of the section. This does not affect the investment in the electricity grid for the electric road, as this is assumed to need to be built along 100% of the section.

This is illustrated in a hypothetical scenario in Figure 4 where the total section between point A and B is 35 kilometres, of these 35 kilometres, 25 kilometres consist of electric road, which is equivalent to 70% of the section. Of the 25 kilometres of electric road, 17 kilometres of the road section include electric road infrastructure, this means that approximately 70% of the electric road is electrified. The calculation model presupposes that the trucks are driven with battery assistance on the part of the electric road section that is not electrified. It is also possible that the sections at the start and end of the road (5 + 5 kilometres) can be driven with battery assistance.

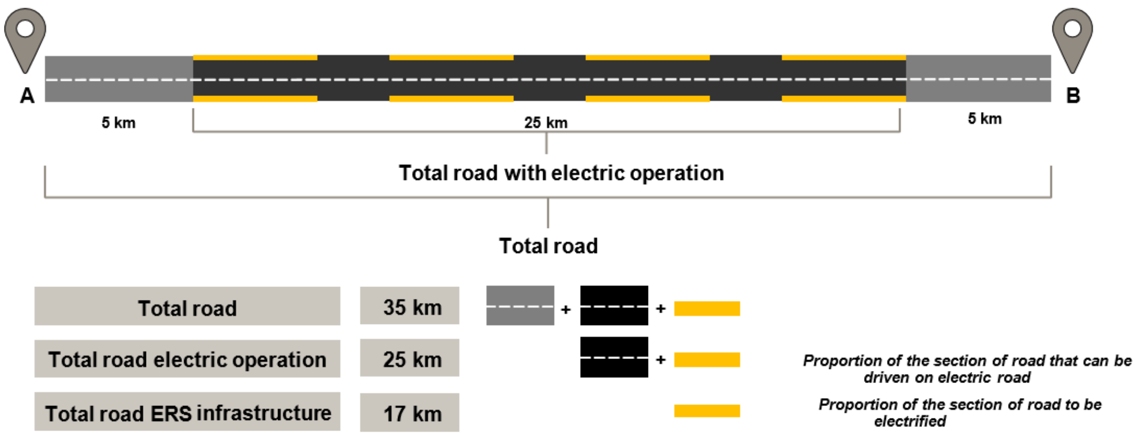

Figure 4. Illustrative example of the dividing up of the section to be electrified and driven on electricity

Investment components
Three main investments have been included in the calculation model:

1. Construction of electricity grid to electric road
    - Includes the construction of the electricity grid and the investments required for connecting the electric road to the existing electricity grid. The responsibility in this investment component includes, and ends with, the rectifiers/transformer substations located along the electric road.
2. Construction of electric road infrastructure and technology
    - Involves investment in electric road technology and associated infrastructure in order to provide the technical conditions to allow electric vehicles to drive on the electric road.
3. Construction of road furniture
    - Includes what is required in addition to electric road infrastructure in order to allow a safe and operationally stable traffic on the roadway, such as building the barriers.

These three categories represent the main investments required to make the electric road system possible. In addition, there will be investments in trucks (described further below) as well as investments in systems for access control, measuring and billing. The overall expenditure for the investment for the three investment components above is estimated to amount to approximately SEK 14 – 31 million per kilometre and depends on which electric road technology shall be built [11] [10]. The uncertainty over investment expenditure is significant, which is partly due to the choice of technology. Different electric road technologies also have different costs for construction and maintenance of the electric road as well as road furniture such as barriers, etc. Another uncertainty is over exactly what is included in each investment package. Defining what is included in the different packages is important so that none of the investments is counted twice or is missed in the calculation.

Since the model shows the results based on a profit-and-loss account, these investment expenditures are included, among other things, as an annual cost given the depreciation period for each investment. It is possible that the depreciation period for electric road technology, for example, will vary in pace with the continued development in the technology, and that the technology risk should be considered as being higher in the short term as there are currently several competing technologies that claim to be standard in the area. Against this background, a reasonable assumption might be that the electric road built early in an expansion phase should be written off over a shorter period in order to take into consideration that another technology might gain recognition and should then be the obvious choice for a more long-term expansion.

In addition to depreciation costs, the cost of operation and maintenance is linked to the size of the investment. The costs for operation and maintenance are specified as a percentage of the investment amount and are estimated to be around 1.5%. Interest costs are also affected by the size of the investment, which is described in more detail below.

In pace with the establishment of a more comprehensive electric road system, at the same time as the technology becomes more mature, it will also be interesting to consider any economies of scale that may result in a price reduction compared with the initial investment for the installation. On the basis of how volume transactions work in other industries, this is not an unreasonable assumption. In relation to the investment volume required by the electric road system, a few percentage points for volume discount can have a major effect on the combined investment expenditure.

Road traffic
Another input value in the calculation model is traffic volume on the electric road, which governs the amount of user fees generated. To calculate these, annual average daily traffic (ADT), among other things, has been used as a parameter. ADT describes the annual average daily flow of traffic in both directions on a section of road or at a single point (actually a cross section) on the road [12]. A high ADT means a larger flow of traffic. In the model, the value of ADT also affects how many trucks need to be in the system. The higher the ADT, the more traffic in the system; the more traffic, the higher the revenues in the form of user fees.

For the calculation, only ADT for heavy goods vehicles (including trucks heavier than 3.5 tonnes with a total weight of 18 tonnes or more) [13] that can be driven on the electric road is calculated. Other traffic that may be driven on the same section is not included. The calculation model is also based on a constant ADT over the whole section. For the short term, during a pilot phase, an ADT of 150 has been adopted. For the longer term, an ADT of 1 000 – 1 500 has been adopted.

Truck
Compared to a diesel truck, certain adaptations will need to be made to the vehicles to be driven on the electric road. The adaptations needed will depend partially on the technology selected for the electric road. The cost of the vehicle adaptation will reasonably be higher in an initial phase when the vehicles must be hand-built outside of the normal production process. In the longer term, in a more developed electric road system, it is likely that the truck technology will be commercialised and competitive, which is expected to reduce the costs. In such a scenario it is also likely that the trucks will not be converted for adaptation to a certain electric road technology, but that models will be available for order that are already adapted to operate on electric roads.

Traffic Analysis has suggested the introduction of an eco-friendly goods vehicle premium intended to cover part of the investment cost for trucks with a total weight of at least 16 tonnes, and that are powered by renewable fuel, in order to create incentives for haulage contractors and vehicle manufacturers to invest in this technology. The eco-friendly goods vehicle premium amounts to approximately 40% of the additional cost for the vehicle compared to the equivalent vehicle powered by diesel. Under certain circumstances, the eco-friendly goods vehicle premium can amount to 60% of the additional cost. It has been proposed that an eco-friendly goods vehicle premium cannot exceed SEK 400 000 per vehicle. These subsidies, even if not yet decided, are included in the model. [14]

The model also takes account of how large a proportion of the truck's total annual mileage takes place on electric roads. In a less developed electric road system, it is likely that a proportion of the vehicle's mileage will be driven outside the electric road. See e.g. Figure 4, where 25 kilometres of the distance is driven on an electric road, and 10 kilometres of the distance is not on an electric road. In a more long-term scenario with longer sections of electric road, it is possible that a higher proportion of the total mileage will be driven on electric roads. In the long-term scenario, approximately 70 – 90% has been assumed to be vehicle kilometres that take place on electric roads. The higher the proportion of the vehicle's mileage driven on electric road, the higher the user fees generated.

Depending on the type of truck that uses the electric road, the number of vehicle kilometres per year may vary, such as if the truck drives in national, regional or local traffic. This parameter has an effect on how much revenue is generated with the starting point that the more vehicle kilometres driven on electric roads, the higher the user fees available to contribute to the system. In the short term, the assumption is for another type of traffic, probably shuttle services given the limitation of the section, than in the long term, where it is possible to build sections that are adapted based more on the conditions of the traffic. During discussions with market participants, the number of vehicle kilometres per year for a heavy goods vehicle varied between 40 000 – 125 000 kilometres on average depending on application area. For this analysis, we have used a value of 100 000 vehicle kilometres per year for all trucks in the system.

The service life of a truck also needs to be included. The service life can vary depending on the type of vehicle (diesel, electric, hybrid) and the type of electric road technology it is prepared for. Since the calculation model views the electric road system at a system level and not for one actor, the service life of the truck has been equated with the depreciation period. However, during its service life, it is likely that the truck will have different owners.

When it comes to the business model for truck manufacturers it is possible that alternative forms may be tested with, for example, leasing of electric trucks to haulage contractors instead of more conventional models where the haulage contractor purchases the truck from the vehicle manufacturer. It also emerged during the workshops that the maintenance costs for electric trucks are believed to be lower than for diesel trucks, something that affects the business for the haulage contractor.

Fuel

In the category for fuel, the cost for diesel or electricity is entered, given the cost per kWh for electricity, and the cost per litre of diesel and the assumed consumption of these. The price of diesel per kilometre is used as the starting point in order to set a user fee ceiling for the use of the electric road, see Figure 2.

As a starting point in the short term, the cost of electricity is SEK 1.13 per kilometre and the cost for diesel is SEK 4.55 per kilometre. In long-term scenarios, it is reasonable to assume both a higher electricity price (SEK per kWh) and a higher diesel price (SEK per litre), partly as a consequence of a higher reduction obligation, which is reflected in the diesel prices that are used in the Electric Road Calculator [6]. It has been assumed in the calculation that haulage contractors currently have the basic options of buying or leasing a diesel truck, and for this reason, the fuel cost per kilometre for these is the ceiling price that electric trucks are compared with. In the longer term, it is possible that haulage contractors have basic options other than diesel trucks, and then other considerations with regard to pricing of transport on electric roads can become relevant.

Environment

The positive environmental effects of developing electric roads is one of the primary driving forces for an electric road system. Even though environmental effects are partially priced into the economy through CO2 taxes, and CO2 effects could therefore be considered as being counted into the current diesel price, the calculation model highlights what reduction in CO2 emissions could result from an introduction of electric roads. As illustrated in Figure 5, there is great potential for a reduction of CO2 emissions with electric roads. In a well-developed system of 3 000 km, the reduction of CO2 emissions is equivalent to approximately 47% of the emissions from heavy goods vehicles over 3.5 tonnes. Such an assessment should also take into consideration how many vehicles are assumed to drive on the electric road, how large a proportion of their total mileage is on the electric road, but also if they are assumed to be powered by electricity or diesel for the section that is driven outside the electric road system. There is also the possibility that operation outside the electric road is powered by battery, or diesel. All operation on the electric road (regardless of whether it is on an electrified section) is assumed to be via electricity, either from the road or from a battery.

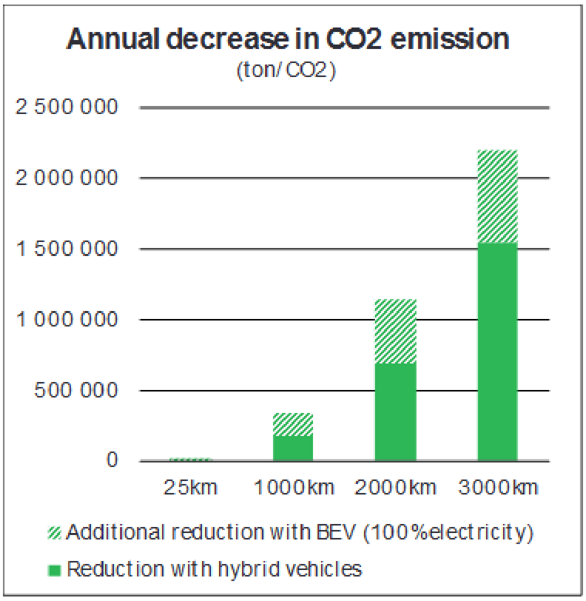

Figure 5. Reduced emissions per year (tonnes CO2) for four different scenarios for development

Financing

It is reasonable to assume that part of the investment in infrastructure, technology and trucks will be financed by loans, which has effects on results. This perspective has therefore been included in the calculation model. The amount for the interest cost is affected by the future interest rate, which is unknown, like many other assumptions in the calculation model. Our assumption is for an interest rate of 3% for investment in infrastructure as well as that approximately 50% of the business is financed by loans. In the calculation, the input of shareholder's equity (the remaining 50%) has not been assigned any return on investment or cost for shareholder's equity, which is naturally a simplification compared with actual conditions. However, such requirements for return on investment may not have any direct consequences for the profit-and-loss account, which is why they have been excluded.

Additional services

The basic product of the electric road system is considered to be transport on electric roads. It is conceivable that other additional services may become necessary in the long term. No additional services have been included in the calculation in the current situation. Additional services is an area that can be further investigated as it is likely that it includes opportunities that an operator can test, given the information collected in connection with measuring, billing and access control.

Distribution of responsibility between actors for different investment components.

The calculation model includes a number of investment components as well as maintenance costs for these. This section describes various ways to allocate these investment components between different actors.

While the project has analysed the operator's role, it has become evident that there are different ways to interpret the main responsibility areas of the operator's role. One of these responsibility areas is investing in electric road infrastructure. Since there are different ways for the actors in the electric road market to be organised, the calculation is designed on the basis that different actors, see Figure 1, can be responsible for investment and/or operation and maintenance for the various investment components.

Table 1 illustrates an example of distribution of responsibility for the various investment components. This feeds back to what is described in Chapter 3 as the operator's role according to Scenario 1, where the operator is responsible for the whole or part of the investment in the electric road infrastructure. This example aims to demonstrate different ways of organising the actors and the investments required.

Investment component	Actor responsible for investment	Actor responsible for operation and maintenance
Electricity grid for electric road	Electricity grid operators	Electricity grid operators
Electric road infrastructure and technology	Operators	Operators
Road furniture	Swedish Transport Administration	Swedish Transport Administration
Vehicle adaptation	Haulage contractors	Haulage contractors
System for measuring and billing	Operators	Operators

Table 1. Example of distribution of responsibility between actors for the various components of the electric road system

For certain actors, the investment components are equivalent to the investments made by the actors today. In the current situation, the electricity grid operators are the actors responsible for investment in, as well as operation and maintenance of, electricity grids. It is therefore likely that the electricity grid operator will hold the responsibility for the investment for building the electricity grid from the existing network to the electric road, this means that the electricity grid operator is the actor that owns the electricity grid. It emerged during dialogues with market participants that it is likely that the electricity grid operator may continue with this role, even in an electric road system. In the same way, the Swedish Transport Administration is already currently working with the construction as well as operation and maintenance of road furniture within the roadway, which is why the Swedish Transport Administration can be seen as a natural actor to be responsible for investment in, as well as operation and maintenance of this area.

The electric road infrastructure in the roadway can be considered as a new business area for the market. In the current situation, there is no given actor responsible for the necessary investments for this part of the electric road installation. There are several potential actors for this, and it is also possible that more than one actor will invest in this area. How the roles are allocated between the actors can be assumed to vary in the short and long terms.

The investments required for the electric road system can, in some cases, mean a new business area, or completely new business model, such as for an operator, for example. It may also mean the same type of business that is already established, such as for an electricity grid operator, where electric roads instead become a new market in which to sell the same type of product as before. There are also certain legal constraints regarding which actor can make which investment. The calculation model takes into account the distribution of roles between actors at system level, but does not define which organisations may be included under the categories of electricity grid operator, operator, vehicle manufacturer and haulage contractor.

Application of the calculation model – consequences in the short and long terms

In the development of electric roads, it is interesting to take into consideration both the short and long-term perspective, and how the financial robustness is affected in these different time perspectives for the various actors as well as for the system as a whole. Different input parameters have been used for both a long and short-term scenario. See Figure 6 below.

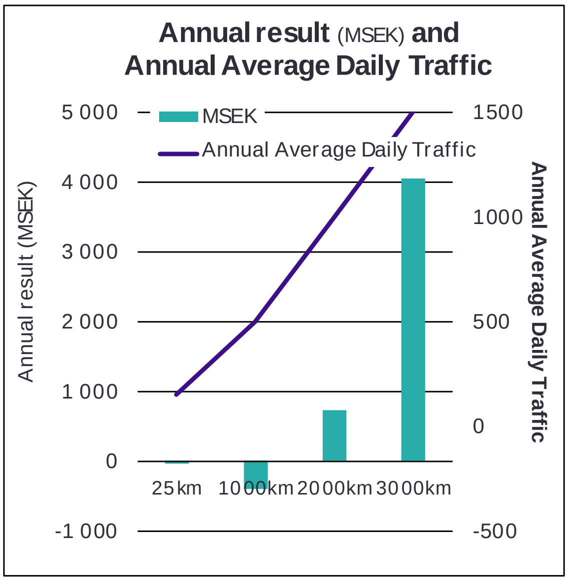

Figure 6. Annual result for an electric road system (MSEK) with different lengths, as well as varying ADT in the short and long term

A short-term perspective can be treated as equivalent to a pilot section, and for these calculations, an ADT of 150 and a section of 25 kilometres have been assumed The result, based on these as well as other parameters, indicates that the investments required will not be covered by the revenues generated by the system, consequently leading to an annual negative result. There is therefore no financial robustness in the electric road system for a pilot section. Given the conditions that an electric road investment should consist of 50% public and 50% private financing, the already limited financial robustness is made more difficult.

In this situation, EY considers that additional measures probably need to be taken in order to create incentives for different actors to enter the electric road business at an early stage, at least if the incentive is to be justified by financially robust commerce. It may be a question of subsidies for vehicle manufacturers or that the Swedish Transport Administration takes responsibility for the majority of investments as well as operation and maintenance. In addition, a conceivable measure would be if the Government could provide guarantees that a certain traffic volume is achieved on the selected section of road, or that co-ownership between Government and actors in the private sector is arranged. Both these forms of risk sharing are complicated to arrange within the framework of the regulations in force for government authorities.

In the longer term, with a higher ADT of approximately 1 000 – 1 500 ADT and a longer section of approximately 2 000 – 3 000 kilometres of electric road, the result appears to be positive. The long-term perspective shows that when there are longer sections of electric road and primarily higher volumes of traffic then financially robust business between the actors within the electric road system is possible, based on the knowledge available today. In the long term, the calculations should be viewed with a certain caution since uncertainty remains surrounding the development of many input values, such as fuel costs and technological developments.

The main difference between the short and long-term perspectives is the assumption of higher volumes of traffic in a more developed scenario. The more users in the system there are, the more revenue per kilometre of electric road will be generated. Since financial robustness is not achieved until there is a more developed system, the purpose of the pilot should primarily be seen as one stage in the long-term development. In addition, this phase represents a learning opportunity where technology, operational activities and business models can be tested, evaluated and developed. It also means that it is not realistic to expect to achieve financial robustness in the pilot phase installations.

To incentivise private sector actors to participate in the long-term development on normal business terms initially requires, according to EY's assessment, a clear undertaking from the Government and the Swedish Transport Administration that a large-scale development of electric roads will be pursued and supported. However, the profitability in these efforts is ensured, as indicated by the calculation.

On the basis of technology risk, there is uncertainty over which technology will become standard in Sweden and in other countries as well, where Germany, among others, is a driving force. There is a risk that standardisation decisions will make selected electric road technology obsolete, while at the same time a clear orientation is required for which standard for electric roads should apply.

Uncertainty remains over which type of technology will be chosen for electric roads in Sweden, and clearer indication of this type of prerequisite can create greater incentive through reduced risk for vehicle manufacturers, for example, to develop pick-ups and for haulage contractors to purchase trucks. It is also likely that uncertainty over maintenance and capacity for difference technologies will be reduced in the long term as technologies are implemented and tested. In addition to this, it is possible that construction costs for electric road infrastructure will be lower as technologies are industrialised and mass produced. This type of economy of scale is included in the calculation model and is expected to have an effect of 2–10% in the longer term. See investment amounts in Figure 7 below.

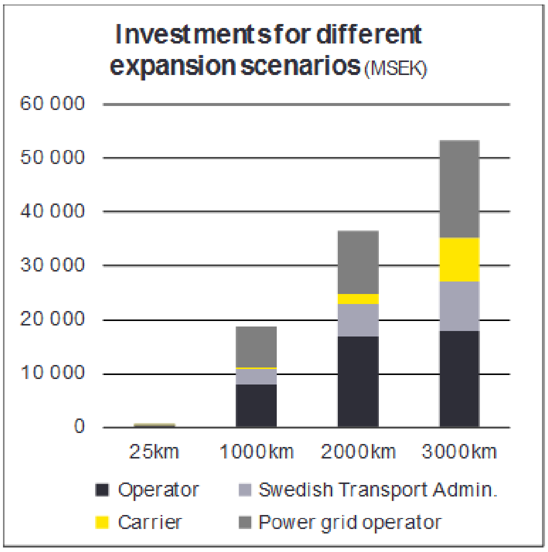

Figure 7. Investment amounts (MSEK) for different development levels (km)

In addition to the technology risks, there is uncertainty surrounding market organisation. As mentioned earlier, there are different investment components that may be taken on by different actors. See Table 1 above for an example. The revenues for the electric road actors, based on user fees and any additional services, should reasonably be divided in accordance with which investments and maintenance costs an actor has. If a large part of the investments, as well as operation and maintenance, is taken on by the operator, an equivalent proportion of the user fees should go to this actor in order to cover these costs.

In the distribution of user fees between actors it is also possible to reason in a way that user fees can be concentrated to certain actors in order to create incentives for these to become a part of the system. In a competitive market, the final distribution between actors will be established in the market and then determined by the competitive conditions. The Government/Swedish Transport Administration can influence the outcome of this process by setting the rules and conditions of the game, as well as by adapting taxes so that the available margins are distributed appropriately between the actors. The Government and the Swedish Transport Administration need to closely follow how the market continues to be established and grows in these respects. In general, the best guarantee for an efficient use of resources in the economy is the establishment of good competition and that transparency is maintained regarding the rules, among other things.

Another risk to consider is the market risk that may, for example, include lower demand than expected or that the payment solution is more complicated and expensive than expected. The consequence of this risk is that the revenues needed to cover the investment and operational costs for the electric road system's actors are not realised. Even if there is positive profitable business in the longer term, it may be difficult for certain actors to justify large initial investments in return for very long-term repayment. This risk can be reduced when the conditions for long-term development become clearer, e.g. through a plan for the development of electric roads in the Swedish Transport Administration's National Transport Plan 2022 – 2033.

Summary

The analysis for financial robustness within the electric road system considers the system as a whole. There is the possibility for the calculation model to experiment with input values and scenarios for an actor responsible for the investment components as described above. In this way, different scenarios with different input values can be tested and various approaches to organising the market can be investigated. The model has been verified and discussed together with market participants and is based on previous experience from the Electric Road Calculator, among other things. The calculation model is a basis for discussion and is used to gain an initial understanding of financial robustness in the system from a profit-and-loss perspective. The analysis can go into more depth and detail in pace with increasing knowledge about e.g. technology choices, costs, etc.

For the short term, the assumption has been made of a road section of 25 kilometres and an ADT (annual average daily traffic) of 150. For the long term, the assumption has been made of a road section of 2 000 – 3 000 kilometres and an ADT of 1 000 – 1 500. The results show that financial robustness can probably be achieved in the long term, but not in the short term, for the system overall. The calculation model includes the requirement for larger volumes of traffic to cover the large investments for developing electric roads. These traffic volumes are reasonable to generate in pace with more electric roads becoming available, which conforms with a more long-term scenario. Therefore, clarification of the conditions in future development plans will be an important part of minimising uncertainty in the market.

3. THE OPERATOR'S ROLE IN THE ELECTRIC ROAD SYSTEM

In the previous section, the description focused on a quantified system perspective with various actors. One of these is the operator's role. The following chapter describes the role of operator in the electric road system in more detail based on the project's hypotheses on the role's possible responsibilities, activities, mandates, etc. As a basis for describing the operator's role, the project has centred on dialogues and workshops.

METHODOLOGY

When it comes to the operator's role, the project has discussed and reasoned around a description of it by developing a number of hypotheses based on experiences from earlier reports and the project's analysis. In a next step, these assumptions were tested during a workshop session together with market participants. Based on the discussions in various groups during the workshop, as well as a joint reflection, the project has learned further lessons and made a qualitative analysis of what an operator's role may involve. The method is illustrated in Figure 8 below.

Figure 8. Method description for description of operator's role

The purpose of the workshop session was to create a common perspective of how the actors that can be active in the emerging market for electric roads view the role of operator. A basic proposal for what an operator's role could involve was drawn up for the workshop and presented to the market participants. The workshop participants then had the task to validate and discuss the operator's role based on the proposals presented with the aim of finding a role description for an operator that is as attractive, interesting and feasible for as many actors as possible.

Knowledge, ideas and insights about the operator's role have been compiled by challenging and discussing the hypotheses that have been proposed. In turn, these inputs have contributed to a more nuanced perspective of how an operator's role can be described.

The analysis of the operator's role is largely based on the preliminary view of the market participants on the operator's role, and should therefore be considered as an indication of how the role could be defined.

THE OPERATOR'S ROLE SEEN FROM DIFFERENT PERSPECTIVES

In order to define and describe the operator's role, eight different perspectives have been analysed. These are reflected in Figure 9. The perspectives are based on the project's analysis of what is important to define for an actor within the electric road system, combined with earlier insights during the previous project phases. The perspectives from which the operator's role is described are as follows: assignment, responsibilities/activities, mandates, additional services, interfaces and business model. The way in which the perspectives are described determines the perception of the opportunities and risks.

Assignment
During earlier work, the hypothesis has been that the operator can be the connecting bridge between road, electricity, vehicle and infrastructure. This role was used as a starting point for the workshop session and was developed further according to the group discussions. Based on these discussions, the operator's assignment has been formulated in accordance with the following:

The operator's assignment is to offer the opportunity for access to secure and green transport on electric roads by means of the physical and/or operative link between road, electricity, vehicles and infrastructure.*

This description of the operator's assignment also leaves space for designing the role in different ways, depending on conditions and incentives.

**Refers to the physical and/or digital security required for using electric roads*

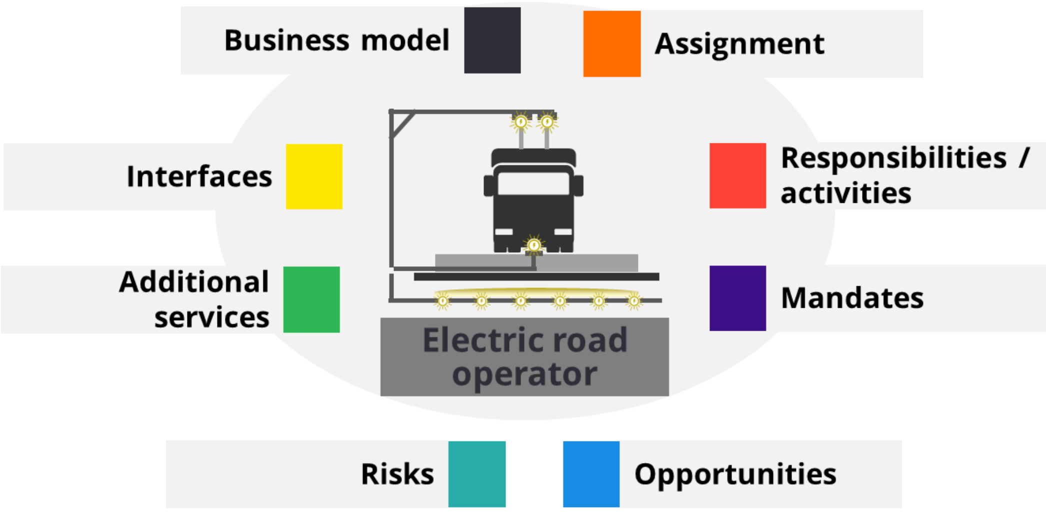

Figure 9. Perspectives that define the operator's role

Responsibilities/activities
The operator's responsibility areas and activities are what largely defines the role. The primary outcome of the workshop session consists of three different ways to consider the operator's main responsibility areas and activities. These three areas will govern the scope of the operator's role as well as how the other perspectives are designed. For example, if an operator has the responsibility of investing in the electric road infrastructure there will naturally be certain risks related to technology choices and volume of traffic. This may also lead to a certain type of business model that may also differ from one for an operator that does not make investments in the electric road infrastructure.

Three main responsibility areas for the operator were defined, based on discussions in the workshop.

1. **To be responsible for all or parts of the investment for developing the electric road infrastructure.**
   Includes investment in the electric road infrastructure (within the roadway), investment for connecting the existing electricity grid with the electric road and investment in the road furniture such as barriers. The investment may include all or parts of these.
2. **To be responsible for measuring, billing and access control for transport on the electric road.**

3. **To be responsible for operation and maintenance**
   Operation and maintenance is defined as activities to ensure that the traffic can flow by means of maintaining the standard of the road with preventive and fault-rectifying maintenance measures, improvements in the standard of the road, keeping the road clean and ensuring accessibility. For the operator, operation and maintenance can only be linked to the electric road infrastructure, but it cannot be ruled out that it can also include other parts of the infrastructure.

The aforementioned responsibility areas can in turn be held by one or by different actors/operators, and the three most likely scenarios are described in more detail below.

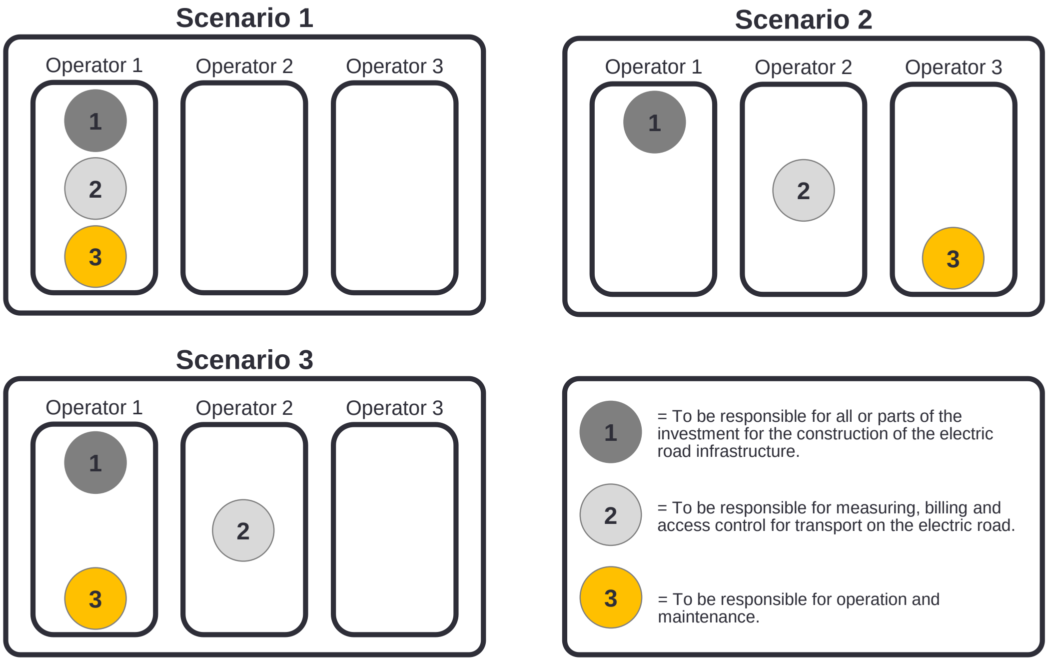

Figure 10. Distribution of the operator's potential responsibility areas

Scenario 1 – An operator is responsible for all three responsibility areas

- In this scenario, the operator's role is most comprehensive. The operator makes an extensive investment in electric road infrastructure. Since the operator is responsible for the investment in infrastructure, it is likely that the operator will also seek responsibility for operation and maintenance. This scenario also includes responsibility areas relating to measuring, billing and access control. The form of implementation, through the use of subcontractors, for example, is a decision for the operator to make.

Scenario 2 - Three different operators are responsible for the three different responsibility areas

- One operator is responsible for all or part of the investment in electric road infrastructure, another for its operation and maintenance, and a third for measuring, billing and access control.
- This way of organising the operator's possible responsibility areas reduces the responsibility for each operator, but at the same time it creates a relatively fragmented distribution of tasks. This may probably be a disadvantage, especially when it comes to the division of investment in electric road infrastructure and operation and maintenance.

Scenario 3 - One operator is responsible for measuring, billing and access control, while another is responsible for investment in electric road infrastructure and its operation and maintenance

- The operator responsible for measuring, billing and access control focuses primarily on transaction-related activities and interfaces in relation to the user. This role is more easily accessible to more actors because the same scope of investment is not required as for the operator that is responsible for the electric road infrastructure. What is primarily required to process measuring, billing and access control is a technical system that supports this. It is possible that this type of operator's role may be held by someone who is currently working on this type of operator service but in another market. Since the investment is primarily considered to be in technical systems, there is also potential for financial robustness here if the electric road infrastructure is scaled up and there will be more users and transactions. Given the lower risk in investment, the expectation for return on investment should be lower compared to the other operator's role.
- The operator's role with a focus on the electric road infrastructure and its operation and maintenance is probably another type of supplier compared to a supplier responsible for the measuring system as above. This operator's role is associated with higher risk in that the investment is likely to be greater, which is why this operator needs to be able to make use of a larger proportion of user fees.

Distributing an operator's possible responsibility areas in accordance with Scenario 3 creates scope for different actors to adopt a position in the electric road system in order to have an interchange of their respective strengths, while at the same time maintaining the interconnection of responsibility areas that are logically connected. Based on the design of the responsibility areas, the conditions for different actors in terms of investment horizons and which activities are advantageously held by same individual actor, Scenario 3 in Figure 10 appears to be the most likely.

Mandates

The operator's mandate should be linked to the assignment as well as to the activities and responsibilities of an operator. For example, if the operator is responsible for ensuring that electricity reaches the electric road in an efficient and safe way, and that the electric road infrastructure remains intact, it is reasonable for the operator to have a mandate to choose the way in which this responsibility area should be designed and handled. There is also a balance between how much risk an operator takes and what mandate this operator should have. Risk and resource availability must be linked.

Additional services

Additional services refer to potential opportunities for additional revenue streams for an operator. Depending on the type of role the operator has, it is conceivable that various additional services can be offered. One possible additional service is to provide processed data on traffic information to, for example, haulage contractors and vehicle manufacturers.

Interfaces

The operator is likely to have different interfaces to various actors. Some actors are likely to become customers of the operator; these actors may include carriers, freight forwarders and haulage contractors. Actors that can be considered as being suppliers to an operator are, for example, electricity grid owners, electricity suppliers, technology providers and telecom companies. This interface is dependent on which responsibility the operator holds. For example, if the operator invests in, and is responsible for, the operation and maintenance of the electric road infrastructure, delimitations for the technology provider for the electric road are a likely interface.

Business model

The operator's main source of revenue is assumed to be user fees, and revenue from potential additional services may also be added. A mandate that is a natural one in a competitive market for a profit-making operator is to determine the price and business model for its activities. There should be a balance between what costs and investments an operator charges and what revenues are allocated to that actor. The balance in the distribution of user fees based on investment is discussed further in Chapter 2.

Opportunities and risks

A number of additional opportunities and risks associated with the operator's role have been identified.

When it comes to opportunities, some of these are related to being a pioneer and to taking market position in a newly established market. Being an operator should also be seen as an opportunity to generate revenues, especially if the operator is a private and profit-making actor. In addition, if the operator's role is performed by an already established actor but which basically conducts business in another area, a role as an operator can be seen as an additional service to current activities and thus a vertical, or horizontal, integration in the value chain.

If the operator's role includes activities such as measuring, billing and access control, there are opportunities to access data from the traffic, which in turn can be combined in different services and packages for haulage contractors or vehicle manufacturers, for example, in order to obtain information.

The electric road is one way to make transport more environmentally friendly and to ensure that the climate goals are met, thereby enabling an electric road operator to develop a profile of promoting more environmentally friendly road transport which can lead to positive reviews as a "green" or "sustainable" actor.

The risks that are relevant to the operator largely depend on what responsibility is held and what activities are performed. Regardless of responsibility areas, the operator's income is assumed to depend on the traffic volume on the electric road system. For an operator with responsibility for investing in electric road infrastructure, there is a predominant risk that the investment in electric road infrastructure will not be repaid for various reasons. The underlying risk for the investment not to be repaid is that traffic volumes fall short of the level required for the return on investment, either in the short or long term. There is also a risk that the electric road technology chosen will become obsolete or require more maintenance than originally estimated.

A further risk lies in competition arising from other operators in the market who can compete for customers and exert downward pressure on prices, thus posing a risk of not achieving profitable business. At the same time, competition can be regarded as positive from a market point of view, and for the system as a whole.

The above risks can be mitigated in various ways, for example through risk premiums in user fees, agreements with vehicle manufacturers and haulage contractors, or government support or guarantees. An important risk mitigation measure from the Government could be to provide a clearer strategic and long-term plan for the development of electric roads with a grounding in transport policy.

POTENTIAL OPERATORS

When it comes to suitable actors who might conceivably hold an operator's role, the starting point is that there are several potential candidates for taking on the role. It is important that there are incentives for an operator to operate in the electric road market. Various actors in the electric road system have been discussed during the work on previous reports where some could possibly take on an operator's role [8] [7]. The financial incentives for the various actors in terms of depreciation period and return on investment may be useful to bear in mind when discussing a possible operator's role. These incentives are illustrated in Figure 11.

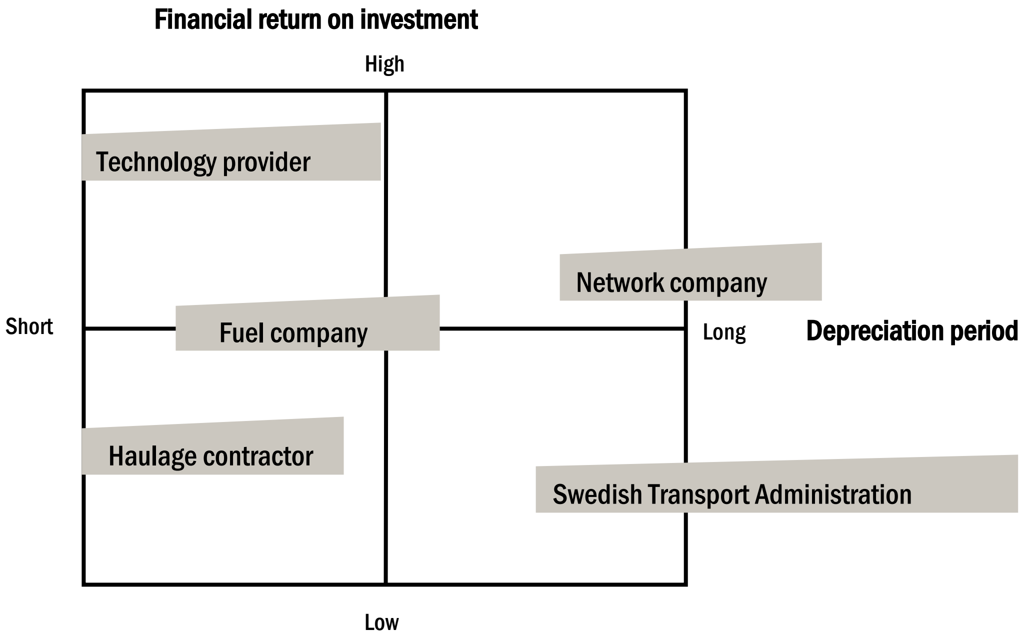

Figure 11. Financial incentives for some of the potential actors in the electric road system

It should be noted that the positioning of the actors in the matrix is based on general assumptions about the incentives and profitability requirements for these actors. Depending on whether an operator has high or low requirements for return on investment in the short or long term, the operator may become suitable for different types of roles in the electric road system. Investment in infrastructure is a capital-intensive venture with a long depreciation period. These conditions may mean that a technology provider with high requirements for return on investment in the short term does not have the same incentive to take the type of investment that Swedish Transport Administration or electricity grid companies may have, for example. At the same time, investments related to measurement and billing systems are of a different nature with shorter depreciation periods and probably higher return on investment in the short term, which may be better suited for actors such as technology providers.

When it comes to the distribution of the various responsibilities, this is something that should be defined by the operator. It is likely that one actor will be responsible for one area, but through contracting, it will use other actors to carry out activities in that responsibility area. The type of implementation an operator chooses (to carry out the activities itself, to use subcontractors and partners, or a mixture of these) will probably be linked to the business model applied.

Once the electric road market has reached a higher level of maturity, it is likely that there will be several operators able to carry out activities within the same responsibility area. In this way, the operator's role can be competitive and held by an actor interested in entering such a market. For example, in a scenario where the operator is responsible for measuring, billing and access control, there may be different actors for different sections of road. It is also possible to have a layout similar to the telecom operator's role, where the user has the opportunity to choose which operator to subscribe to, even if there is only one physical electric road infrastructure.

Prerequisites for the operator's role

One area that influences the design of the operator's role consists of the legal conditions, since both the electricity market and roads are regulated activities. This is an area that is being investigated in a separate project within the Electric Roads Programme. For example, the electricity grid owner's commitment and business opportunities are determined, among other things, by whether the electricity grid for electric roads should be regarded as a concessionary network or not, an issue that is currently being investigated in the Grid Concession Commission [15]. If legal conditions change in the future, in terms of a less regulated market, it will affect the business opportunities for many actors in the system. A starting point for the analysis in this report has been openness to various legal conditions in order to be able to explore possible hypotheses. Potential changes in legal conditions are believed to be imminent and to have an impact in the medium and long term.

The Swedish Transport Administration may also undertake some of the roles described in this section. In some cases, this would require changes to the current regulatory framework, which would then need further investigation.

Summary description of the operator's role

The starting point for the discussion has been that an electric road system needs one or more actors to be the interconnecting link between different interfaces such as electricity, road, vehicles and infrastructure, and that one or more operators can hold such an assignment. This is a role that is not currently defined because the electric road system and its associated market are not developed and tested in their entirety. In the work to define an operator's role, three main alternatives for the responsibility areas of an operator have primarily emerged.

- To be responsible for handling all or part of the investment for the construction of the electric road infrastructure.
- To be responsible for measuring, billing and access control for transport on the electric road.
- To be responsible for the operation and maintenance of the electric road.

Depending on how the operator's role is defined, it may become relevant for a range of actors. Based on conditions such as the design of the responsibility areas, which actors are involved, investment horizons, etc., Scenario 3 in Figure 10 appears the most likely. That is, the electric road system is managed by two operators. One responsible for investment in the electric road infrastructure, as well as operation and maintenance, and one responsible for measuring, billing and access control.

The reasoning over the operator's role here is based on financial incentives to drive the operator. Therefore, the operator must be able to see profitable business in electric road investments, which will be an important aspect in shaping the role or roles in the future.

4. Discussion on conditions for the operator's role and financial consequences for the development of an electric road system

Transport has a significant climate impact and in order to meet Sweden's climate goals by 2030 and 2045, a change is required in the transport system. Electrifying heavy goods vehicles is one way of improving the environmental efficiency of transport. In this project, the prerequisites for the implementation of electric roads for heavy goods vehicles in Sweden were investigated by building upon the previous reports that have been drawn up in the area. This analysis focuses on gaining a deeper understanding of the conceivable role as electric road operator. This has been carried out by describing the scope of such a role and examining the monetary consequences, not only for the operator but also for all actors in the electric road system.

Incentives and driving forces of various actors in an electric road system

Building and holding responsibility for the operation and maintenance of an electric road system is a complex assignment that has elements of both completely new technical aspects as well as proven technology. Building and maintaining electrical installations has been carried out for a long time, and roads are something that the Swedish Transport Administration builds and maintains on an ongoing basis. However, combining these two assignments in order to create the conditions for an electric road is, in essence, a new assignment. In terms of the technical level of maturity and level of innovation, there is a broad range between the different electric road technologies that are emerging, each with its own advantages and disadvantages. In addition, trucks will need to be modified to suit a selected electricity transmission technology and haulage contractors will need to buy or lease these trucks in order to transport goods between various locations on assignment from transport buyers. The trucks that drive on the electric road also need authorisation to use the electric road, and systems for managing access and payments need to be in place.

It is likely that new and old solutions will need to be coordinated in order to create the necessary infrastructure, and that several different actors have important roles to play in order for this to be realised. In addition to the purely infrastructure-related aspects of the electric road, there is also the new role of electric road operator, which in turn can be shared by several actors. Prior to the introduction of an electric road system, there is a need to ensure that all these actors are pulling in the same direction, and that incentives are created for the actors to want to be involved in the development of an electric road system.

On the basis that efforts from both the public and private sectors are required, which is a basic assumption in the Swedish Transport Administration's analysis of the electric road market, an understanding of what it is that drives the various actors must be created in order to be able to design and structure the electric road system in a way that allows an actor to find incentives to participate based on its own circumstances. Further exploration of this could be appropriate during a pilot phase.

For actors in the public sector, EY sees above all two basic driving forces: the Government's environmental goals and the efficient use of fiscal resources. That is, the Swedish Transport Administration works to reduce CO2 emissions and in its pursuit of this goal, the Swedish Transport Administration has a number of different alternatives and tools that can help meet these goals. Building electric road systems is one such tool and this should be balanced against other tools for meeting the same goal. EY's assessment is that the Government needs to evaluate how the fiscal resources can be used most effectively in order to meet these goals and give clear indications to the market about future plans.

Another goal the Government could have in this context is to safeguard Swedish industry and reputation as an innovative nation. Being early, or even first, with new technology is challenging and can entail more risks and uncertainties, but it can also have its advantages in being able to participate and create demand in a market. If the thesis is that electric road systems will be a global solution, in addition to environmental goals, it could be in the Swedish Government's interest to create the conditions for Swedish industry to gain competitive advantages in such an emerging market. In addition to this will also be the question of reputation, where Sweden as a country can gain a positive status by being considered to be at the leading edge of developments in technology and the environment.

When it comes to the interests and driving forces of the private actors, EY's view is that there basically needs to be financial incentives. The actors identified for the electric road market (Figure 1) are assumed to have different financial and monetary incentives, as previously described in Figure 11. Based on the incentives and driving forces of the actors, and seen from the perspective of depreciation period and return on investment, it is likely that the private actors will have differing views of risk as well as return on investment based on size and long-term perspective. This is something that has been further investigated in the calculation model at system level, but which requires deeper analysis to understand each actor's business in more detail.

In addition, it appears that environmentally responsible behaviour can be seen as a basic criterion of success in markets for private actors. Based on this reasoning, it is possible that an actor with a profit interest may conceivably incur a cost in the short term in order to win climate-adapted and financially favourable business in the long term. However, a high degree of environmental adaptation is more to be considered as a necessary prerequisite for private actors to be able to successfully act in competitive markets, for which it can be difficult to attract additional revenue.

With this as a starting point, the electric road system for private actors needs to be able to combine both an interest in environmental effects as well as an interest in conducting good business**.** When the project has analysed the prerequisites for the electric road system based on a profit-and-loss calculation perspective, two conclusions can be drawn:

(1) the electric road system appears to be financially unprofitable in the short term, and

(2) the electric road system appears to be capable of providing long-term financial robustness, but this will need to be followed up with substantial investments.

The primary reason for why there is financial robustness in a more developed scenario is that the calculation model assumes a higher diesel price (which creates a basis for more revenue to the system), a reduced need for investment per kilometre of electric road construction (due to economies of scale and technology maturity), lower cost of trucks adapted for electric roads (due to technology maturity and demand) as well as more trucks (and truck kilometres) in the system (as a result of the system being a longer distance and business opportunities being recognised in obtaining trucks adapted for electric roads, which have also become cheaper), as well as that each truck is assumed to be able to drive a higher proportion of its annual mileage on electric roads).

There is therefore a need to define how to move from where we are today to the long-term scenario of a business with positive financial consequences and implications for different business models for each actor and for the system as a whole. With the starting point of discussions with haulage contractors, one way to achieve this could be to collect applications of interest/orders with the proviso of adapted trucks that provide truck manufacturers the opportunity to assess the short-term volume. This approach can allow vehicle manufacturers the opportunity to estimate a final price for such a vehicle. The number of applications will allow traffic volumes to be clarified, which will reduce uncertainty about the short-term inflow of user fees into the system. From that starting point it will then be easier to discuss the remaining risks and what will be needed to manage them.

An essential criterion for the bridge between the short and long-term perspectives for the development of electric roads is the management of risk, or rather how risk, uncertainty, resourcefulness and opportunities are divided between the actors in the system. The lowest level of risk-taking in which there are still participants contributing to the system is the case where an actor sells its products or services as a subcontractor, without taking into account the overall financial robustness of the system. For example, it could be a question of a vehicle manufacturer who receives payment to convert a truck to be compatible with the electric road based on what it costs to manufacture it, or a question of an electricity grid operator who routes the necessary electricity to the electric road and receives payment in the short term for what it costs.

Although the short-term perspective of pilot installations does not appear to provide financial robustness for the entire system, there are still lessons to be learned for the long-term perspective. To deal with the uncertainty in the long-term perspective, the Government and Swedish Transport Administration can give clear indications of the long-term development plans for the electric road. As a result, the various actors in the system can be given clearer conditions for adapting to an expansion.

EY's assessment is that it would be advantageous if all parties with a role to play in the electric road system take part in the system under the same conditions, so that joint responsibility is taken for the architecture, risks and opportunities of the system. Developing the system based on that premise can add complexity, but it also brings benefits in commitment and long-sightedness. Such a market structure means that every actor has an incentive to create financial robustness in the system as a whole, but also to ensure the profitability of its own venture. In such a line of thought, it is reasonable to assume that extensive investments entail a high risk, which is why an actor adopting such a role should also reasonably receive a higher share of the revenues in the system generated by user fees. This is likely to be primarily a question of the actor(s) responsible for building the electric road infrastructure and the electricity grid for the electric road.

In summary, it is a prerequisite to be aware of risk levels and to be able to understand what roles the various actors can take in the long term in the system. It is important to deal with the fact that user fees simply do not appear to be sufficient to generate a positive result in the short term for all of the system's profit-driven actors. One way of dealing with this situation could be that the Government and the Swedish Transport Administration initially take a more extensive role in order to make up for the initially unprofitable business in order to reduce the risk and uncertainty for private actors to enter the market.

THE ROLE OF ELECTRIC ROAD OPERATOR

A key role in the electric road system is the role of operator under discussion. The operator's assignment has been discussed within the project and with market participants during workshops in terms of the following:

"To offer the opportunity for access to secure and green transport on electric roads by means of the physical and/or operative link between road, electricity, vehicles and infrastructure."

During this phase, EY has worked based on the hypothesis that the operator's role can be held by one or more different actors, who together constitute the framework needed to finance the system. Within a range of conceivable scenarios, we have presented the following possible responsibility areas for the operator:

- To be responsible for handling all or part of the investment for the construction of the electric road infrastructure.
- To be responsible for billing, measuring consumption, and customer interaction for transport on the electric road.
- To be responsible for the operation and maintenance of the electric road.

One reason why EY considers that several types of operators may come to be required is that the activities above vary in nature, with different suitability for different types of actors. The construction, operation and maintenance of electric roads represent one type of assignment while measuring, billing and customer interaction is another. In addition, the latter will probably also include a common system that can handle these assignments and, in addition, a technology provider can become a subcontractor to one of the operator roles, alternatively a separate type of operator. We assess that against this background there are primarily two different types of operator's role: one is as operator for systems for measuring, billing and customer interaction, while the other is as operator of an electric road with regard to construction as well as operation and maintenance.

The operators who will work in the system are likely to find it difficult to generate a profitable business in the short term (i.e. during a pilot phase). One way to reduce the lack of profitability in the short term can be to simplify systems and measurement to an absolute minimum in order to hold costs down. If this is possible, it is necessary to further investigate what can be simplified and what can be gained from it. In the same way, it is of great importance to clarify the distribution of responsibility, mandate and resource availability for the actors who will be operators. The initial development during a pilot phase is a good platform for testing different organisations of one or more operator roles.

5. Recommendations for the next step

Based on the analysis of the operator's role and financial robustness in the electric road system that has been carried out, EY wishes to make four recommendations for further analysis as a next step.

Recommendations regarding the next step based on the project's work:

1. **The continued work on the choice of pilot sections should be linked to the work on business models.**
   By establishing a link between the choice of pilot sections and the work with business models for the electric road system, the financial consequences in each pilot installation can be evaluated in order to create the optimal conditions for the pilot project. In addition, and perhaps more importantly, knowledge of the driving forces and conditions for the various actors can be transferred to future planning so that the issue of reducing risk and uncertainty can be dealt with as soon as possible.

2. **The understanding of calculation conditions and monetary consequences should be deepened.**
   For the calculation model and calculations of financial consequences within the electric road system, the proposal is to conduct a more in-depth analysis of the various actors, as well as detailed financial analysis of each actor in the system. This can be performed either by the Swedish Transport Administration or by the respective actor. In addition, there is a need for a further examination of the investment conditions in the electric road system. For example, the cost of shareholder's equity, cash flow analysis, repayment period, robustness and consequences for the financial market, etc., have not been covered by this analysis. Such a financial analysis should form the basis for investment decisions.

Recommendations for creating increased momentum in the development of the electric road:

3. **The Government should issue undertakings on its long-term intention to develop electric roads.**
   One way to demonstrate long-sightedness in order to reduce risk and uncertainty in the market is for the Government and the Swedish Transport Administration to establish and communicate their intentions and plans when it comes to developing electric roads beyond the pilot phase. If a plan is presented that demonstrates good long-term business opportunities that can make up for investments with poorer business opportunities in the short term, this can contribute to creating interest in private actors to become involved. The clarification of a more defined plan from the Swedish Transport Administration for the development of electric roads is proposed in the future national plans for 2022-2033 in order to give the market a clearer forecast of future plans. The dialogue with stakeholders within the electric road system should continue to focus on how an expansion of electric roads should take place in the long term while discussing issues such as the obstacles faced and what can be done to overcome them.

4. **In the short term, before the electric road system becomes financially viable, the Government and the Swedish Transport Administration should take a more prominent role than that likely to be required for the long term.**
   Since there seems to be a lack of financial incentives (followed initially by low traffic volumes on electric roads and high investments) in the short term, the route towards the long-term scenario needs more comprehensive support from the Government before the system can achieve financial robustness. The transition can take different

forms, such as by means of the Government providing guarantees or otherwise to cover the unprofitable business of the private actors in the short term.

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2. Payment and access control for electric roads - report from Governo

Payment and access control for electric roads

Overall system description and analysis

2019-08-29
Thomas Wästfelt & Jon Jakobsson

Table of Contents

Summary

The purpose of this report is to provide an overall description of the system for payments and access control for electric road systems (access control, payments and information management). In line with other work within the Electric Roads Programme, the report has a focus on a long-term large-scale solution, but also on the pilot project that is planned to start operation in 2021.

The inquiry has been conducted with the support of interviews and discussion meetings with actors within different parts of the system. These actors can be drawn from the areas of payment, information management, access control, fuel delivery and electricity companies. Discussions have also been conducted with representatives from the Swedish Transport Administration and other key actors.

The development of electric roads is a long-term undertaking, carried out in a rapidly changing environment. New access solutions, payment solutions and new ways of using information are being established at a fast pace. The inquiry has taken this rapid development into account, while at the same time it has used the current legislation as a starting point. However, this may also be affected in the long term.

The inquiry proposes a common and highly automated and digitalised platform, with a large element of information sharing with regard to access, energy measurement, clearing and payment. An interest to participate in the development on a commercial basis can be identified among major international commercial actors, and the actors have displayed flexibility in terms of what roles they are prepared to take in a future venture.

There are a number of different pricing models that may be relevant for electric roads. Governo's assessment is that it would be prudent to consider the possibility of simplifying pricing for the service early on in the establishment of electric road solutions, although there are also short-term challenges to this in the form of electricity legislation and the special conditions for electricity consumption.

Different approaches are available in order to utilise the extensive knowledge and experience in the area held by commercial actors. One conceivable approach is to establish cooperation with actors in the private sector, or that they take on roles spontaneously within the framework of guidelines drawn up by the Swedish Transport Administration. Governo considers that an alternative to this could be to initiate a process for detailed procurement in the area. Our assessment is that the actors are prepared to create different types of consortia, where different and strong competencies are combined and cost-effective solutions are created.

1. Introduction

Background

Sweden has a long-term climate goal to have zero net emissions of greenhouse gases by 2045, to then achieve negative emissions thereafter. In order to meet this goal, there is a goal within the area of domestic transport (aviation excluded) to reduce greenhouse gas emissions by 70% from 2010 to 2030. Here, electrification of heavy goods vehicles is one of several options that can contribute to meeting the goal, and on this basis, the Swedish Transport Administration is conducting development work linked to electric roads in Sweden.

Within the framework of the Swedish Transport Administration's Electric Roads Programme, work has continued on investigating business models for electric roads, work that has resulted in two reports[1] describing the system's actors, the relationships between the actors, as well as risk sharing.

Among other things, an important prerequisite for the continued work is to develop an understanding of how to design access control, measurement and billing for individual users of electric road systems. Based on this, Governo has been asked to assist the Swedish Transport Administration and the Electric Roads Programme in the investigation of the issue.

Purpose

The purpose of this investigation is to identify and analyse on an overall level the prerequisites for access control, payment and information management for the electric road system.

The investigation focuses both on a short-term perspective, in the form of the pilot phase that the Swedish Transport Administration has been assigned by the government to carry out, and on a long-term perspective, in the form of a broad development in the longer term.

Implementation

The investigation has mainly been conducted based on working meetings, interviews/discussions and document studies. The discussions have been held with representatives of market participants who are assessed as relevant for the purpose of the study. The actors have been drawn from different types of industries, and have been identified based on a number of actor areas, as well

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[1] See the reports *Business models and financing for the development of electric roads in Sweden* (2018)
and *Roles, actor relationships and risks in the electric road market* (2019).

as constituting the starting point for the analysis work (for more information on these areas and interviews conducted, see Chapter 2).

Consolidation meetings have been held continuously with a working group for the business model project within the Electric Roads Programme, where preliminary conclusions have been quality assured and supplemented with support in a workshop with the Swedish Transport Administration's reference group, which was held on 3 June 2019.

The work as a whole was carried out during the period April-June 2019. The client in the Swedish Transport Administration was Björn Hasselgren.

2. Definitions and starting points

Definitions

Access control

Access control involves identification and gathering information in order to manage a vehicle's access to an electric road. This refers to using the equipment installed in the roadway for the transmission of electricity to the vehicle during travel. Identification can take place in various ways, but probably needs to address issues related to authorisation and payment. Other information may also be relevant when gathering information for access control.

Energy measurement

Measuring energy consumption, in the case of this investigation, in the form of electricity measured via an electricity meter, which measures the electrical flow at a measuring point connected to an electricity grid.

Payment solutions

In this investigation, payment solutions are defined as the systems intended to ensure an automated payment flow between the electric road system's consumers/customers and producers/suppliers.

Information management

This includes the processes and structures used for processing information. In turn, the processes aim to ensure that sensitive information is collected and processed in a secure manner, that the data produced is of good quality, and that the information is used in an appropriate way.

Summary description of potential actors

The data collection and analysis have been based on the work within the Swedish Transport Administration, but also on the work relevant to the market. The hypothesis is that there may be a large number of market participants with different backgrounds with the opportunity to contribute knowledge based on their areas of expertise, as well as to be involved as actors in any expansion of electric roads in Sweden.

The actors currently considered most relevant within the framework for the areas of access, measurement and payment for electric roads can be clustered into a number of groupings. The groups represent areas where actors have the potential to provide support and to contribute to the development of access control, measurement and payment for electric roads, and they have been divided as follows:

- **Actors linked to modern payment solutions.** Banks and other financial actors. The payment market is undergoing rapid change, where new actors are using new technology to challenge the large and established actors. The banks have long experience of commercial collaborations and the creation of common tools.
- **Actors linked to information management.** Large global groups from the IT industry, as well as other actors with a possible interest in seeking commercial values from expanding their business into new areas. With the extensive infrastructure they normally have access to, large amounts of information can be stored and used with high efficiency and at low costs.
- **Actors linked to access control.** There are access solutions already available for urban tolls as well as other specific road tolls, from where experience can be drawn both nationally and internationally.
- **Actors linked to fuel delivery.** Among other things, petrol companies can recognise value in identifying new areas to maintain profitability and growth based on a changing environment (e.g. electrification).
- **Actors linked to electricity companies.** Technological development is advancing rapidly in the area and electricity companies can recognise long-term opportunities to expand their business into new areas (as well as strengthening the brand in the area of sustainability).

Representatives from Swedish Transport Administration (within the Electric Roads Programme, but also within the Swedish Transport Administration's work on Roadmap for a connected and automated road transport system[2]) and actors from all of the groups described above have contributed to the interview work with their own perspectives in order to provide a broad basis.

Interviews and discussion meetings held

Interviews and discussion meetings have been held with representatives from the following organisations:

Modern payment solutions
Bankgirot
Swish

[2] Swedish Transport Administration. *Roadmap for a connected and automated road transport system.* 2019.

Information management

IBM

Tieto

DXC

Microsoft

Access control

The Öresund Consortium

Swedish Transport Agency

Drivmedelsleverans (Fuel Delivery)

Preem

Electricity grid companies

E.ON

Other actors

Siemens

Elways

Elonroad

RISE

Props

Swedish Transport Administration

ElectReon

An electric road system sets new requirements

Account needs to be taken of the legislation surrounding the area for access, measuring and payment. Electric roads represent a new area that is likely to set requirements for adaptation of current regulations both nationally and at EU level. The starting point in this investigation is to first identify what a system for access, measurement and payment might look like in the future.

In a future realisation phase, the existing regulations need to be taken into account, but it is also reasonable to assume that a developed system for electric roads will set new requirements on the legislation. It is therefore also relevant for this investigation to consider how a future solution should be assembled in order to be adapted to changes in the environment that will take place in the coming years, even though the regulations currently need further adjustments for this to work.

Starting points with regard to regulations for measuring energy

When it comes to the actual measurement of electricity consumption, this is affected by EU legislation and Swedish legislation. Based on the regulations currently in place and which influence measuring linked to an electric road system, we have noted that the Swedish Transport Administration is conducting the work on a requirements specification for the electric road system with the following preliminary interpretation of the current regulatory framework:

- EU law does not impose any requirements on the design of measurement methods, this is instead the decision of each Member Government.
- EU law contains (so far) few explicit provisions on measurement. It follows from EU law that only customers shall have the right to receive relevant consumption data - which in practice is to be understood as an indirect obligation to measure electricity consumption.
- Swedish law (Electricity Act[3]) has placed the responsibility for measuring electricity consumption on the network concession holders. More detailed regulations on how to measure are contained in regulations and provisions.
- According to Swedish law (Electricity Act), the legislator assumes that measurement must be made at the outlet point (the point where the electricity user takes out electricity for consumption).
- For "IKN" (non-concessionary networks[4]), there are no provisions on measurement and measurement methods.
- In order to avoid measurement requirements in the vehicles on the electric road, as the regulations appear today, it is assumed that (at least) certain parts of the electric road can be built as a non-concessionary (IKN) network.

However, whether such a design is compatible with EU law should be further investigated.
In the current situation, it has not been decided whether a future electric road system will be designed with the support of the rules on non-concessionary networks (IKN) or as a concessionary network. Based on the regulations above, there is therefore reason to consider that both alternatives may be relevant. Among other things, this means that measurement of consumption may take place individually and at as detailed a level as possible, as well as that there needs to be the option to choose between electricity companies.

Starting point with regard to the upcoming pilot project

The report refers throughout to the upcoming pilot solution (2021). In the report, a pilot project for payments and access control is integrated with the planned pilot installation for electric roads. A separate pilot project for payment and access control is not an option that is discussed in the report.

The information-driven society

A key starting point that needs to be considered in the long-term design of a system for electric roads is the large digital pressure to change that society is

[3] SFS 1997:857. *Electricity Act.*
[4] SFS 2007:215. *Regulation on exemptions from the requirement for network concession in accordance with the Electricity Act* (1997:857).

facing. In principle, this affects all areas. Many industries are subject to strong pressure to change, and remaining relevant to users (customers, employees and citizens) will be important for public actors, among others, to take into account. The ability to remain relevant in an information-driven society is based on an understanding of a number of key conditions:

- Customer expectations and requirements are changing. New generations are setting new standards where digital communication is the starting point.
- Accelerated technological development opens the door to new boundaries between businesses and individuals. Previously obvious commercial and operational interfaces are challenged when technology enables alternative contact points.
- As part of the organisational efficiency improvements, the degree of automation is increasing in many different areas. Automation of simpler mass processes has been taking place for a long time and at an ever-increasing pace. We can now see the next step as even more complex processes are being automated with the help of Artificial Intelligence (AI).
- In pace with technology opening up new opportunities, new actors can create solutions and exploit these commercially.
- Service offers in the future will not, as today, be offered by *one* actor. Combinations of offerings are created through new ecosystems, and commercial use of information from different sources. Information itself is becoming an increasingly important asset for being able to offer new services.
- Organisations that have traditionally offered products are increasingly adding service to their offering with the aim of increasing customer loyalty and value.
- In parallel with new technologies, large parts of the economy's actors will be interlinked under the denomination "Internet of Things" (IoT). A broader discussion of this subject is being conducted, and the concept of "Internet of everything" is becoming increasingly relevant.

The development of an electric road system is a long-term undertaking, pursued in a rapidly changing environment. In this investigation, this is demonstrated not least by new behaviours linked to payment, and new ways of using information. Governo considers it important that there is an understanding of the points above in order to be able to develop solutions that are so dynamic that they can withstand a changing environment.

3. Overall process description

The Swedish Transport Administration has published system descriptions for electric roads in previous reports[5]. Figure 1 below is taken from one of these reports and illustrates the different parts of the electric road system identified so far.

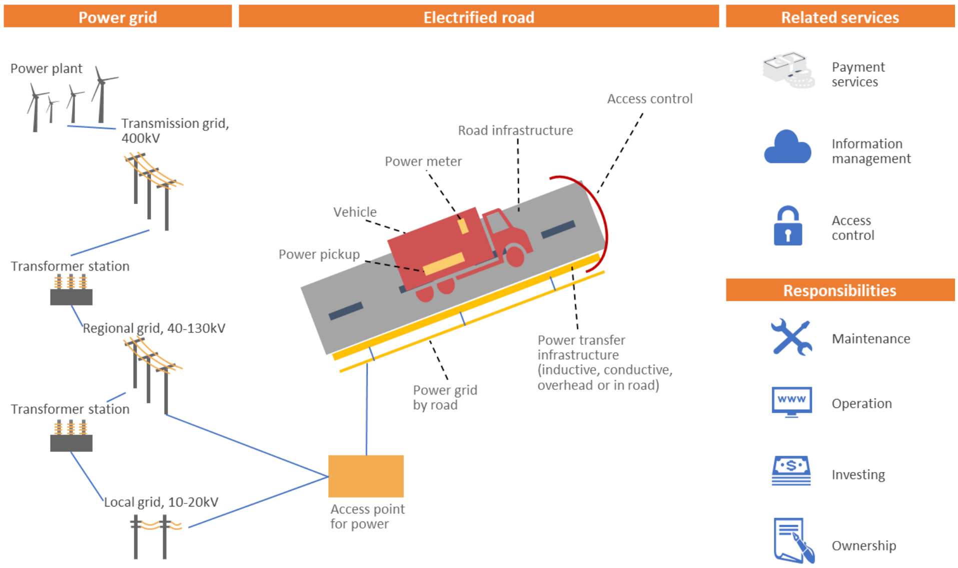

Figure 1. Electric road system services and components.

In order to gain knowledge about how the related services mentioned above (access, payment and information management) should be built up and linked together, an understanding is needed of the elements included in this business process as a whole. Below is a description of the processes that can be identified as key components in order for the system to be able to comprehensively fulfil its purpose.

[5] See the reports *Business models and financing for the development of electric roads in Sweden* (2018) as well as *Roles, actor relationships and risks in the electric road market* (2019).

Basic process

In order to ensure a functioning and cohesive system for electric roads, the following overall processes need to be included:

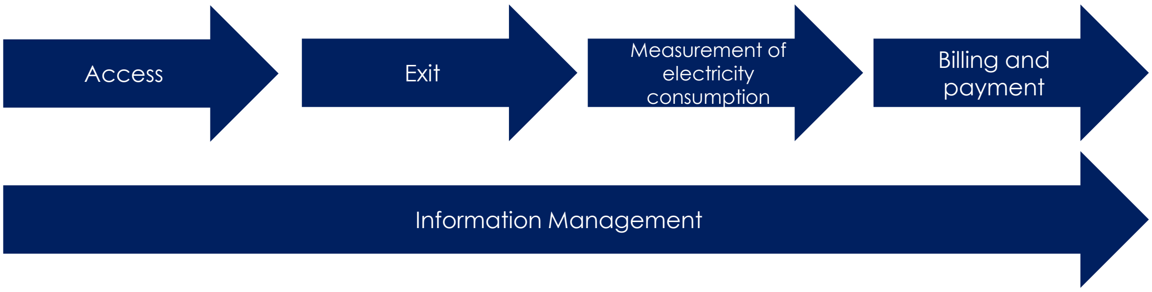

Figure 2. Process for access, exit, measuring and billing/payment.

Initially, a system will probably need to be in place that can handle the entry/exit to/from an electric road by a vehicle. Entry and exit need to take place with the aid of systematic scanning (fixed or mobile) in order to identify each individual vehicle in the system. Among other things, this includes the need for the system to have effective functionality to prevent cheating or other unauthorised use in connection with measuring energy. In addition, entry and exit probably need to be integrated with a system for measuring electricity consumption (measurement of electricity consumption and processing of the data before billing), which in turn should be possible to link to a system that can process the continuous payments.

Throughout the process from access to billing and payment, it is vital to ensure that the data is processed correctly and with the right purpose. It is therefore necessary to have a consistent process for information management in order to allow every element to be linked together and handled correctly, as well as on the basis of the regulatory framework in force. The information management should preferably be handled by a central function in order to avoid lock-in and to facilitate standardised work for storage and information security.

The process should be highly digitalised and automated. As mentioned, digitalisation has had an impact on many industries in recent years. As a basic requirement, the related services covered by this report should have the essential foundation that they are predominantly fully integrated and digital. This should also mean that the need for investments in physical scanning and measuring equipment is minimised. However, other investments for digital solutions may be included. Transmission of information regardless of content should be possible digitally on one or more digital platforms.

Relevant areas of competence and detailed process map

The process from a vehicle's access to final payment involves the need for a number of functions that cover different competency types. The functions will probably need to be included in all parts of the process for access, exit, measurement of electricity consumption and billing/payment in order for it to be possible to maintain the system as a whole.

There are a number of functions that may be necessary to integrate into the system in order to safeguard the flow chain:

- A function that is intended to secure the supply of electricity, that the supply works technically, and that energy consumption is measured appropriately.
- A function that manages a central platform for receiving, processing and converting information in the dividing line between measurement and payment.
- A function that ensures that the process for entry/exit to/from an electric road is scanned in an individualised and legal way.
- A function that ensures the development and operation of a payment solution that can receive energy measurement information and convert the information into payment data and transactions.
- A function that ensures that correct information in the entire flow chain is also handled in a correct manner.
- A function that handles the operational service.

The functions above can either be handled by an overall actor that is responsible for all areas, or by several collaborating actors to provide the requested services.

The areas of competence in themselves cover specific phases within the processes for access, measurement and payment. These phases can be specified according to the following model:

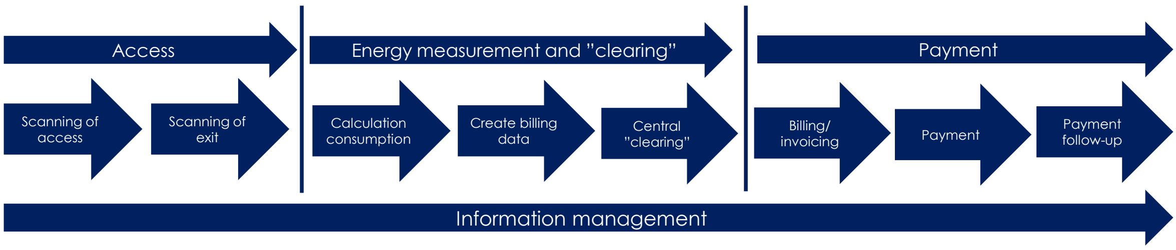

Figure 3. Sub processes.

For entry/exit to/from an electric road, one function is likely to be responsible for the management and development of the continuous identification of each individual vehicle. Identification can take place in different ways, probably integrated with a system that handles measurement of consumption.

To measure the energy probably requires a function to be responsible for the measuring itself, and to convert the measurement data into a basis for an upcoming payment. This information needs an operator that handles the payment to be responsible for receiving and processing, and then to handle the business through billing and payment follow-up.

As illustrated in the figure above, each sub process includes a number of main activities and solutions. Below is a description of these, and what is likely to need to be established in each individual sub process.

Access

Upon vehicle access, vehicle identification needs to take the form of scanning. Scanning may have several different purposes, but should primarily aim to:

1) Ensure that each individual vehicle is identified upon access.
2) Ensure that the individual vehicle using the electric road is also authorised to consume electricity on the road.

For the latter point, a system for access to electricity supply should have the ability to deny access to the electrical installation for a vehicle that does not have correct identification. In addition, there is probably other information that is relevant to identify when scanning, such as related to time, vehicle type and geographical location.

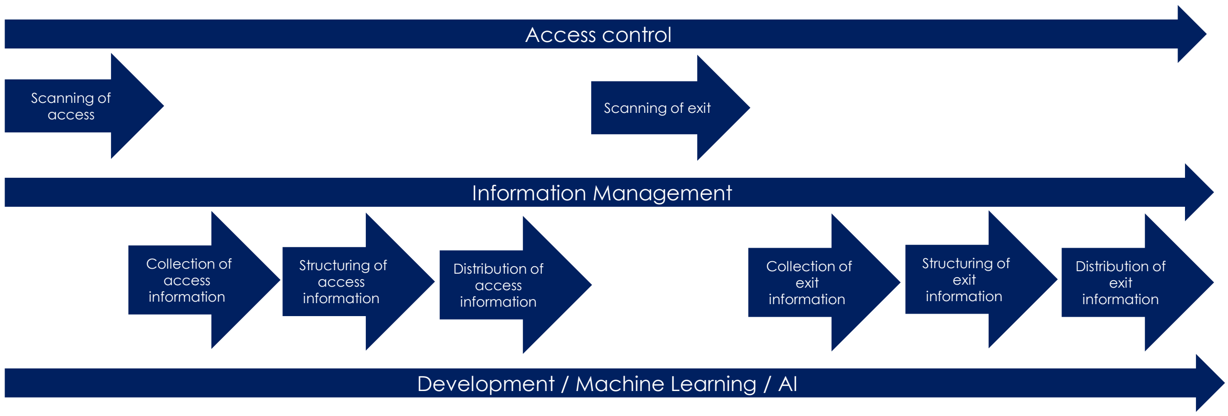

Figure 4. Process for access control.

Access requires a process to gather, structure and distribute information prior to an upcoming scanning upon exit. Exit information also probably needs to be collected, structured and distributed. Cumulatively, a large amount of information will be generated in the controls. For the future analysis of all of this information, it should be possible to develop processing with the aid of AI-adapted solutions. Modularity and flexibility should be seen as important prerequisites for the system in respect of this option. This also contributes to future-proofing the system's ability to analyse and make practical use of the information collected.

Access control and measuring electricity consumption can take place, but not necessarily, at different times. Electric road technologies are available that include access control according to continuous communication between electric road and vehicles in the live sections of the road. In this case, scanning does not take place at the time of entry, but continuously during the vehicle's use of the electric road while electricity consumption is measured at the same time. Depending on electric road technology, access scanning can therefore also be handled continuously while driving on the electric road. For this solution, the same individual actor could handle both access and energy measurement. Consequently, the choice of electric road technology has an influence on how the process for access control is designed.

Energy measurement

Energy measuring process

In order to be able to produce data on the vehicle's energy consumption, the energy consumption needs to be measured continuously. Calculation information needs to be collected, structured and distributed for the process to calculate the consumption. Measuring electricity consumption should be able to provide data for upcoming billing. This means that information related to billing needs to be collected, structured and further distributed prior to an upcoming payment.

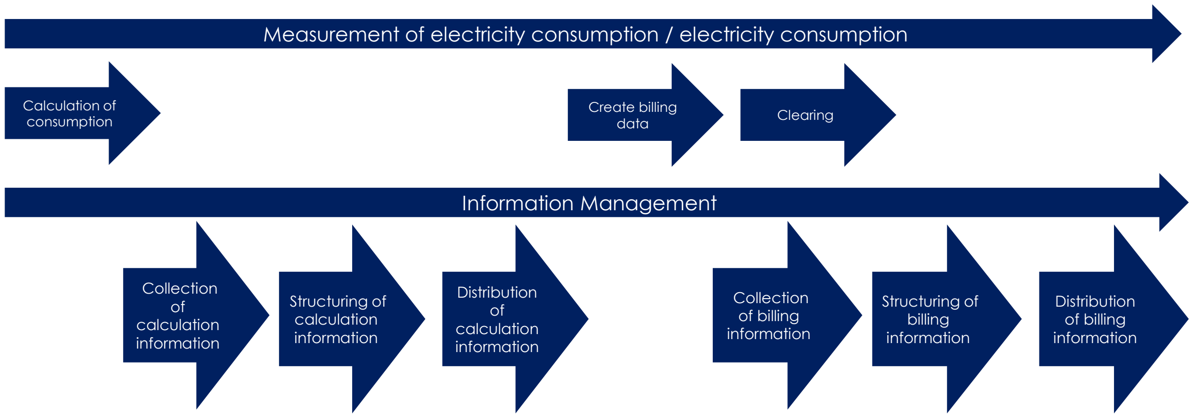

Figure 5. Process for measuring electricity consumption.

Principal examples from the railway sector

In a future design of a system that can handle the measurement of energy, there is reason to also consider the area of energy measurement for railways, which has been in use for a long time. A number of overall characteristics are relevant to consider[6]:

- Trains are equipped with instrument transformers to measure current and voltage, and here, an energy meter calculates the energy consumption. A data logger adds GPS position and stores data.
- The energy meter sends measurement values to a measurement value collection system where an initial measurement value processing takes place. The measurement values are then sent further to a system that converts the information to be adapted to country with a focus on train operators instead of individual trains. Finally, information is sent further to a system for creating invoices for individual train operators.
- Costs in the measurement chain are borne by the train operator.
- Trains move across national borders as well as different electricity price zones.
- Energy meters can be used to diagnose the condition of the overhead line.

[6] Ållebrand, Björn (Swedish Transport Administration). *Electricity meter on train.* 2019.

As described above, there is a system for rail traffic to collect, process and convert information (in this case, measurement value information) in order to prepare for a final payment process. This type of solution may also be relevant for consideration in the electric roads field, where a similar central solution (clearing, see below) will probably be needed in order to handle the measurement and payment information.

Clearing

In line with the electricity market's work method with several electricity zones along a road, in the shorter as well as the longer perspective, there will probably need to be a process for collecting billing and payment information based on the energy consumption measurements made.[7] This process should be able to solve a number of challenges, for example:

- Separate customers from "visitors" in host networks.
- Apply pre-pricing of data.
- Communicate between all connected electricity suppliers and electricity grids.
- Receive and invoice pre-priced data, possibly from several different electricity grids and several countries.

The collection, structuring and distribution of consumption and related payment information is likely to need to be facilitated by the provision of a central and common central clearing solution. These types of initiatives are available in the commercial market today, and Governo can see an interest in external, commercial actors with responsibility for operation and development, as an isolated part but also as part of a larger and broader commitment.

The clearing solution for electric roads could have many similarities with the roaming solutions that have been a foundation in the development of global mobile telephony, where a number of basic principles in central information management can be used to draw lessons in the development of the system for electric roads. Consequently, a good way to describe a clearing function for electric roads is to start out from the action mechanism for roaming within mobile telephony:

- A user is normally connected automatically from one telecom operator's network to another operator's network.
- National roaming can be used if there is no radio coverage from the normal operator but radio coverage is available from another operator.
- It is normally referred to as international roaming in everyday speech. In this case, when the subscriber leaves his/her home country and leaves the radio coverage of the normal operator, a phone switches over to an operator in the country being visited.
- Operators enter into roaming agreements between themselves to provide this function, so that the call can be billed on the normal invoice, and there is no

[7] See also Börjesson, Conny (RISE). *PM Work Package 7, Part 2: Measurement, Access and Payment Systems.* 2019.

need for a foreign invoice to be sent to the end customer/mobile phone owner.
- Among other things, the agreement regulates what kind of compensation the operators charge each other for allowing another operator's subscribers to use the mobile phone in their own network.
- The operators have a collaborative organisation for, among other things, roaming (GSM Association).

Payment

The payment process

The payment process needs to be able to ensure a smooth flow of payments where payment takes place in an efficient and automated way, and where billing, payment and follow-up can be ensured according to the subprocesses below:

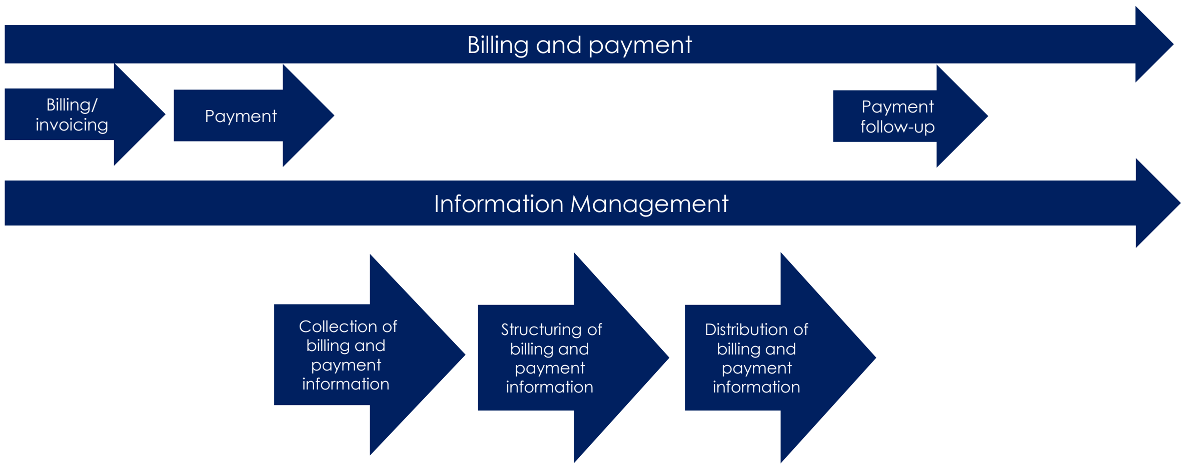

Figure 6. Process for billing and payment.

There is reason to assume that payments made in real time are preferable to traditional payment by invoice. Among other things, the reason for this is that there is currently a high degree of expectation from consumers and companies that payment should be made quickly, efficiently and without intermediate steps that require timely efforts. There is also much to indicate that the general development in the payment field is moving towards real-time transactions, and real-time transactions are a starting point that can facilitate important value creation to encourage actor collaboration with the market.

Payments are increasingly a volume business with low prices and very limited margins. Scalability in the payment solution is therefore likely to be a prerequisite for external actors to create long-term sustainable profitability. Large transaction volumes in a common solution facilitate the implementation.

In recent years, the Swedish payment market has been subject to high pressure to change. After having long been strongly linked to bank activities, new EU rules, among other things, have opened the market for new solutions, to some extent outside the core business of the banks. The Swedish banks have a long and internationally successful history of cooperation (Bankgirot, VPC, etc.) around "common industry solutions". In the payment field, a solution for real-time transfers between private individuals, Swish, was established in 2012 based on Bankgirot's BIR payment platform (real-time payments). The opportunity and ambitions for the development of Swish-like solutions even for a B2B environment are great, in particular given the long-term forward planning involved in the electric road system from a payment perspective. The Nordic banks also established a joint cooperation in 2018 to develop real-time payments with a Nordic focus (P27).

Pricing models for electric roads

As mentioned in the introduction to this report, a starting point for the analysis is that individual measurement is likely to be needed, and that there needs to be the option to choose between electricity companies. In the current situation, there are at the same time a number of different options for what form payment in the system might take. Different starting points are given below for creating a general pricing model. Since the construction of an electric road system will take place over a longer period of time there is the possibility that the prerequisites and parameters may be affected. For example, legislation that is currently considered to have a major impact may be adjusted over time.

In this perspective, it may be valuable to look at the nature of the trends in pricing models around the world. Many industries are moving towards more fixed and subscription-based solutions, and fixed monthly fees have gradually replaced the previously detailed call-driven prices in the mobile phone market. New services based on new technology, such as Spotify, are paid according to a subscription model. Customer understanding and payment acceptance seem to increase with increased simplicity and clarity, which has been confirmed in this investigation by actors in areas related to future electric road solutions.

Governo assesses that it would be prudent to also take account of the possibility of simplifying pricing for the service early on in the establishment of electric road solutions, although there are also short-term challenges to this in the form of electricity legislation and the special conditions for electricity consumption. All the following models, which include the cost of electricity, could therefore be evaluated (based on Siemens work for the German market[8]):

- **Fixed fee:** Made for a specific section or region per month or per year. The payment is completely independent of the actual use of electricity, and the amount for the fixed fee may vary depending on the type of vehicle.
- **Fee for a period of time:** Payment is made per use of a section or region and is not dependent on actual use of electricity. Urban toll solutions in cities often have this approach, and the fee may vary depending on the type of vehicle.
- **Fee for connected kilometre or time:** Payment is made per unit of time or section of road. Here, a statistical calculation of consumption can be

[8] Siemens. *E-highway utilisation fee.* 2019.

made, but actual consumption is not measured. The fee may vary depending on the type of vehicle.

- **Fee based on actual consumption:** Payment is made based on actual consumption of electricity. Vehicle classification is not necessary. Regulations for measuring must be considered.

Information management

Data is and will be an increasingly important asset in all activities in the future. Data creates knowledge about customers, suppliers and business models, and can result in a faster capacity to adapt to new rapidly changing conditions. Within the electric road system, other actors may also have an interest in the activity's data, which creates new financing opportunities, but clear consideration for privacy issues.

For electric roads, information management at the overall level needs to be able to collect, structure and distribute entry and exit information, as well as calculation and billing information before final payment:

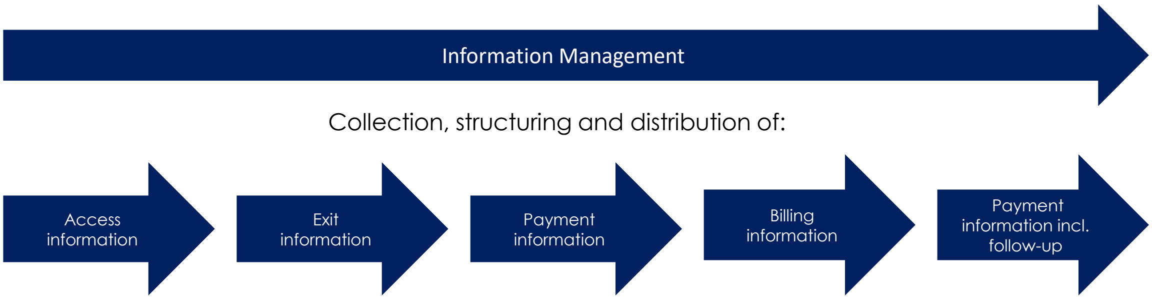

Figure 7. Process for information management.

Based on the data collection in this study, it is possible to identify an interest in the electric road market from actors whose core business is to handle (collect, structure, package and distribute) large amounts of information. Large global, Nordic and Swedish companies are already established in the Swedish market in this field, and several large companies in the tech industry are in the starting blocks for establishing and developing activities in the Swedish market.

The large amount of information that can be generated in an electric road system has the potential to create the conditions for various forms of additional services. In the long term, these may be of great importance but should probably be less prioritised in the shorter perspective so as not to distract focus from the establishment of the system. Examples of information-generated additional services could be:

- Information that can be used to optimise traffic flows and facilitate varying driving patterns.
- Information that can be used to optimise fuel handling and to choose between dynamic charging and battery.
- Prioritising of certain vehicles based on battery level and final destination
- Dynamic pricing with regard to how much electricity the vehicles need.
- Information that can be used by companies or public actors in order to develop new knowledge and new services.

4. System description, actors and roles

System description

Using the above reasoning as a basis and starting point, a system for access, payment and information management can take the appearance as described below:

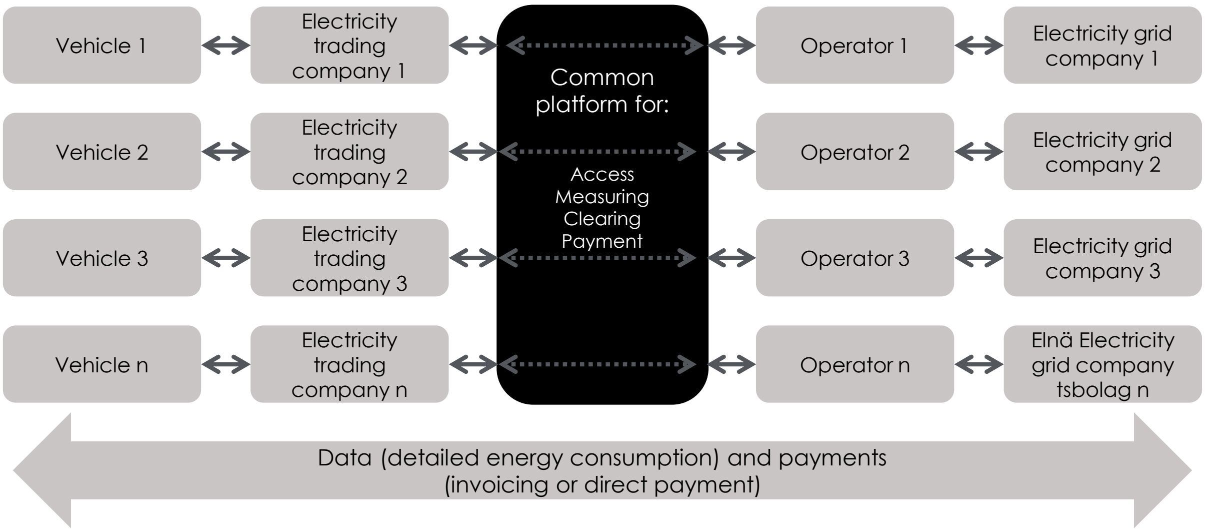

Figure 8. Conceivable fundamental system description.

The **common platform** should be highly automated and digitalised with a large element of information sharing with regard to access, energy measurement, clearing and payment. The proposal is that the platform can be developed, used and evaluated early in the establishment, i.e. in the implementation linked to the pilot phase.

In the current situation, there are actors in different segments interested in demonstrating commitment in a future process, and Governo can note an interest from actors in potentially different areas: the large IT companies and energy companies, but also from other parts of the ecosystem surrounding the electric road venture. Within the framework of the platform, deliveries can be made by more specialised actors, e.g. within the clearing and payment field.

The platform should be able to handle information and solutions from a large number of actors, both in terms of pricing models as well as customer relationships and exchange of information. Flexibility and transparency should characterise the solution.

The customer relationship for the end customer, i.e. **driver of an electric vehicle** and the haulage contractor, can be organised in many different ways. For example, the driver and haulage contractor may have a direct customer relationship with any of the following:

1) Electricity trading company.
2) Electric road operator.
3) The actor that is responsible for and operates the common platform.

Other customer relationships may also occur. The platform is recommended to support transparency in order to create flexibility towards the end customer.

For the **electricity trading company,** we do not see any significant difference to the current customer relationship. The agreements are signed as in the current situation, with the important addition that consumption can also be recorded for objects in motion, and in view of this the consumer can travel through different price zones.

The system is based on an actor or actors holding the role as **operator** of the electric road. A separate investigation into this role is in progress[9], where the definition of the operator is as follows:

> "The operator's assignment is to offer the opportunity for access to secure and green transport on electric roads by means of the physical and/or operative link between road, electricity, vehicles and infrastructure."

Whether the operator should also be responsible for the common platform does not have to be decided in the current situation, but should be further investigated and/or be a forum for the future pilot process. There can be many different alternatives, and different actors have different agendas and interests, both short-term and long-term. In Governo's opinion, it is vital to incorporate their experiences and preferences into the ongoing work.

Some reflections on actor collaboration and roles in the future

In order to develop a working process for access, measurement and payment, there are many different conceivable approaches to how actors can take responsibility for the system. One of these possible scenarios is that an established market participant expands its existing business by taking overall responsibility for the common platform as described above (illustrated in Figure 8). The role is then probably taken by an actor with a strategic interest in taking overall responsibility and also adding digitalisation skills. This actor could, for example, be any of the following:

1) An established electricity grid company with a strategic ambition to develop the business.
2) An established actor within the framework for access control/measurement.
3) An established actor within payment.
4) An established actor within the area of information management.

Based on the study, Governo can identify that prominent actors within the above areas are likely to have large parts of the organisation in place in order to adapt to the requirements of the electric road system. In general, there are

[9] EY. *The electric road system's actors and financial conditions – An analysis of the operator's role and short and long-term scenarios.* 2019.

also structures in the activities for establishing relevant functions to provide services for access and measurement.

The operator's role can either be provided by the same actor as the party responsible for the common platform, or be distributed to one or more other actors. Here, the interface between operator and common platform may have a different appearance depending on what will eventually be included in the operator's role.

The electric road system requires a wide range of specialist skills. An actor responsible for a common platform is strongly recommended in this case to have established structures for connecting skills and collaborating with partners/subcontractors. This is to be able to provide the parts that should be accommodated within the framework of a common platform. However, to avoid risks associated with lock-in (that the system becomes dependent on one individual supplier), it is desirable that systems and interfaces are based on open and modular standards. This is needed in order to adjust and develop the system over time.

Another possible scenario for ensuring a common platform is that the responsibility is divided between strong niche actors within each process. This means that a specialised actor in payments, for example, is responsible for the payment flow, or that a specialist actor in access control is responsible for this part of the system. There are both local and global actors with specific solutions that can combine to contribute to a cohesive platform solution.

A platform that consists of this type of actor collaboration is likely to continue to include an actor with overall responsibility for the platform. However, responsibility in this case is likely to be primarily a matter of coordinating the platform's other actors. The scenario can create the conditions for a high level of competence in each sub-area, not least with links to digitalisation. However, there are risks that niche actors may lack relevant industry experience, which is one of several challenges that need to be considered in the future if that is the case.

The above examples are two of many possible alternatives for how actors can organize themselves in the future in order to provide a working process for access, measurement and payment. Governo's assessment is that Swedish Transport Administration's upcoming pilot project can provide important answers on how the distribution of responsibility can be designed to best meet the requirements that the system needs to meet. Regardless of how constellations eventually take shape, the system will need to build on a high degree of collaboration - both between Swedish Transport Administration and the market, and between market participants – in order for the parts of a system to be cohesively connected.

5. Crossroads and the next step

Crossroads

The assignment of the electric road programme to develop an electric road system is both extensive and complex. For example, there are uncertainties about which regulatory frameworks should be applied and how these should be interpreted. New actors from new industries will develop an interest in having increased commercial involvement, but in this way will also challenge existing rules of the game and structures.

Governo's assessment is that there are different paths to choose between for the pilot phase. One way of working is for the initiating organisation to take a position on the issue of which path to choose and allow it to characterise the continued work. Alternatively, a description is given of the alternative paths ahead and the relevant party/parties is/are invited to describe possible future approaches.

The alternative paths that Governo can recognise as needing to be initiated can be noted in the list below. This list is not comprehensive, but is related to the issues of this investigation and other issues on alternative paths may therefore be relevant.

- The relationship between traditional actors or actors of a niche or start-up nature with a strong focus on new technology (start-up actors).
- Traditional billing solution or payment solutions based on real-time payment solutions.
- The relationship investment in comprehensive physical scanning equipment and more flexible and digitally based access solutions.
- The extent to which the Swedish Transport Administration and/or market participants intend to prepare for AI, Machine Learning and IoT in future solutions.
- The need for a long-term clearing solution similar to the mobile phone industry's roaming solutions.
- Potential boundaries and integration between the parts of the overall system.
- Short and long-term view of potential additional services/commercialisation.
- Legal aspects of the continued development of the system.

Proposals for further work and the next step

The work on electric roads within the framework of the Electric Roads Programme has, based on reasonable grounds, been characterised by the creation of knowledge about the area through a number of knowledge bases/reports describing, among other things, the current situation and conceivable paths for development.

Governo wishes to emphasise the importance of making early decisions on the scope, structure and other details of the pilot. With key decisions in place, it will be easier to create commitment and willingness to invest with different key actors.

There are different approaches for taking advantage of this willingness on the part of the commercial actors. One way is to establish interaction with actors in the private sector and that these assume roles spontaneously within the framework for the guidelines set by the Swedish Transport Administration.

An alternative to this could be to initiate a process for a detailed procurement of functions and services within access control and payments, together with other parts of the electric road field. Our assessment is that for such procurement the actors are prepared to create different types of consortia where varied and strong competencies are brought together and cost-effective solutions are created.

Conceivable next steps in the work may be as follows:

- **Conduct "vision exercise".** With many alternative solutions, actors and constellations, the elimination and clarification of alternatives are facilitated by some form of future work including a joint vision exercise/process focusing on 2030-2045 with actors on electric road investment. In this case, many actors with different perspectives will be able to contribute important knowledge and experience.

- **Develop various alternatives for pilot solutions as part of the pilot section**. This should be done on the basis of completed investigations and, preferably, through the completed vision exercise – in order to safeguard both long-term and short-term requirements and wishes.

- **Consider more than one pilot section.** Governo's assessment is that the continued work with the pilot project should be more clearly defined and alternative solutions described. Since there are many solution options, there may also be reason to consider more than one pilot project. Although the initial investment with the most certainty is larger, it can in many cases be cost-effective to test more solutions in a pilot stage in order to get things more right and more cost-effective in the long-term solution (i.e. do more right from the start).

- **If procurement of a pilot solution is carried out,** this should be characterised by a far-reaching dialogue with various actors, which will probably consist of different consortia.

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